Jasper Ridge Biological Preserve

Annual Report 2010-11

STANFORD

School of Humanities and Sciences

Contents

From the Faculty Director

Chris Field

In the early days of ecology, researchers made observations with their eyes, often from a horse or a Model T. They asked sophisticated, modern questions about topics like the controls on biodiversity. But there were no such things as specialized ecological instruments. Early vegetation ecologists typically had extensive training in taxonomy and theory, but the tools were limited to microscopes, meter tapes, and shovels. With these tools, researchers in the era of Warming, Schreve, Gleason, and Clements built the foundations of the modern science of ecology. But the scale of the work and the ambition of the questions were limited by the available tools. Research was plot based, and the process of forging regional or global understanding required arduous travel to distant sites, for surveys of a few small plots. The community of researchers was small, and observations accumulated slowly.

Front Cover: Banana Slug on moss, between rains, beneath the redwoods. Herb Dengler Memorial Trail (Trail 1). **Left:** Morning mist lifts from Jasper Ridge. Deer browse at dawn beneath a valley oak covered in mistletoe, Road F. **Right:** Carnegie Airborne Observatory at the San Carlos Airport.

In some subfields within ecology, the development of new instruments and new techniques has been transformative. For example, over the last several decades, new instruments have allowed researchers in ecophysiology and more recently ecosystem physiology to ask questions at a finer level of mechanistic detail and also over larger spatial scales and more regions. Even more recently, the emergence of molecular techniques has opened new vistas, especially for microbial ecology and population ecology.

But in other areas, research has remained more or less in the era of the Model T. This is especially the case for topics that require huge numbers of observations over large areas. Some of these topics represent core issues for global ecology, carbon accounting, and the ecosystem stewardship that is the focus of the new initiative of the Ecological Society of America.

The picture is finally starting to change. The last few years have seen the emergence of some exciting, powerful technologies aimed squarely at the topics that have been the most difficult to address. For two very different but potentially complementary technologies, Jasper Ridge has been something of an incubator and a test bed. These two technologies, the Carnegie Airborne Observatory (CAO) and iNaturalist, address important aspects of biomass, biodiversity, and community composition at previously unimaginable scale.

The CAO is a set of aircraft-based remote sensing instruments that measure key aspects of ecosystem structure and composition at high spatial resolution, over very large spatial scales. One of the CAO instruments, a wave-form LIDAR (an acronym for LIght Detection And Ranging) provides a 3-D map of vegetation structure. Once calibrated against traditional ground-based data, a LIDAR map can be converted into a biomass map. The Carnegie Institution's Greg Asner, developer of the CAO, has been deploying the system to measure biomass in tropical forest regions around the world. Biology graduate student Kyla Dahlin has led the effort to use CAO LIDAR data to map the biomass of Jasper Ridge. Kyla can tell you the average aboveground biomass of grassland, shrubland, and forest as well as the total aboveground biomass of the preserve (50,263 tons). While you may not care today about the total biomass of Jasper Ridge, this kind of information will be critical for basic questions about ecosystem storage and release of carbon as well as for the development of carbon markets and efforts to protect forest carbon through avoiding deforestation (often called REDD or Reduced Emissions from Deforestation and forest Degradation). For an area the size of Jasper Ridge, developing a wall to wall map of biomass requires less than an hour of aircraft time, but lots of effort, as Kyla can attest. In contrast, a similar map based on direct measurements would require many person-years of fieldwork.

A second instrument on the CAO is a spectrometer, an instrument that measures the color of reflected light. The differential reflection of each color (including infrared light that we don't see) provides a signature of the chemical composition of the vegetation. At Jasper Ridge, Kyla has used these measures of chemical composition to map vegetation types. Her map is based on the equivalent of over 600,000 observations of community composition. With this technology, the creativity of the researcher does not need to be constrained by the difficulty of gathering huge numbers of samples. On June 7, before heading to South America, Greg made a test flight over Jasper Ridge using his newest CAO equipment, providing even higher resolution than Kyla's maps.

But there are, of course, many kinds of patterns that are not visible to the CAO, even at its highest level of resolution. That is where technologies like iNaturalist come in. The brainchild of Carnegie Research Associate Scott Loarie, along with colleagues at Microsoft and UC Berkeley, iNaturalist is an exciting development in crowd-sourcing, or harnessing the enthusiasm of thousands of volunteers to document important ecological patterns.

In its current form, iNaturalist is configured to be very easy to use for recording distributions of organisms that are big enough to be recorded with a cell-phone camera. By combining a photo with the phone's time stamp and GPS location, iNaturalist allows any interested user to contribute to a rapidly expanding database of documented species observations. If the observer knows the identity of the organism, she can upload that as well, but the beauty of iNaturalist is that the observations are automatically placed on a website where experts can provide definitive IDs. Even though it has been available for less than a year, iNaturalist has already become the goto tool for a number of research and conservation groups focused on particular groups of organisms (like amphibians) or particular locations (like Jasper Ridge). iNaturalist has the potential to be a very powerful tool for mapping range shifts and the early stages of biological invasions, as volunteer users take on the challenge of asking whether you really can find, for example, a banana slug or a stinkwort at Jasper Ridge.

These two examples, the CAO and iNaturalist, illustrate something important about progress in ecology and something important about Jasper Ridge. In ecology, we are finally finding ways to harness advanced technologies to move out of the era of the horse or the Model T. The questions are not always new, but the ability to ask them on the basis of massive amounts of data, potentially at the scale of the globe, is empowering and transformative. This kind of technique is truly launching the era of global ecology as well as enhancing our ability to provide responsible stewardship for the home planet. For both these, as well as for other new technologies, Jasper Ridge is an invaluable testing ground. With well-studied ecosystems, easy access, and the potential for long-term observations, Jasper Ridge is the perfect partner for the kind of creativity and innovation we see in the CAO and iNaturalist.

Jasper Ridge Advisory Committee

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

Chris Field (chair), *Biology and Environmental Earth System Science*

Eric Abelson, *graduate student, Biology*

Nicole Ardoin, *School of Education*

Kyla Dahlin, *graduate student, Biology*

Rodolfo Dirzo, *Biology*

Paul Ehrlich, *Biology*

David Freyberg, *Civil and Environmental Engineering*

Tadashi Fukami, *Biology*

Elizabeth Hadly, *Biology*

David Kennedy, *History*

Katharine Maher, *Geological and Environmental Sciences*

Stephen Palumbi, *Biology*

Philippe Cohen, *ex-officio, Jasper Ridge*

Nona Chiariello, *ex-officio, Jasper Ridge*

Jasper Ridge Coordinating Committee

Is composed of individuals from Stanford and non-Stanford organizations representing the broad range of groups the preserve interacts with. Provides advice and guidance to the Administrative Director on significant management challenges facing the preserve.

Philippe S. Cohen (chair), *Jasper Ridge*

Julie Andersen, *Midpeninsula Regional Open Space District*

Lisa Bankosh, *Midpeninsula Regional Open Space District*

Leonie Batkin, *Stanford Real Estate Operations*

Angela Bernheisel, *California Department of Forestry and Fire Protection*

Rick DeBenedetti, *Woodside Trail Club*

Denise Enea, *Woodside Fire Protection District*

Jerry Hearn, *Acterra*

Don Intersimone, *Office of the Dean, School of Humanities and Sciences, Stanford University*

Leslie Lambert, *Town of Portola Valley Planning Department*

David Lenox, *University Architect/ Campus Planning and Design*

Jean McCown, *Stanford University Government/Community Relations*

Elizabeth Meehan, *Jasper Ridge docent*

Trish Mulvey, *Palo Alto Community Volunteer*

Ellen Natesan, *San Francisco Water Department*

Chindi Peavey, *San Mateo County Mosquito and Vector Control District*

Diane Renshaw, *Jasper Ridge docent*

Jeanne Sedgwick, *neighbor and Jasper Ridge docent*

David Smernoff, *Acterra*

Susan Witebsky, *SLAC National Accelerator Laboratory*

Tom Zigterman, *Stanford University Facilities Operations*

JRBP Staff

Chris Field, PhD	Faculty director
Philippe Cohen, PhD	Administrative director
Nona Chiariello, PhD	Staff scientist
Cindy Wilber	Education coordinator
Trevor Hébert	GIS and data manager
Carolyn Taylor	Administrative assistant
Cary Tronson	Operations manager
Brooke Fabricant	Resident ranger
Steven Gomez	Temporary maintenance assistant

Managing a Biological Field Station

Philippe S. Cohen

The broad and diverse activities that occurred this past year were breathtaking in scope and speak to the preserve's maturity as a biological field station: from a prescribed burn to a report on mountain lion presence; from the development of a visiting artist program, to students visiting from the Asian University for Women. As the preserve approaches its 40th anniversary (2013), these programs and activities are examples of its vibrant contributions that span multiple disciplines, generations, and spatial scales. What follows are just a few of the 2010-11 highlights.

Management that touches the world outside our boundaries

The Jasper Ridge Coordinating Committee (JRCC) focused much of their attention this past year on the future of Searsville Dam. This preceded an important turning point in the future of the reservoir—at the request of provost John Etchemendy and under the direction of Robert Reidy (VP of Land Buildings & Real Estate), a Searsville Alternatives Study was convened (**http://jrbp.stanford.edu/Searsville**). This initiative, which includes a steering committee (faculty and executive administrators) plus a working group (university staff), will provide strategic recommendations and assistance in developing alternative actions and evaluation criteria for the future of Searsville Dam and its reservoir. This development is important to the preserve and the University for several reasons:

- Recognition by the university that the preserve's future is inextricably linked to successfully managing the future of Searsville Dam;
- The committee's interdisciplinary make-up assures a broad and holistic approach to this land management challenge;
- This establishes a process for study and evaluation of the numerous issues associated with the dam such as ecological impacts, water resources, sedimentation, flooding, and programmatic opportunities, etc.;
- It provides a template for integrating faculty expertise and interests into other Stanford land management challenges.

The outcome of this estimated two-year effort will have a profound influence on the future of the preserve and the kinds of programmatic activities the preserve is best suited to support while significantly influencing the future trajectory and health of the ecosystems associated with the reservoir.

Another event, which took many months of planning and coordination, culminated on July 18th with a prescribed burn at the Jasper Ridge Global Change Experiment (JRGCE). You can learn about the important scientific questions this effort addresses in the Research section. The amount of coordination and effort required for this two-hour project was impressive. While the size of the prescribed burn was small at 1.2 acres, several factors made it a complex undertaking, as a partial list of agencies and organizations involved attests:

- Cal Fire (especially Angela Bernheisel, Vegetation Management Program Coordinator, Jamie Norton, Incident Commander, Richard Sampson, Division Chief, and John Ferreira, Unit Chief)
- Woodside Fire Protection District (Densie Enea, Fire Marshal)
- CalTrans
- Stanford University's Office of Risk Management (Tina Dobleman)
- San Mateo County Sherriff's Department
- Land Buildings and Real Estate (Alan Launer and Laura Jones)
- California Department of Fish and Game (Conrad Jones)
- Palo Alto Fire Department
- Bay Area Air Quality Management District

This list reflects the urban/wildland intermix zone in which the preserve is embedded. Not only was it vital to take all necessary safety precautions, but to also communicate those efforts to the surrounding communities and explain why this undertaking was important.

One unique component was the decision to stream live video of the prescribed burn (**http://jrbp.stanford.edu/fire.php** for video and photos). Other community outreach strategies emerged from discussions within the JRCC. These had a real impact on how the community viewed the effort and significantly enhanced subsequent communications.

Left: A typical winter storm flow through Searsville Dam. **Right:** CalFire equipment and personnel shortly after the prescribed burn at JRGCE was completed. **Page 6**: Harvester ant, *Messor andrei*

A Call from the Wild: From Mountain Lions to Ant Surveys

While the video streaming of the prescribed burn was made possible thanks to the ongoing deployment of an NSF-funded wireless mesh network (see 2010 Annual Report), the network also included the deployment of wireless cameras that have recorded several compelling images of mountain lions (http://jrbp.stanford.edu/ctgallery/ctgallery.php). These images, in turn, raised questions about current JR policy. This was turned into a partnership opportunity with the Rising Environmental Leadership Network at Stanford's Aldo Leopold Leadership Program, which in turn put together a team of graduate students and postdocs to study the policy and management implications of mountain lion presence at Jasper Ridge. This team provided the preserve with a multidisciplinary management analysis and recommendations (report is available on our website) while the effort provided the team with a real-world opportunity to look at a management problem—living with wildlife in an urban/wildland transition zone. The results are compelling, and in the coming years several of their recommendations will be implemented.

One of the more memorable activities I engage in each year are the semi-annual ant surveys. My wife, Cindy and I team up and go out on the trails along with other dedicated volunteers, to continue the almost two-decades-old survey started by Deborah Gordon's lab. No longer are names like *Linepithema*, *Crematogaster*, *Camponotus*, or *Prenolepis* strange or unfamiliar. The results of this effort are helping answer important questions about what drives species invasions, the interactions between Argentine and native ant species, and the long-term impacts of invasive species on native ecosystems and community composition.

Another Face for Creativity

Some time ago I had a conversation with renowned photographer, Robert Buelteman, expressing regret there wasn't a stronger connection between the preserve and the humanities and arts programs on campus. Rob talked about visiting artist programs he had been associated with and offered that JR would be a great venue for a comparable experience. So it is with considerable delight that Jasper Ridge was able to help create its first visiting artist program for the coming academic year.

After several meetings with the Stanford Institute for Creativity in the Arts (SiCa), agreement was reached to pilot a visiting artist program, adding an exciting new dimension to the preserve for the coming year. Thanks to a generous donation from Tony and Rosina Sun, support from the Dean of the School of Humanities and Sciences, SiCa, and the Department of Drama, Jasper Ridge will have its first visiting artist—Ann Carlson. Ann's work will include the active participation of Stanford students as well as members of our community, so stay tuned.

On the Road to Net Zero Emissions

There were some subtle changes in our award winning green building—the Leslie Shao-ming Sun Field Station. While the building is at least 15 times more efficient than other comparable buildings (see 2008-2009 annual report), we still are striving to achieve the original goal of annual net-zero carbon emissions. To reach that goal, some fluorescent lights were replaced with LED fixtures. Results from this installation include visitors and docents expressing a strong preference for the quality of light from LEDs, finding it more soothing and easier to adjust to. The LEDs also appear to use less than half the energy of the energy-efficient fluorescents. I say "appear" because, unfortunately, the energy monitoring system that has been operating non-stop for almost nine years ceased to function. A new monitoring system will determine whether we have acheived our goal of net-zero carbon emissions.

Above: Participants in docent field trip to La Selva Biological Station in Costa Rica. Below: Students from Asian University for Women visit Jasper Ridge for a tour with Nona Chiariello and Philippe Cohen.

Visits to and from Jasper Ridge

Over the summer, Dean Richard Saller taught and hosted a Stanford course on women in western civilization for 25 undergraduates from the Asian University for Women. The Dean asked that Jasper Ridge host the students for a day. This turned into one of my highlights for the year. The students represented a first generation of female college students from Bangladesh, Myanmar, Nepal, Pakistan, Sri Lanka, and other Asian countries. The challenges these students overcame, and the leadership and courage their remarkable stories represent, were inspiring. I was as enthralled with them as they seemed to be with Jasper Ridge. It was the kind of experience and opportunity that adds meaning to the work I do at the preserve. These students further deepened my own sense of privilege of being associated with a biological field station such as Jasper Ridge.

Working with my counterpart Deedra McClearn, Director of La Selva Biological Station, we organized the 17th annual October docent field trip, our first venture outside the country to Costa Rica. Deedra's attention to detail and generosity provided for a field trip that left us with lifelong memories.

While reflecting upon the past year, the spring days working in my office at the Sun Station's east end come to mind: Listening to the din of Bio 44Y students preparing for field work on the *Mimulus* project (see Research section), and then returning to process data and specimens and analyze data. Seeing and hearing these engaged students not only brought home the meaning and importance of the preserve, but also provided hope for how the next generation might overcome the many failings of my own. Observing these students engaged in daily acts of discovery helps soften the blow of the loss of so many long-standing members of our community (see In Memoriam, p. 29). For me, one of the best ways to honor the contributions and support of the amazing people recently lost is to assure that Jasper Ridge continues to provide similar opportunities for coming generations.

Remote Camera Systems

Trevor Hébert

The National Science Foundation (NSF) grant received by the preserve in 2009 included funding to purchase camera systems to monitor wildlife activity within the preserve, with some of the cameras set aside for student and researcher use. To date, 18 motion-activated wireless camera traps have been deployed.

In addition to being installed in permanent locations within JRBP, these cameras have been used on a temporary basis in a variety of faculty, undergraduate, docent and staff research projects to try to document various kinds of animal behavior, such as the possible trampling of oak seedlings by deer, the presence of seed-eating rodents and birds at study plots, the feeding habits of dusky-footed woodrats, and avian interactions with the JRBP outdoor mesh WiFi masts and guy wires. The camera traps have produced many remarkable images of wildlife at the preserve, including 60 photos of mountain lions alone. The cameras have captured rarely seen animal behaviors such as male black-tailed deer sparring with their antlers, black-tailed deer standing on hind legs to browse leaves on tree branches, and a great horned owl stealing a plastic petri dish from a student's research plot during the night.

In all, nearly 40,000 camera trap images have been collected and archived since late 2008. Stanford Biology PhD student Eric Abelson is overseeing a project to tag all the images with metadata (i.e. species and quantity of individuals) and summarize those data. Abelson is using Stanford undergraduate volunteers to tag the images using PhotoSpread—photo tagging, search, and archiving software developed in collaboration with the Stanford Computer Science Department's BioACT project. The volunteers will be trained in the use of the Photospread software and will learn how to identify any mammals that might be visible in the photos.

In addition to the standard camera traps, the outdoor wireless mesh network has allowed for more sophisticated remote camera systems such as solar-powered, motion-activated network video cameras. In Spring/Summer 2011, six of these video cameras were deployed in support of Stanford professor Tadashi Fukami's study (see page 12) of *Mimulus aurantiacus* (Sticky monkeyflower) and the role of hummingbirds in the transport of yeasts between flowers. Anna's hummingbirds (*Calypte anna*) were mist-netted and fitted with numbered tags to allow identification of individual birds as they were recorded on video visiting the *Mimulus* plants. Over 300 visits were recorded between May and July. In September and October, videos of mountain lions at Jasper Ridge were recorded by the same type of camera system that had been used successfully on the hummingbird project.

Plans for the near future include testing remote video cameras in conjunction with flame sensors as part of a wildfire detection and alert system for the preserve, improving the resolution of nighttime video and imagery, and leveraging the outdoor wireless mesh network to further expand coverage of JRBP with both still and video cameras for research and education.

Research and Monitoring

Nona Chiariello

Research at Jasper Ridge takes many forms, from solitary observers relying on experienced eyes and ears, to teams of investigators using the most advanced aircraft-mounted sensors. Their subjects range from processes that build mountains and move tectonic plates, to atmospheric changes that are altering ecosystems. During 2010-11, 75 field studies were conducted by members of nine Stanford departments in six of the university's schools and divisions, and by researchers from 22 institutions in six states and four countries (appendix 3). It was a very productive year, with 29 peer-reviewed papers and three dissertations added to the list of publications (appendix 4).

Traditional accountings of research activity based on numbers of projects or publications are important, but they provide a limited view of the broadening role and benefits of research at Jasper Ridge. As crystallized in the 2005 strategic plan, we view research not just in the sense of advanced scholarly study, but equally in the sense of educating for scientific literacy using techniques that foster scientific reasoning and love of discovery, and also in the sense of acquiring knowledge that has conservation value. Viewing research in this broad way underscores the educational benefits of "learning by doing," as well as the conservation benefits of applying new knowledge about resource protection. This view expands the traditional definition of research and is essential to the more unified mission established by the strategic plan.

The integrating role of research in the JRBP mission is evident throughout this annual report. My discussion of research therefore is not intended as a section unto itself. In fact, I take the opposite approach, focusing on examples of research that explicitly connect to education and conservation, as well as the benefits of those connections.

The unifying role of research at Jasper Ridge is evident in many other contexts as well, and an important example is the JRBP restoration fellowship. This section concludes with a report from JRBP's inaugural restoration fellow, Jennifer Funk, on her fellowship research during 2010-11.

JRGCE prescribed burn

On the morning of July 18, JRBP's first prescribed burn in a decade took place within the Jasper Ridge Global Change Experiment (JRGCE). Planning for the burn began three years ago with a grant from the National Science Foundation to professor Chris Field to study grassland recovery from fire under future environmental scenarios. The study is one of JRBP's most integrated partnerships of science and land management, involving collaboration among researchers from seven institutions, coordination with multiple agencies and fire authorities by Philippe Cohen, and public outreach facilitated by Stanford.

The JRGCE provides unusual degrees of control, replication and background data for an experimental study of grassland fire ecology under future climates. The study consists of eight parcels, each roughly a quarter acre, and each with the same 16 global change treatments in plots that have been intensively monitored for 13 years. In July, four of the eight parcels were burned in separate, sequential fires, and the remaining four parcels were left as unburned controls. Measurements of flame height and spread by Scott Stephens' fire ecology group (UC Berkeley) indicated that the four fires were very similar and met the JRGCE's goal of four replicate burns.

One goal of the study is to examine interactions between fire and global change factors, especially those interactions that help or hinder restoration of

Opposite: Separated by narrow firebreaks, a prescribed burn in progress, a completed burn in the background, and an area at left next in line. **Above:** Post-fire regrowth of a scorched, native perennial grass.

Surveying and sampling *Mimulus* flowers during the new core undergraduate course in Biology.

native perennial grasses within the predominantly non-native annual grassland. Perennial grasses that survive a fire have several advantages over the seed bank of annual grasses, such as a root system poised to grab nutrients that leach from the ash, and less vulnerability to granivores that scour burned fields for seeds and young seedlings. If some combinations of global change factors improve the fire survival of perennial grasses, the effect will be compounded by post-fire advantages of perennials relative to annuals, and will help shift dominance toward the perennials. This would be one example of a potential interaction between fire and global change factors. To test whether and how this might occur, the JRGCE is studying the pre- and post-fire growth of perennials that were seeded uniformly into all plots one and two years before the burn.

Another goal of the experiment is to re-test results from an accidental fire in 2003 that scorched a quarter of the JRGCE. Those results included other examples of interactions between fire and global change factors. For three years following the 2003 fire, burned plots released twice as much nitrous oxide from the soil as unburned plots, an effect that jumped to sixfold in burned plots that received elevated CO_2 and nitrogen. Because nitrous oxide is a greenhouse gas (like CO_2), higher emissions potentially contribute to climate warming and to a positive feedback loop between climate and fire. Another result from the 2003 fire was that yellow starthistle, a persistent invasive, had twice the establishment rate in burned plots as in unburned plots. These results from the 2003 fire are described in two new publications (pages 24-25) with lead authors Audrey Niboyet (nitrous oxide) and Jeff Dukes (starthistle).

The research team for these two components of the prescribed burn includes investigators from Stanford and the Carnegie Institution for Science (Chris Field, Todd Tobeck, Shane Easter, Mike Dini, Yuka Estrada, Ben Cohen-Stead, and myself), UC Berkeley (Scott Stephens, Tim Kline, Danny Fry), UC Santa Cruz (Adina Paytan, Katie Roberts), Université Pierre et Marie Curie (Audrey Niboyet), Helmholtz Centre (Jessica Gutknecht), and University of Oregon (Kathryn Docherty, now at Western Michigan University).

A third goal of the prescribed burn was to test two technologies for improved fire management—a fire detection system and a fire-retarding emulsion. For the fire detector, the goal is a continuous and reliable detector that provides immediate fire alerts via JRBP's wireless mesh. The candidate detector senses ultraviolet light produced in flames, and a key question was whether it would be able to "see" flames through smoke. To test this, the detector was positioned downwind of the four fires. It successfully detected all of the fires, though it was inconsistent in further tests. The fire-retarding emulsion was tested as a strategy for buying time should a fire occur. Three areas were sprayed with emulsion prior to the fires, and matched areas received either an equal volume of water or nothing. The emulsion was uniformly successful in preventing burning, whereas water was effective only if sprayed less than an hour before the fire. These studies were carried out by Jasper Ridge staff and summer intern Caitlin Ortega.

Mimulus floral ecology

In the past three years, professor Tad Fukami's research at JRBP has established *Mimulus* floral ecology as a model system for integrating research across a multitude of investigators, from undergraduates to senior scientists. As part of his research, Fukami has led a joint effort by members of the biology department and the school of education to redesign a high enrollment, core undergraduate course (BIO 44Y) to focus on field research using *Mimulus*. The course gives students the type of mentoring usually found only in small, upper division courses, yet at the same time, students participate in a large collaboration and investigate a pooled data set. Among the project's achievements this year are the first peer-reviewed publications that evaluate research-based education at Jasper Ridge. Lead authors of the two publications (page 24) are Sara Brownell and Matt Kloser, each of whom completed a PhD this year as well—Brownell in biology and Kloser in education. The educational team also includes education professor Rich Shavelson, Daria Hekmat-Scafe, Shyamala Malladi, Pat Seawell, and three cohorts of teaching assistants.

At the core of Fukami's research on *Mimulus* is the idea that each pumpkin-colored, tubular flower is essentially a natural test tube, with nectar as a culture medium, where natural experiments unfold as microbes colonize the nectar and compete with or facilitate other species. Fukami's goal is to understand what determines the fate of those microbes, and the fate of colonizing species in general. He studies large numbers of *Mimulus* flowers to identify statistical regularities—nature's rules—regarding how many kinds of microbes can coexist and in which combinations.

The analogy between flowers and test tubes is apt because many of the field experiments on *Mimulus* flowers are well suited to manipulation in the lab. A new publication by Kabir Peay, Melinda Belisle, and Fukami (page 25) describes one such study about the importance of "who gets there first." Using mock flowers made of plastic micro-

tubes filled with sterile nectar, the team added first one strain of yeast inoculum and then a second, drawing from *Mimulus* six major yeast species in all possible pairs and sequences. They observed that the first colonizer effectively stakes a claim on the nectar and resists challenges from other yeasts, especially those that are close relatives. Another publication by the same authors reports that in the field, plants that have many colonized flowers tend to occur near other highly colonized plants, forming a spatial pattern that is best explained by the pollination behavior of hummingbirds.

With the redesign of BIO 44Y, undergraduates are contributing to the *Mimulus* studies in growing numbers. The course expanded from two lab sections in 2010 to four in 2011, and was approved by the biology department to completely replace the previous version of 44Y beginning in 2012, roughly a hundred students in total. Although one goal is to impart a deeper appreciation of the field of ecology, the bigger goal is a research experience that helps students navigate and contribute to a data-rich world by working with peer investigators to study unanswered questions.

Heritage assessment

In the past two years, Jasper Ridge has been part of a comprehensive survey of prehistoric and historic sites and structures on Stanford lands carried out by the department of heritage services under director Laura Jones. The Jasper Ridge studies consist of seven prehistoric sites and three sites from the historic period 1840-1960, including some sites associated with Searsville Dam and the downstream benches along San Francisquito Creek. In addition to their academic significance and contribution to the history of Jasper Ridge, these studies attest to the enormous complexity and scope of Stanford's longterm planning for Searsville Dam and Reservoir, in this instance owing to the cultural legacies throughout much of the affected area.

Resource protection at Jasper Ridge includes cultural resources ranging from deeply buried artifacts, to a few still-standing witness trees, and the even more towering Searsville Dam. In between are surface deposits, altered contours, old fences, and fading signs. Many of these cultural resources are vulnerable in ways that the preserve's self-renewing biota is not. This is why any excavation at Jasper Ridge—whether for research, maintenance, or otherwise—requires prior approval from the heritage services director and, depending on the site, may require archaeological monitoring.

The sites most relevant to Searsville planning were surveyed with help from teams of students. In 2011, Jones, Dave Daly and Katie Turner taught an archaeological survey methods course (Archaeology 108/208A) in which students helped document deposits and structures downstream of Searsville Dam. Their study included underwater surveying, a first for Jasper Ridge. They also surveyed settler Dennis Martin's North Ranch and determined the likely sites of a mill, house, and church. In summer 2011, the instructors turned their attention to prehistoric areas along San Francisquito Creek in the area formerly occupied by the Boething Nursery. With help from 15 high school and college students, they excavated seventeen 1m by 1m pits, some within Jasper Ridge boundaries and some farther downstream. Each pit was dug by hand, some as deep as 1.2m, and the soil was carefully screened.

The archaeological testing was in an area familiar to Jones. Based on digs and surface surveys several decades ago, she anticipated that this area might be archaeologically rich. But rather than excavate extensively, Jones decided some time ago to hold the area in reserve until new technologies became available or until circumstances necessitated a closer look. The latter came first, in part because of Searsville Dam planning.

What they found might be viewed as either disappointing or liberating. Some of the seventeen pits contained evidence of stone tool production. Other test units were by and large "culturally ster-

The archaeological field methods class carrying out the first-ever underwater archaeological survey at JRBP.

ile." The research team is comparing the stone tool production data with data from other nearby prehistoric sites. The implication for resource management is that archaeological considerations within the old Boething Nursery area may place fewer constraints on longterm planning for the dam and reservoir. Other aspects of the heritage survey are continuing, including an assessment of the dam by historian Julie Cain. Her report will address the dam's significance to the history of California water projects and to the recreational history of the area.

Clare Sherman and Mariel Pereyda using white flannel "flags" to survey ticks for an interdisciplinary course in conservation medicine.

Field epidemiology

A careful reader of JRBP's liability waiver is likely to think that the preserve is not so much a bounty of natural diversity as a gauntlet of risks. Like any natural area, JRBP does present multiple risks, and therefore faces many challenges in terms of effective communication to a diverse community of users and visitors from many age groups. The risks range from the routine likelihood of sun exposure to the miniscule likelihood of attack by a mountain lion. Somewhere in between is the risk of tick-borne disease, including Lyme disease. This year, a Stanford study and undergraduate course led by ecologist Dan Salkeld began assessing the risk of Lyme disease at Jasper Ridge, and it has evolved into a community-based study for Lyme surveillance and risk reduction. Together the course and study demonstrate how undergraduates can contribute to interdisciplinary research that has public health importance for a neighboring community.

In Spring 2011, Salkeld's course "Conservation Medicine in Practice" undertook a field study of the bacterium *Borrelia burgdorferi*, the Lyme disease agent. It is one of a half dozen microbial disease agents in California that are transmitted to humans through tick bites. Salkeld taught his students how to sample a habitat for ticks by sweeping a white flannel blanket along the vegetation or forest floor. Student teams sampled natural habitats at Jasper Ridge, Dish Hill, and other locations, and submitted the ticks for Lyme testing. When results on the assays become available, the JRBP website will incorporate the new information on Lyme risk in each of three habitats—grassland, woodland, and chaparral. Posting should take place before the next generation of tick nymphs appear, which is the life stage expected to present the biggest risk of Lyme to humans.

The response from students, interest from the local community, and overall success of the undertaking led Salkeld to think bigger for 2012. He and professor Eric Lambin are broadening the project so that students can help develop and test sampling methods that will be used by community volunteers. Combining elements of medical entomology, field epidemiology, and a geographical perspective on public health, the 2012 course will develop protocols for determining the habitats and activities that present the greatest risk of exposure to Lyme disease in JRBP and the towns of Portola Valley and Woodside. The course will run in winter so that the protocols will be in place for a spring study. Once collected, the ticks will be tested by Nathan Nieto (University of Nevada) and Charles Chiu (UCSF) for both the Lyme agent and co-infections. Community interest is strong; by early fall, local resident Bonnie Crater had already signed up more than a dozen volunteers for the spring sampling. This project is sponsored by the Bay Area Lyme Fund.

A principal theme among the studies discussed here is the involvement of undergraduates in studies that will help inform decisions made by individuals, land managers, and Stanford University regarding topics as diverse as how to reduce Lyme risk, how to adapt fire management to a changing climate, and how to integrate the fate of a century-old dam into a biotically and historically significant landscape. The convergence toward integrating research and education is one example of the influence that the 2005 strategic plan has had, as well as the extent to which studies influence one another. Field methods classes and summer internships are increasing across the board at Jasper Ridge, providing students first-hand experiences linking research and resource management. The success of the *Mimulus* studies in cultivating curiosity in students through authentic research provides a model for other high-enrollment undergraduate courses.

To read more about these studies and other Jasper Ridge research, please visit:

http://jrbp.stanford.edu/db/projects/list.php

Testing the trait-based community framework: can limiting similarity increase invasion resistance in restored grassland?

Jennifer Funk, Jasper Ridge Restoration Fellow

One of the greatest challenges for ecological restoration is to promote the growth of native species while simultaneously suppressing the growth of invasive species. The field of restoration ecology has enjoyed a recent surge of theoretical development in the area of community assembly, which has led to a number of testable hypotheses for managing invasive species in restored systems. One specific hypothesis is that community resistance to invasion can be strengthened by selecting native species that are similar to invasive species in resource use (e.g. timing and patterns of water use), thus increasing competition. This is based on the theory of *limiting similarity* which posits that there is a finite limit to the similarity between the resource-use of co-existing species. The goal of this project is to evaluate the efficacy of limiting similarity as a tool for restoration in invaded systems. Following the theory of limiting similarity, I predict that invasive species will have lower fitness when grown in the presence of native species with similar timing and pattern of resource use.

Serpentine grasslands are unique systems characterized by soils that are deficient in critical macronutrients, enriched in toxic metals, and have low calcium to magnesium ratios. Furthermore, serpentine soils are often thin and prone to rapid desiccation. Because these soil conditions decrease the availability of nutrients and water to plants, serpentine communities have resisted invasion by nonnative species for decades. This is because invasive species have traits like rapid growth rates, thin leaves, and high reproductive output, which is advantageous in resource-rich environments, where soil, water and light availability are high. For unknown reasons, serpentine grasslands throughout the state are now being invaded by a host of annual grasses, including ryegrass (*Festuca perennis*), soft brome (*Bromus hordeaceus*) and barbed goatgrass (*Aegilops triuncialis*). The Jasper Ridge serpentine grassland is an ideal system to assess the utility of limiting similarity as a restoration tool because annual species enable this project to be conducted in one year and productivity is often limited by both water and nutrient availability.

The project is currently ongoing. In spring 2010 and 2011, I collected functional trait data from over 50 species in the serpentine grassland, including timing of germination, leaf nitrogen content, leaf mass per unit area, photosynthetic capacity, root depth, root to shoot biomass ratio, and specific root length. I then used multivariate analyses to identify native species that were similar in water and nutrient use to the two dominant invasive species, ryegrass and soft brome. During Fall 2011, species will be grown in competition with each other to test whether functional traits can be used to predict competitive outcomes and, consequently, invasion resistance.

If one or more of the native species is found to be a good competitor, then the best restoration protocol for these grasslands may be the manual removal of ryegrass and brome seeds in spring (to decrease the seed bank the following year) followed by seeding of competitive native species in fall. While this framework is most relevant on a local scale (e.g., 1 – 200 ha) where entire communities must be restored, these restoration strategies may be effective at larger scales by establishing native communities that can act as seed sources to neighboring areas where native seed banks are depleted.

Education and Outreach: From Local to Global and Back Again

Cynthia J. Wilber

In thinking about the breadth and accomplishments of the JRBP education program; it is the students of all ages who pass our way while acquiring new knowledge, skills, and experiences through hard work and interdisciplinary learning that truly sustain the vitality of the program. But where do these students go from here? I am incredibly fortunate to be able maintain contact with many students—learning of their work both near and far and I am delighted to share a few stories of our very global students. Here is a glimpse of where they are now and what matters to them in their own words.

Cara Brook

"I graduated from high school in 2006 unsure of my future academic plans, but firmly convinced that I wanted to spend as much of my life as possible outside. Upon arriving at Stanford, I discovered that there are few universities in the world better suited to an outdoor, experiential college education and eventual future in environmental science. I found the Jasper Ridge website before I ever arrived on the Stanford campus and spent my freshman fall quarter fruitlessly searching for ways to involve myself at the preserve. In winter quarter of my freshman year, I enrolled in the docent class and at last made my way across JR's hallowed doorstep. That two-quarter introduction to field ecology and the divergent ecosystems of Jasper Ridge set the stage for the rest of my life.

Throughout my four years at Stanford, I was privileged to take part in almost every educational opportunity available to undergraduate students at Jasper Ridge—I taught at JR with the educational outreach program with Eastside College Preparatory School, and in my junior year, I advanced my understanding of scientific field technique with the Field Studies in Earth Systems class. Jasper Ridge paved the way for further undergraduate research experiences abroad in the Sea of Cortez, the tropical dry forests of western Mexico, the east coast of Australia, and the mountains of the North American West.

After graduating in 2010, I took my Jasper Ridge field techniques and conservation awareness even more global with a three-month internship with World Wildlife Fund (WWF) in Madagascar and a seven-month appointment on a Stanford field ecology project in central Kenya. I am now back in the Bay Area and applying to PhD programs in field ecology—a future that was laid out for me that very first day I arrived at Jasper Ridge. Though the far-flung reaches of the planet are ever fascinating, there are few places in the world that make me happier than Jasper Ridge. The friends, mentors, and many memories that I associate with this magical place will stay with me for years to come.

In the words of climber and photographer Galen Rowell, "I've known all along that more of what I am seeking in the wilds is right here in my home state of California…but I couldn't say it with authority…until I had all those journeys behind me."

Opposite page: San Francisquito Creek in early fall. **Right:** Cara Brook teaching a sustainable development initiative with villagers in Vohilava, Madagascar

Left: Mattias Lanas and an Australian king parrot near Springbrook National Park in Queensland, Australia, while studying abroad through Stanford's Bing Overseas Studies Program.

Right: Erica Fernández Zamora measuring diameter at breast height (DBH) of trees in Reserva San Nicolás, Yucatán, México.

Mattias Lanas

"After taking BIO 96 (now BIO 105), I became interested in ecology as a tool for teaching science. I led tours at the preserve and then, with encouragement from Cindy Wilber, became involved in Strategies for Ecology Education, Diversity and Sustainability (SEEDS), a program of the Ecological Society of America (ESA). Little did I know then how involved I would become with this group—the next year I applied for and received a SEEDS Fellowship for undergraduate research in ecology and traveled to Ecuador to carry out my project. I spent a summer in the mountainous cloud forest quantifying biodiversity data of caterpillars, and learned first-hand the thrills and the hardships of research. Incredibly, a year later I got to talk about my experience and present my preliminary findings at the ESA annual meeting, in front of a full audience.

Jasper Ridge opened up a world of opportunities for me by inspiring confidence in the field of ecology, networking and associations with other students, and exposure to the Jasper Ridge community. My junior year at Stanford I went on to conduct a research project in Veracruz, México, working with Dr. Rodolfo Dirzo. I sampled dung beetles in varying tropical ecosystem grades and looked for trends in biodiversity from which to extrapolate and I am continuing the analysis of data this year with Dr. Dirzo.

Currently, I am pursuing a co-terminal master's degree in Earth Systems with an emphasis on environmental education, biodiversity, and tropical ecosystems. I have been given the opportunity to be this year's teaching assistant for BIO 105A/B, the docent training course, so in some sense I have come full-circle."

Erica Fernández Zamora

"Although I grew up in a very rural area surrounded by nature, I did not know what the term ecology meant until my freshmen year at Stanford when I enrolled in BIO96A/B at Jasper Ridge and was introduced to ecology, natural history, and environmental education. Before this class, I lacked the self-confidence to pursue anything related to science and math, however, once given the opportunity to explore the field of ecology I have found my current research focus in human ecology.

Since freshman year, I have been working both locally and internationally using what I first learned in those two quarters to develop programs that hopefully will help solve global issues like deforestation in both the US and México. Learning how to do a forest transect and then how to use that data to determine biodiversity while at the preserve was an

essential skill last summer in the tropics when I taught Maya villagers the same method in order to understand better the biodiversity of their lands. This work is now part of my honors thesis that compares forest biodiversity in two sites in Yucatán, México and also compares the local traditional knowledge of those forest species by villagers living in proximity to an intact forest vs. those living in deforested areas.

Because I believe passionately about outreach education, I also work with under-resourced youth in both countries to promote the importance of ecology, environmental protection, and responsibility. Starting with that first class at Jasper Ridge I have obtained opportunities that I never thought possible including presenting my work at three ESA annual meetings, and this year as a member of the Ecology for the New Generation Committee. Jasper Ridge opened my eyes to the world of ecology—greatly influencing my four years at Stanford and I am committed to providing the same experience for others."

Continuing Education at Jasper Ridge

Gary Nielsen

For many of us, years have gone by since our docent class days, and the wealth of natural history information we learned has now begun to flee to the dark corners of our memories. Certainly, there have been refresher walks to help recover what we learned through the years. However, I thought that we needed both an organized approach to schedule the seasonal walks we have had before, and also to expand into other areas of natural history. From this, Continuing Education emerged.

Already, we have had walks and classroom sessions for wildflowers, grasses, lichens, butterflies, geology, trees and shrubs, and preserve projects such as research programs and the future of Searsville Lake. We want to add subjects such as birds of JRBP, nature photography, edible and useable plants of the preserve, the magic of dragonflies—and I'd really like to have an astronomy night with a star party sometime. The list is growing as some docents have suggested interesting subjects. What is remarkable and most gratifying to me is that most of our leaders for our walks and classroom sessions are from our own docent classes. JRBP abounds with these assets.

I see Continuing Education as a way to further our knowledge and interest in science complemented by the social aspect it offers. Getting to know our fellow docents better is a real benefit. I'm not ready to stop learning—and neither are the docents and JR community members that continue to attend our Continuing Education events.

Brown Bag Lunch Lectures

http://jrbp.stanford.edu/bbvideos.php

October 2010: Kimberly (Kye) Epps
Postdoctoral Fellow, Environmental Earth Systems Science, Stanford University

More than the sum of its parts: gauging the effects of dead plant diversity

November: Peter Green
Associate Research Engineer, Department of Civil and Environmental Engineering, UC Davis

Mercury: from mines and marshes to microbes and the food chain

January 2011: Chris Field
Professor of Biology and Environmental Earth Systems Science, JRBP Faculty Director

Jasper Ridge Biological Preserve town meeting

January: Mary Power
Department of Integrative Biology, UC Berkeley; Faculty Director, Angelo Coast Range Reserve

Algal based food webs and river-watershed-coastal ocean links along California's North Coast

March: William Gilly
Professor of Cell and Developmental Biology and Marine and Organismal Biology, Hopkins Marine Station, Stanford University

Spreading squid

April: Kyla Dahlin
PhD candidate, Department of Biology, Stanford University; Department of Global Ecology, Carnegie Institution

Mapping plant diversity and biomass at Jasper Ridge

May: Jennifer Funk
Assistant Professor, School of Earth and Environmental Sciences, Chapman University; JRBP Restoration Fellow

Trait-based approaches to ecological restoration in invaded plant communities

Appendix 1: Financial Summary & Projection

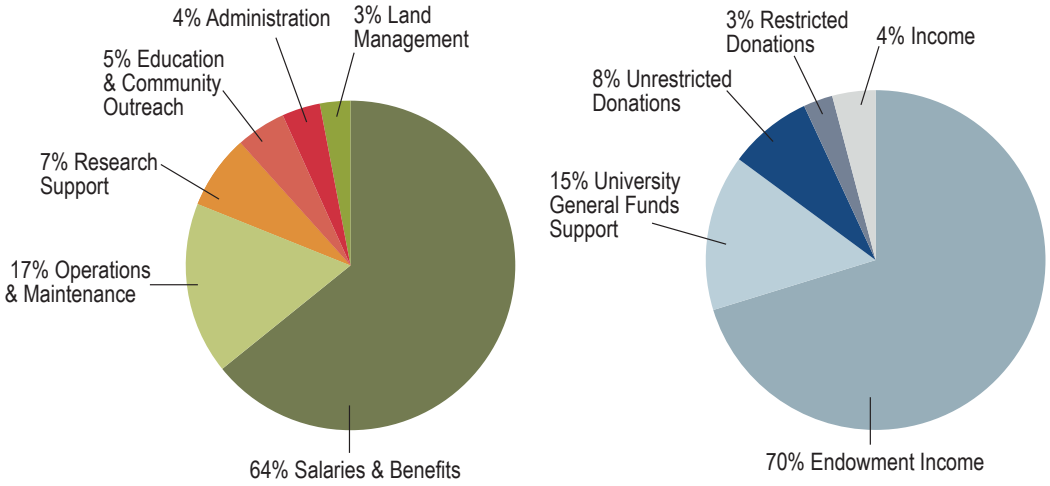
Financial Summary 2011

Expense Summary

Salaries & Benefits	$571,153
Operations & Maintenance	$150,233
Research Support	$64,732
Education & Community Outreach	$43,558
Administration	$33,343
Land Management	$26,649
Total	**$889,668**

Revenue Summary

Endowment Income	$628,584
University General Funds Support	$132,963
Unrestricted Donations	$71,355
Restricted Donations	$25,000
Income (tours, sales, etc.)	$36,869
Total	**$894,771**



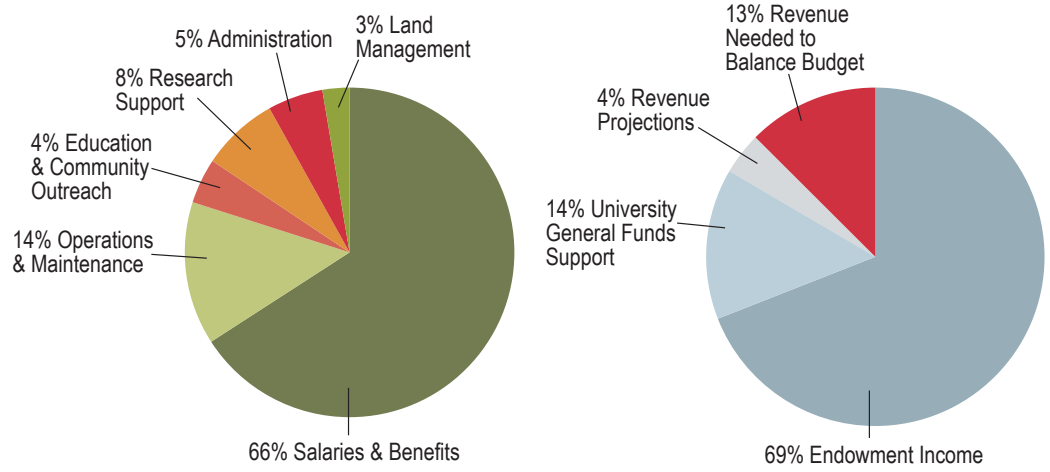
Fiscal Year 2012 Projections

Expense Summary

Salaries & Benefits	$621,377
Operations & Maintenance	$132,559
Research Support	$71,333
Administration	$51,176
Education & Community Outreach	$41,800
Land Management	$25,000
Total	**$943,245**

Revenue Summary

Endowment Income	$651,156
University General Funds Support	$135,914
Revenue Projections (sales, tours, etc.)	$38,000
Revenue Needed to Balance Budget	$118,175
Total	**$943,245**



We originally projected a shortfall of about $100,000 for FY11 (see last year's annual report), but thanks to increased revenues from unrestricted donations, we were able to close that gap and end the fiscal year with a small surplus. Beginning with FY12, endowment payout will have stabilized and show a modest increase from previous years. If donations and revenue are comparable to FY11, then the projected shortfall plus the FY11 surplus will cover the currently projected shortfall. FY11 expenses included about $30,000 for replacement of two electric vehicles. For FY11 & FY12, the Research Support category includes support for the JR Restoration Fellowship.

Appendix 2: Donors

Our generous community of donors provided gifts to the preserve between September 1, 2010 and August 31, 2011:

Mindy Adams
Adobe Systems, Inc.
Russ B. Altman
Amber Foundation
Glenn & Nancy Atkinson
Dr. Lisa Katherine Barrett
Barbara C. Bartlett
Nancy C. & Clayton W. Bavor
Kathleen Bennett & Tom Malloy
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Gail Andrews Whelan
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Dr. Kathy Sue Williams
Marian Williams
Phyllis Willits
John W. Working
Lysbeth Working
Richard I. Yankwich

If you would like to make a gift to support Jasper Ridge, contact Gift Processing at (650) 725-4360 or http://givingtostanford.stanford.edu

Appendix 3: Summary of Research Activity

	Projects	Faculty	SS/PD	Grad	UGrad	Vol & tech
STANFORD UNIVERSITY						
School of Humanities & Sciences						
Anthropology	1	1				
Biology	22	4	6	7	5	11
Chemistry	1				1	
History	1			1		
Jasper Ridge	6		3			32
School of Earth Sciences						
Environmental Earth System Science	2	1	2		2	
Geophysics	3	2		1		
School of Education	1	1		2		
School of Engineering						
Civil & Environmental Engineering	7	1		5		2
School of Medicine						
Genetics	1		1	1		
Land, Buildings and Real Estate						
Heritage Services	1		1			5
Planning	2		3			15

	Projects	Faculty	SS/PD	Grad	Other
Non-Stanford					
Balance Hydrologics, Inc.	1		3		
California Academy of Sciences	1	1			
Carnegie Institution	5	3	1		5
Chapman University	1	1			
Cornell University	1	1			
Geometrics, Inc.	1		2		
Helmholtz Centre, Germany	1	1			1
Instituto de Ecología, Mexico	2		1		
Iowa State Univ.	1	1			
Michigan State University	1			1	
San Jose State University	2	1		1	
SRI International	1		1		
US Geological Survey	2		3		
Université Paris-Sud, France	1		1		
University of California, Berkeley	4	2	2	3	2
University of California, Davis	1			1	
University of California, Santa Cruz	5	3	2	1	
University of Oregon	1		1		
University of Western Australia	1	1			

The breadth of research activity by the Stanford community is illustrated above left. Members of 11 departments and divisions participated in Jasper Ridge field studies. For any given department or division, the number of research projects (Projects) reflects the total number of studies in which members of that department were regular participants. Interdisciplinary studies are included in the counts for several departments, hence the sum of projects in the table slightly exceeds the actual total number of projects. The columns for Faculty, SS/PD (staff or senior scientists and postdoctoral fellows), Grad (masters and doctoral students), UGrad (undergraduates), and Vol & tech (volunteers, technicians) indicate the number of individuals at different academic levels who regularly participated in research. Individuals with multiple departmental affiliations contribute a fractional count to each of their departments. UGrad counts are a combination of independent research and summer research internships.

For a complete list of research projects, access http://jrbp.stanford.edu/research2011

Appendix 4: Publications

Adams RI. 2011. Ecological and evolutionary connections between genetic and species diversity. PhD Dissertation, Department of Biology, Stanford University.

Adams R, Hadly E. 2010. High levels of gene flow in the California vole (*Microtus californicus*) are consistent across spatial scales. Western North American Naturalist 70(3): 296-311.

Andonian K, Hierro J. 2011. Species interactions contribute to the success of a global plant invader. Biological Invasions: 1-9.

Belisle M, Peay KG, Fukami T. Flowers as islands: spatial distribution of nectar-inhabiting microfungi among plants of *Mimulus aurantiacus*, a hummingbird-pollinated shrub. Microbial Ecology (in press).

Blankinship J, Brown J, Dijkstra P, Hungate B. 2010. Effects of interactive global changes on methane uptake in an annual grassland. Journal of Geophysical Research 115(G2): G02008.

Bonebrake TC, Navratil RT, Boggs CL, Fendorf S, Field CB, Ehrlich PR. Native and non-native community assembly through edaphic manipulation: Implications for habitat creation and restoration. Restoration Ecology (in press).

Brownell S, Kloser M, Fukami T, Shavelson R. Undergraduate biology lab courses: comparing the impact of traditionally-based "cookbook" and authentic research-based courses on student lab experiences. Journal of College Science Teaching (in press).

Cadotte MW, Davies TJ, Regetz J, Kembel SW, Cleland E, Oakley TH. 2010. Phylogenetic diversity metrics for ecological communities: integrating species richness, abundance and evolutionary history. Ecology Letters 13(1): 96-105.

Cadotte MW, Borer ET, Seabloom EW, Cavender-Bares J, Harpole WS, Cleland E, Davies KF. 2010. Phylogenetic patterns differ for native and exotic plant communities across a richness gradient in orthern California. Diversity and Distributions 16(6): 892-901.

Cleland EE, Clark CM, Collins SL, Fargione JE, Gough L, Gross KL, Pennings SC, Suding KN. Patterns of trait convergence and divergence among native and exotic species in herbaceous plant communities are not modified by nitrogen enrichment. Journal of Ecology (in press).

Cornwell WK, Ackerly DD. 2010. A link between plant traits and abundance: evidence from coastal California woody plants. Journal of Ecology 98(4): 814-821.

Cowan PD, Ackerly DD. 2010. Post-fire regeneration strategies and flammability traits of California chaparral shrubs. International Journal of Wildland Fire 19: 984-989.

Craine JM, Jackson RD. 2010. Plant nitrogen and phosphorus limitation in 98 North American grassland soils. Plant and Soil 334(1): 73-84.

Craine JM, Fierer N, McLauchlan KK. 2010. Widespread coupling between the rate and temperature sensitivity of organic matter decay. Nature Geoscience 3(12): 854-857.

Docherty KM, Balser TC, Bohannan BJM, Gutknecht JLM. Soil microbial responses to fire and interacting global change factors in a California annual grassland. Biogeochemistry (in press).

Dukes J, Chiariello N, Loarie S, Field C. 2011. Strong response of an invasive plant species (*Centaurea solstitialis* L.) to global environmental changes. Ecological Applications 21(6): 1887-1894.

Flegal AR, Gallon C, Hibdon S, Kuspa ZE, Laporte LF. 2010. Declining—but persistent—atmospheric contamination in central California from the resuspension of historic leaded gasoline emissions as recorded in the lace lichen (*Ramalina menziesii* Taylor) from 1892 to 2006. Environmental Science & Technology 44(14): 5613-5618.

Gutknecht JLM, Henry HAL, Balser TC. 2010. Inter-annual variation in soil extra-cellular enzyme activity in response to simulated global change and fire disturbance. Pedobiologia 53(5): 283-293.

Houlton BZ, Field CB. 2010. Nutrient limitations of carbon uptake: From leaves to landscapes in a California rangeland ecosystem. Rangeland Ecology and Management 63: 120-127.

Kloser M, Brownell S, Chiariello NR, Fukami T. 2011. Integrating teaching and research in undergraduate biology laboratory education. PLoS Biology (in press).

Knight CA. 2010. Small heat shock protein responses differ between chaparral shrubs from contrasting microclimates. Journal of Botany 2010, 7 pages.

Mansy K, Gunderson G, Palmer M. 2010. Design guidelines for sustainable biological field stations. Oklahoma Academy of Sciences.

Mendoza E, Martineau P, Brenner E, Dirzo R. 2011. A novel method to improve individual animal identification based on camera-trapping data. The Journal of Wildlife Management 75(4): 973-979.

Moles AT, Wallis IR, Foley WJ, Warton DI, Stegen JC, and 43 others. 2011. Putting plant resistance traits on the map: a test of the idea that plants are better defended at lower latitudes. New Phytologist 191(3): 777-788.

Niboyet A, Brown JR, Dijkstra P, Blankinship JC, Leadley PW, Le Roux X, Barthes L, Barnard RL, Field CB, Hungate BA. 2011. Global change could amplify fire effects on soil greenhouse gas emissions. PLoS ONE 6(6): e20105.

Niboyet A, Le Roux X, Dijkstra P, Hungate BA, Barthes L, Blankinship JC, Brown JR, Field CB, Leadley PW. 2011. Testing interactive effects of global environmental changes on soil nitrogen cycling. Ecosphere 2(5): art56.

Owens J, White C, Baggett T, Brown S, Hecht B. 2011. Water quality and streamflow monitoring of San Francisquito and Los Trancos Creeks at Piers Lane, and Bear Creek at Sand Hill Road, Water Year 2010, Long-term Monitoring and Assessment Program, San Mateo and Santa Clara Counties, California. Report by Balance Hydrologics, Inc. to Stanford University Utilities Division.

Pasari JR. 2011. Grassland invasion, management, and multifunctionality. PhD Dissertation, Department of Environmental Studies, University of California at Santa Cruz.

Peay KG, Belisle M, Fukami T. 2011. Phylogenetic relatedness predicts priority effects in nectar yeast communities. Proceedings of the Royal Society B: Biological Sciences (in press).

Porter SS. 2011. Evolutionary responses to environmental context in the legume-rhizobium mutualism. PhD Dissertation, University of California at Davis.

Sanders NJ, Suarez AV. 2011. Elton's insights into the ecology of ant invasions: lessons learned and lessons still to be learned. In: Richardson DM, editor. Fifty Years of Invasion Ecology. Wiley-Blackwell. p 237-251.

Ustin SL, Gamon JA. 2010. Remote sensing of plant functional types. New Phytologist 186(4): 795-816.

Wu Z, Dijkstra P, Koch G, Peñuelas J, Hungate B. 2011. Responses of terrestrial ecosystems to temperature and precipitation change: a meta-analysis of experimental manipulation. Global Change Biology 17(2): 927-942.

Appendix 5: Educational Use

Stanford University Classes (1803*)

	Stanford Graduate Summer Institute (Masters)
AP 79N	Energy choices for the 21st century (Fox)
ARCHLGY 125/225	Archaeological Survey Methods (Jones)
ARTSTUDI 12AX	Drawing Intensive: Revisiting Nature (Hewicker)
BIO 44Y Core	Core Experimental Laboratory for Ecology (Malladi)
BIO 44Y Pilot	Core Experimental Laboratory (Fukami)
BIO 105 A/B	Jasper Ridge Docent Training Class (Dirzo, Wilber)
BIO 117	Biology and Global Change (Vitousek, Arrigo)
BIO 133N	Conservation Science and Practice (Daily)
BIO 139	Biology of Birds (Root)
BIO 164/264	Biosphere/Atmosphere Interactions (Berry, Field)
BIO 175	Tropical Ecology & Conservation, (Dirzo)
BIO 184	Art and Biology (Splan)
CEE 136/236	Green Architecture (Sperry)
CEE 166A/266A	Watersheds and Wetlands (Freyberg)
CEE 166D/266D	Water Resources and Water Hazards (Freyberg)
CEE 179S/CEE 279S	Environmental Engineering Seminar (Freyberg, Ong)
CEE 266C	Advanced Topics In Hydrology And Water Resources (Freyberg)
DBIO 202	Assisted Reproductive Technologies (Porzig)
EARTHSYS 10	Introduction to Earth Systems (Ernst)
EDUC 332X	Theory and Practice of Environmental Education (Ardoin)
EESS 155	Science of Soils (Fendorf)
GSB SGSI	Environmental & Water Studies Summer Course (Masters)
MI 116/216	The Human Virosphere (Siegel, Lee)

Stanford and Affiliated Groups (939*)

BOB House Dorm
Cedro Dorm
Center for Advanced Study and Behavioral Sciences (CASB)
Channing House
Division of International Comparative & Area Studies (ICA)
Donner Dorm
Interdisciplinary Program in Environment and Resources (IPER)
Escondido Village Graduate Students
French House Dorm
Global Climate and Energy Project (GCEP)
Graduate School of Business Alumni Association
Heritage Services, Lands, Buildings and Real Estate
International Innovation Praktik Summer Institute (IIP)
Larkin Dorm
Okada Dorm
Otero Dorm
Public Service Scholars Program (PSSP)
Rinconada Dorm
Rising Environmental Leaders Network
Stanford Alumni Singles
Stanford Club, Palo Alto
Stanford Energy Crossroads & Stanford Energy Web
Stanford Parents' Weekend
Stanford Singles Walkers
Stanford University Controller's Office, Investment Accounting Group
Stanford University Corporate and Foundation Relations
Stanford University Department of Bioengineering, Undergraduate Student Services
Stanford University Department of Biology
Stanford University Department of Civil and Environmental Engineering
Stanford University Graduate Community Center
Stanford University Office of Dean of Research
Stanford University Office of Development
Stanford University Office of Land, Buildings, and Real Estate
Stanford University Office of Undergraduate Admissions
Stanford University School of Medicine, Biomedical Informatics Program
Stanford University School of Medicine, Ph.D. Class Reunion
Stanford University Women's Basketball Parents
Spiegel Lab
Stevenson House
Storey House Dorm
Summer Undergraduate Research in GeoSciences and Engineering (SURGE)

*Number of visits. One visit = one person entering preserve on one day. These numbers represent an underestimate; as they do not include informal nor research use. **Right:** Birders on a transect count, Road F: Phil Leighton, Jan Talbert, Boyce Bruge, Sonny Mencher, and Mary Ann Allan.

Other College/University Classes (156*)

Asian University for Women
Foothill College:
Environmental Horticulture and Design
Iowa State University:
Ecology and Evolutionary Biology
San Jose State University:
Plant Communities of California

K-12 Groups (1708*)

Boys and Girls Club of the Peninsula
Corte Madera School
Eastside College Preparatory School
Environmental Volunteers
Fremont High School
Girls Middle School
Gunn High School
Hoover School
Menlo Atherton High School
Redwood Environmental Academy of Leadership (REAL)
Woodside High School

Other Groups (526*)

American Conservation Experience (ACE)
Avenidas Senior Center
Blue Oak Ranch Reserve
Building Futures Now
California Academy of Sciences/JRBP Teacher Professional Development Workshop
California Academy of Painters
California Native Plant Society (CNPS)
Center for Sustainable Development and Global Competitiveness (CSDGC)
Conservation Strategy Fund
Environmental Volunteers
Filoli Nature Education Program
First Nations' Futures Institute
Geoscape Teachers Program
iNaturalist
I.C.E., LLC
IDEO Company
Kiwanis Club of Palo Alto
KQED with David Black (NASA)
Little House Senior Center
Low Carbon Cities
National Audubon Society
Northern California Society of Botanical Artists
Ocean Discovery Institute
Rio Mesa Center, University of Utah
Russian Hill Science Reading Group
San Francisco Bay Bird Observatory Board
Santa Clara Valley Audubon Society
Santa Cruz Mountain Trail Association
Sequoia Audubon Society
Sustainable Business Club
The Science and Policy of Global Climate Change: Professional Development for K-12 Teachers
Tilden Regional Park Docents
U.S. Fish and Wildlife Service
U.S. National Marine Fisheries Service
U.S. Rock Mechanics/Geomechanics Symposium
Vi Residence
Volunteers in Asia

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Eliza K. Jewett: Insert card (*Calochortus alba*)

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In Memoriam

Chris Andrews
Gene Bulf
Ted Chandik
Bill Clark
Kimberly (Kye) Epps
Carol Graham
Jennefer Wineman

http://jrbp.stanford.edu/memoriam

The mission of Jasper Ridge Biological Preserve is to contribute to the understanding of the Earth's natural systems through research, education, and protection of the preserve's resources.

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