Jasper Ridge Biological Preserve

Annual Report 2007–08

STANFORD

School of Humanities and Sciences

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.

Contents

From the Faculty Director

Chris Field

Jasper Ridge is justifiably famous as the site of high-impact ecological research. The best-known studies reflect years of effort and the unique insight that teams of seasoned faculty members or advanced graduate students bring to a difficult problem. These studies, whether they are about impacts of climate change, the structure of populations, or the cycling of nutrients, are a persuasive argument for maintaining research sites like Jasper Ridge. But these are not the only research projects that play a role in changing the world.

A great many other research experiences, often modest in scale and never published in a major scientific journal, are nevertheless important. These projects, undertaken by students or members of the community, can make two significant contributions. If well designed, even small projects can contribute to the kinds of long-term data sets that are increasingly critical for understanding how and why the world is changing, and what we can do about it. Second, modest-scale research can be a monumental part of a student's educational experience, contributing more to the development of a sophisticated worldview than to a specific body of knowledge.

Much of education, especially in primary and secondary school, is focused on mastering specific skills and information. We live in a complex world, and all of us need skills and information, as well as the ability

Undergraduates conducting summer research: Sara Maatta, Chris Fedor, Annie Lindseth, Allison Dedrick, and Briana Swette.

to learn new skills. Debates about the best balance between providing information and developing problem-solving abilities are never ending. I believe, however, that early experiences in ecological research can be unparalleled opportunities for enhancing problem-solving skills and cementing a lifetime of interest in the environment. This concept is at the core of the Jasper Ridge educational mission. Even with primary school visitors, we emphasize finding ways for students to propose and test their own hypotheses. For students at Stanford, course offerings like the biology core laboratory (Bio 44Y) and especially the docent training class (Bio 96) focus more on learning to pose an answer to an interesting scientific question than on memorizing facts about a particular organism or ecosystem process. The entire Jasper Ridge teaching philosophy is built around the idea that research is an effective approach to connecting people with ideas they are passionate about.

Independent research plays a profoundly important role in helping undergraduates become mature, informed thinkers. Research, especially ecological research, is a uniquely powerful way to communicate the concept that many kinds of questions do not have clear, simple answers. The Jasper Ridge strategic plan highlighted the need for more research opportunities for undergraduates.

We have made significant progress in this area. In the profiles section of this report, you can read about Bill Anderegg, Darcy McRose, and Mike Tom, three outstanding undergraduates who tackled important research questions in their senior honors theses. We are also expanding summer research opportunities for students between their sophomore and junior years. In spring of 2008, five Stanford sophomores began planning independent research that they conducted over the summer. Thanks to Stanford support from the office of the Vice Provost for Undergraduate Education, these students had the chance to ask their own questions, discover unexpected complexities, and pursue their own passions.

Chris Fedor is interested in wildfire. He worked with PhD student Kyla Dahlin on developing new techniques for mapping fuel load and flammability from aircraft data. Sara Maatta, who also worked with Kyla, is intrigued with sudden oak death and the prospects for getting a better handle on its spread, especially through alternate hosts like California bay laurel. Sara, Chris, and Kyla spent many weeks mapping and measuring remote corners of Jasper Ridge. Annie Lindseth and Allison Dedrick are fascinated with biological invasions. Annie worked with research coordinator Nona Chiariello on probing the ecological factors that control the establishment of yellow star-thistle, especially in the altered environments of the Jasper Ridge global change experiment (JRGCE). Allison worked with professor Carol Boggs and combed Jasper Ridge for evidence of a major agricultural pest, the light brown apple moth. Briana Swette is interested in global change. Using the root observation system built into the JRGCE, Briana, who worked with me, investigated whether altered climate and pollution shift the amount, depth, and timing of root growth, and whether these shifts explain other changes in ecosystem processes.

All of these students had the chance to make fundamental contributions to new knowledge. They also had the chance to pursue their passions, tackle big goals, and confront unexpected challenges. At this point, I don't know how many of these projects will lead to published papers, but I am confident some will. As they conducted their research, these students also had the chance to be outside, to pause and wonder about a red shouldered hawk soaring near rattlesnake rock or the rounded canopy of a buckeye tree studded with impressively large, chestnut-like fruits. These should all be core elements of a Stanford education.

Management and Operations

Philippe S. Cohen

In previous annual reports I've noted the importance of the preserve engaging with our neighbors, as well as with various organizations and agencies, in order to properly manage JRBP lands. Often, what happens outside Jasper Ridge boundaries plays a significant role in how successfully we are able to manage our natural systems. It is also true that what is learned at Jasper Ridge can make a real difference in what happens outside our boundaries, both in how lands are managed and in the lives of individuals. So I find it helpful to reflect upon how the preserve's activities have rippled beyond its own borders even as the Jasper Ridge community is impacted by the larger world.

While researchers at JRBP frequently address fundamental questions that are significant at the national and international scale, that research can also have local and regional significance. While the local and regional stage may not always be as notable as the larger venues, local applications of knowledge garnered at JRBP often provide tangible evidence that what is learned at Jasper Ridge has identifiable management implications. Hence, JRBP works to build bridges from our research community to local and regional entities.

One such bridge that developed this past year is between Deborah Gordon's lab on the invasion of Argentine ants at Jasper Ridge and the Midpeninsula Regional Open Space District (MROSD).[1] The MROSD Board, along with a local donor (Gibson Anderson), agreed to a five-year project to fund an expansion of Deborah Gordon's 16-year Argentine ant research project to include MROSD lands. This is an important development as Argentine ants are an invader that can have potentially debilitating impacts on the long-term viability of native habitats. While the JRBP Argentine ant research project has led to many important insights into invasion ecology (especially as it relates to interactions with native ants and other arthropods) Jasper Ridge as a single, continuous reserve, is, for some questions, but a single data point. Thus, the collaboration and engagement with MROSD can lead to a better understanding of Argentine ant invasion ecology as well as improved management of our respective lands. It is my hope that this relationship will help pave the way to future regional partnerships that will allow the science at Jasper Ridge to contribute to enhanced management and protection of the natural heritage of the greater region.

The influence of JRBP also was evident in several awards, as the university recognized Jasper Ridge staff for the important differences they make and their significant contributions over the years. What is particularly compelling about the honored staff is how deeply their contributions affect the course of people's lives. For almost ten years, education coordinator Cindy Wilber has nurtured the Jasper Ridge/Eastside Field Studies class. The class—initially born as a Jasper Ridge docent project—provides sixth-grade students from East Palo Alto's Eastside College Preparatory School an opportunity to be mentored by Stanford students and learn firsthand how to collect data in the field, from soil and water temperature to pH and canopy cover. This past April the Stanford Office of Public Affairs honored this effort with a Community Partnership Award.[2] This program, and Cindy's efforts on its behalf, have made a real difference in the lives and aspirations of young students who might not otherwise have ever considered science, especially field sciences, as an option within their grasp.

Argentine ants
(*Linepithema humile*)

Another example of staff making a difference was the awarding of the Cuthbertson Award to research coordinator Nona Chiariello during commencement this past year in recognition of "extraordinary contributions to the achievement of the goals of the university."[3] The testimonials submitted in support of Nona's nomination were truly inspiring. Coming from all around the country, the testimonials spoke to the profound impact Nona has had on lives and careers of students and colleagues, past and present. Descriptors like "professionalism, thoughtful, uncompromising integrity, inspiring, grace, and good humor" can be found throughout the many testimonials submitted on her behalf. There is probably no person more knowledgeable about the preserve's science or who has contributed more to integrating the research and social fabric of the preserve with that elusive but all-important sense of place.


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1. Cindy Wilber receiving the Community Partnership Award from Jean McCown, Stanford University Director of Community Relations.

2. Vice Provost for Academic Affairs Stephanie Kalfayan presenting the Kenneth M. Cuthbertson award to Nona Chiariello.

3. Despite cool temperatures and high humidity, use of a chipper started a small fire at JRBP in July due to the record-breaking dry spring.

4. The First Nations' Futures Institute began its two-week workshop with a welcoming ceremony at Jasper Ridge, led by Muwekma Ohlone tribe members.

During December and January, it was hard to imagine that the threat of fire would loom so large and come so soon. Santa Cruz County had the biggest and earliest season of fire on record in May as the Summit fire highlighted just how dry a spring it had been. Indeed, it was the preserve's driest spring on record. Recent research and climate models suggest that our part of California will experience much longer fire seasons, translating into more frequent and intense fire regimes.[4] This, in turn, has caused

Energy Use of the Sun Field Station

		Sun Field Station	Comparable Stanford University building	PG&E-powered small commercial office building*
Electricity used (kWh/year)	Per square foot	0.89	13.2	15.8
	Total	8,945	132,475	158,569
Natural/ propane gas used (kBtu/year)	Per square foot	11.8	23.4	22.2
	Total	118,084	234,842	222,699
Annual carbon emissions (tons)		10	60†	54
From 6/2002 to 8/2008, total tons of carbon emissions avoided by Sun Field Station as compared to the other buildings			**308†**	**271**

* PG&E data from http://www.energy.ca.gov/ceus/

† While PG&E-powered office buildings use more electrical energy, their carbon emissions are lower compared to those of Stanford buildings due to greater reliance on renewable (wind and solar) and/or non-carbon-emitting energy sources (nuclear and hydropower).


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us to think carefully and deeply about how we manage these lands. As a result, I am in the process of re-evaluating both the types and timing of some of our activities while also working with Chris Field and the Jasper Ridge advisory committee to identify policies that will help us successfully adapt to these changing conditions.

When the Leslie Shao-ming Sun Field Station facility opened in June 2002, it represented one of Jasper Ridge's commitments to minimizing our ecological footprint. A recent event also gives tangibility to how this project has made a difference for others as well. This past year the Chartwell School[5] in Seaside, California, was named the first campus to receive the US Green Building Council's LEED platinum award. Now you may ask what has this to do with the preserve. It turns out the initial inspiration for committing to green facilities at this school originated with a visit by their board of trustees to the Sun Field Station. Motivated by our continuing desire to reduce our own environmental impacts on others, I recently decided to do some calculations to see how efficient our building is in comparison to more traditional approaches. With data from PG&E and help from Scott Gould at Stanford Utilities, I was able to quantify some of that difference, as shown in the sidebar at left.

Since moving into the building (June 2002 to August 2008) the gains from the design of the building have eliminated about 308 tons of carbon emissions compared to a comparable Stanford building or 271 tons when compared to a similarly sized commercial office building. Overall, this represents more than an 80% reduction in carbon emissions since the building became operational.

Through the course of a year, there are certain events, tours, and presentations I look forward to because they help keep my perspective fresh and broad. One of my favorite annual tours is for the First Nations' Futures Institute, whose mission is developing leadership capacity among representatives from indigenous peoples from around the Pacific.[6] Each year the First Nations Fellows come to Stanford for a two-week workshop. They start this workshop with tours of the preserve followed by a welcoming ceremony led by representatives from the Muwekma Ohlone tribe, ending with dinner. What makes this event so enjoyable is the deep "sense of place" this diverse group shares and encourages. I find the ceremony moving as different groups express a welcoming that acknowledges important aspects of the place they come from while recognizing the place they are visiting. It is a testament to how deep an organizing principle connection to place can have in people's identities and the values they promote.

As I reflect on these relationships of the past year, I find myself moved by the poetic connections between natural systems and the fabric of our individual lives and how this small corner of the world is able to send ripples both near and far.

In the end we will conserve
only what we love;

We will love
only what we understand;

And we will understand
only what we are taught.

— Baba Dioum (Senegal)

Doug McCauley, a PhD candidate in biology, checking under one of the cover boards he is using to survey amphibians and reptiles, such as the alligator lizard (*Elgaria multicarinata multicarinata*) he is holding on the opposite page.

Research and Monitoring

Nona Chiariello

In the photographs of this report, many of you will recognize familiar, maybe favorite, places at Jasper Ridge. As this report was taking shape, I found myself picturing these scenes 35 years ago, when Stanford's board of trustees formally made Jasper Ridge a biological preserve. Some of the changes since 1973 have been widely discussed. Bay checkerspot butterflies no longer inhabit the serpentine grassland, and Searsville Lake is now more silt than water. But the preserve has changed in other ways, too. The preserve was created a year before the first published use of the word "Internet," whereas this year, the computer science department awarded the first doctorate that includes work in the preserve. Clearly, many kinds of change have occurred.

Reflections on the past were common this year as we continued to make progress on our "state of the preserve" assessment. This section of the annual report examines some of the chapters of the assessment and related current research. The yearly indices of research activity include 70 research and monitoring projects (appendix 1) and 24 publications, dissertations, and senior theses (appendix 2).

The state of the preserve assessment grew out of the Jasper Ridge strategic plan,[7] and was motivated by some very simple questions. What is the ecological health of JRBP? Where are we relative to the preserve's carrying capacity for various activities? Is the philosophy of "letting nature take its course" working? The assessment is an attempt to organize the existing knowledge of JRBP in such a way as to help answer these questions and guide future research, management decisions, and conservation priorities. The assessment includes three types of chapters: ecosystem processes, biotic and cultural resources, and long-term studies of focal species.

JRBP is in an unusually good position for undertaking this assessment. Research began with the founding of the university (even earlier, for some topics) and is documented in theses, dissertations, scientific publications, student papers, and several databases. We looked to all of these sources for historical data. Even more importantly, the assessment draws on the knowledge of a large, dedicated community. Nearly equal numbers of faculty, graduate students, and volunteers have authored chapters.[8]

Primary production

Jasper Ridge is a remarkably complete mosaic of the plant communities of central coastal California, many of which have matching types in Mediterranean-climate regions around the world. For the state of the preserve assessment, PhD student Claire Lunch explains how we came to see this mosaic as a gold mine of natural experiments for understanding environmental limits to photosynthesis, plant growth, and the distribution of plant communities. These are all aspects of primary production—the conversion of carbon dioxide, water, and solar energy into biomass. Claire's chapter synthesizes four decades of research and over 40 peer-reviewed publications covering the physiology of Jasper Ridge vegetation.

As in most terrestrial environments, primary production at Jasper Ridge is strongly limited by insufficient nitrogen. Studies have documented the ways in which various plants scavenge, hoard, efficiently use, and internally recycle what nitrogen is available to them. Water, too, can limit production because it is moved through plants by the dryness of the surrounding air, and resisting water loss inherently curtails plant growth. Some of the most-cited research from Jasper Ridge examined these limitations and revealed that in order for plants to be frugal with nitrogen, they must waste water, and vice versa.

Since pre-industrial times, atmospheric carbon dioxide has increased by 37 percent. More than half of that increase occurred during the 35 years since Jasper Ridge became a preserve. Much research at JRBP has focused on the ecological consequences of elevated carbon dioxide and other environmental changes. Among many other effects, increased carbon dioxide inherently eases the nitrogen-water compromise in plants, an effect which may have profound consequences. This year Claire repeated some of the most influential work on photosynthesis at Jasper Ridge and used the original field sites. Her study will provide a unique assessment of physiological characteristics across four decades of rising carbon dioxide concentration.

Our understanding of primary production at the level of the ecosystem is greatest for grasslands, thanks to two decades of grassland studies by the Jasper Ridge global change experiment (JRGCE) and related, earlier studies. Primary production in the grassland is very sensitive to nitrogen addition (as fertilizer or air pollution), but added water (as irrigation or high rainfall) has little effect, and instead causes runoff or percolates below the grasses' rooting depth. Claire links this finding to the very existence of oak savanna, where trees require so much water that their root systems may be larger than their canopies, and thus they depend on "the

inefficient water use and high drainage rates of [the] grassland system." The JRGCE has shown that environmental changes such as rising carbon dioxide will increase the moisture at depth in grassland, potentially enough to foster conversion to a woody community. This year the experiment began an explicit test of this possibility.

Plants

The flora of Jasper Ridge has been studied by botanists at Stanford since the university opened. Fifty-four specimens in the Jasper Ridge herbarium were collected before 1900, and a few predate the university by a quarter century. For decades, advanced degrees in systematic botany used material from Jasper Ridge, including the 1958 dissertation of John Hunter Thomas. He collected all but eight hundred of the 5000+ specimens currently in the herbarium, and his published dissertation became the standard flora of the region.

Floristic study of Jasper Ridge has continued in recent years thanks to herbarium volunteers Toni Corelli, Paul Heiple, Ann Lambrecht, John Rawlings, Elizabeth Schwerer, Carol Zabel, and the late Ruth Porter. Their chapter for the state of the preserve assessment is a comprehensive analysis of the status of the flora and the herbarium. They report that in the last 140 years, 880 plant taxa have been recorded at Jasper Ridge. From these taxa, they exclude 92 as either erroneous reports, waifs (non-natives unlikely to naturalize), or hybrids, leaving 788 taxa that constitute the flora of the preserve. Native species make up 72 percent.

With so many species, it is a big challenge to know if any are "missing," but the number appears to be considerable. The herbarium volunteers have never encountered a fifth of the flora, 161 species. The herbarium has vouchers (definitive specimens) for some of the missing species; others were recorded by reliable observers but no specimens were collected. The chapter breaks down the flora into four categories reflecting different levels of certainty about a species' presence, both now and in the past. It also classifies species by ecological and conservation criteria such as rarity and invasiveness. These two breakdowns are quite valuable, especially together. For instance, ten species are considered species of concern, and three of them are missing. The seven still present include peninsular onion (*Allium peninsulare* var. *franciscanum*), the only member of the flora for which Jasper Ridge is the type locality.

Given the long history of botanical studies, one might reasonably hope to assess whether the flora has improved or degraded since formal designation of JRBP. The number of missing species makes this unanswerable for now, and the question itself ignores the difference between a species' presence and its abundance. But the flora does continue to change—since 2002, 15 natives and 25 non-natives have appeared. The authors conclude that "While the rate of invasion by exotics has leveled in recent years, new species capable of moderate to severe impacts continue to arrive." There are two species in particular they are watching for, barbed goat grass (*Aegilops triuncialis*) and giant reed (*Arundo donax*).

Butterflies

Other than the very well studied checkerspots, the butterflies of Jasper Ridge have received surprisingly little formal study, and most of it was decades ago. A 1972 dissertation examined the common ringlet (*Coenonympha tullia*), a 1984 publication reported an experiment on the buckeye butterfly (*Junonia coenia*), and two student papers in the 1970s examined a few additional species. Prior to the state of the preserve assessment, the only peer-reviewed publication that listed butterfly species in

1. PhD student Claire Lunch measuring photosynthetic rates on plants of the JRGCE.

2. Jesus Solorio and Chris Andreassi extracting soil cores in the JRGCE with a pneumatic coring device designed by Todd Tobeck.

3. Peninsular onion (*Allium peninsulare* var. *franciscanum*).

4. Toni Corelli, Carol Zabel, and Ann Lambrecht at work in the the herbarium.

5. Lorquin's admiral (*Limenitis lorquini*), a butterfly of the riparian community.

the preserve was a 1992–93 survey by Rob Blair and Alan Launer. They examined the effect of urbanization on butterfly diversity by comparing JRBP's oak woodland to developed areas that were formerly woodland. They reported 11 butterfly species in the oak woodland of Jasper Ridge.

For the state of the preserve assessment, Jérôme Pellet devoted part of a postdoctoral fellowship to a detailed butterfly survey in eight habitats: six within JRBP, one in a residential neighborhood, and one in a former nursery. Using a widely accepted protocol, he detected 37 butterfly species, 36 within Jasper Ridge proper, over a 22-week period. This is about half of all butterfly species recorded for San Mateo and Santa Clara counties. Twenty-seven of the species at Jasper Ridge are considered residents because they most likely complete their life cycle within the preserve. None of the 37 species is considered threatened or endangered.

A clear message from Jérôme's chapter is the overriding importance of habitat diversity in explaining butterfly diversity. Most species are narrowly distributed. Within Jasper Ridge, seven butterfly species were found only in the riparian community, while others were uniquely found in grassland, woodland, or scrubland. Another 11 species spanned just two habitats. Only seven species spanned four or more JRBP habitats, and a single species, the common ringlet, was present across all.

Jérôme's study also permits a look at possible connectivity between Jasper Ridge and the residential area or abandoned former nursery. One can ask, for instance, whether butterflies that are narrowly distributed within JRBP have external populations nearby. This description fits only four species, all riparian butterflies. The group includes Lorquin's admiral (*Limenitis lorquini*), whose larvae feed on willows, and the cabbage white butterfly (*Pieris rapae*), an invasive species of Old World origin. Many follow-up studies are suggested by these findings.

Birds

Monthly recording of birds was first organized in 1979 by docents Bill and Jean Clark. They were joined by other expert birders and established a tradition of long-term participation. A major achievement of the state of the preserve assessment is that it initiated the first rigorous analysis of data from the bird monitoring program. The chapter came about through the collaboration of PhD student Tim Bonebrake; birders Boyce Burge, Bill Clark, and Marion Smith; volunteer Zoe Chandik; and professor Paul Ehrlich. Their chapter combines results from two independent surveys.

One survey has operated since 1999 and is a constellation of 28 widely-spaced observation points in interior locations of eight habitats. This survey is designed to provide quantitative comparisons across sites, habitats, and years. The results from this survey show that habitat diversity matters for bird diversity. Comparing habitats based on their five most abundant bird species, the authors report that each habitat has at least one unique dominant, and no individual species was dominant across all habitats. But habitats do not contribute equally to overall diversity—species richness is four times higher in broadleaf forest and riparian woodland than in serpentine grassland. These patterns parallel the results on butterflies.

The other bird survey has evolved over time from the one started by the Clarks. This survey is conducted along six transects that cover distinct regions of the preserve rather than single habitats, and it emphasizes recording the bird community in its entirety. The chapter summarizes the data collected since 1998, which is when the current database was started. These data include 172,000 birds and 154


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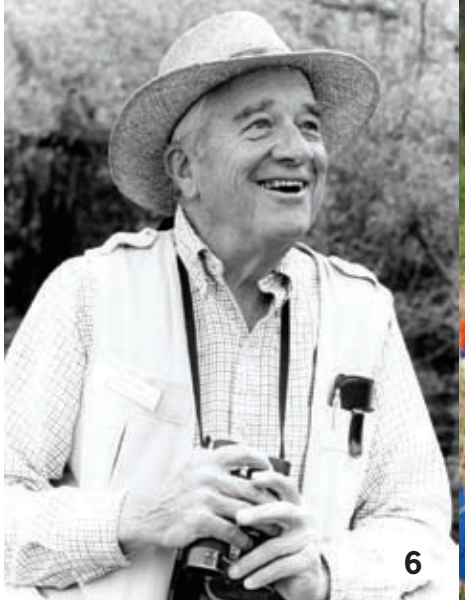
species counted during eight and a half years. The database is also being extended back to 1979 so longer term trends will be discernible. Zoe Chandik spent more than a year incorporating observations from 1989 to 1997, and Bill Clark has contributed the field data from the earliest decade.

Using other historical reference points, the chapter examines long-term changes in the avifauna of the Searsville wetland. Breeding bird surveys were conducted in the wetland by Dave DeSante in 1972 and Bill Kirsher in 1984. Apparent changes since 1984 include increases in the abundance of Violet-green Swallows (*Tachycineta thalassina*), Lesser Goldfinches (*Carduelis psaltria*), and Pacific-slope Flycatchers (*Empidonax difficilis*), and decreases in Downy Woodpeckers (*Picoides pubescens*), Yellow Warblers (*Dendroica petechia*), and Swainson's Thrushes (*Catharus ustulatus*). No Yellow Warblers have been recorded in either survey since 2005, nor Downy Woodpeckers since 2006. A careful repeat of Dave DeSante's survey by Bill Anderegg, a senior in biology, similarly reported a significant decline in avian diversity, especially among neotropical migrants and other species that are sensitive to human activities.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Small mammals

Jasper Ridge had more studies of small mammals during the 1970s than in any decade before or since. Some studies were primarily anecdotal, and others were well-designed experiments. One study became a textbook classic: Bruce Bartholomew's experiments on granivory in the chaparral-grassland boundary. However, in reviewing the literature on small mammals for the state of the preserve assessment, PhD students Hillary Young and Rachel Adams conclude that even during the heyday of small-mammal studies, each study was narrowly focused, and only a few habitats were examined.

To provide a comprehensive assessment of small mammals and a baseline for future research, Hillary and Rachel carried out a catch-and-release survey in five kinds of habitat. Comparisons between their results and earlier studies are possible but limited. Their estimates of California vole (*Microtus californicus*) populations in the grasslands are generally lower than previous findings but consistent with reports of higher densities of voles in non-serpentine grasslands than in serpentine grasslands. In wooded areas (oak woodland, broadleaf forest, and redwood stands), which received little or no study in the past, Hillary and Rachel found higher overall catch rates than in grasslands. The dominant small mammals in wooded areas were wood rats (*Neotoma fuscipes*) and mice (*Peromyscus* spp.). These same species, along with Merriam's chipmunk (*Tamias merriami*), were found in chaparral and scrubland. The survey also documented a new species at Jasper Ridge, the California pocket mouse (*Perognathus californicus*), and cast doubt on the presence of at least one previously reported species, the brush mouse (*Peromyscus boylii*).

The voles in the trapping survey are also being used by Rachel for a study of genetic diversity, the first of its kind at JRBP. Before each animal was released from its trap, a tiny sample of tissue was collected so Rachel could analyze the animal's genetic composition. For one particular DNA sequence associated with metabolism (the cytochrome b locus of the mitochondrial genome), genetic diversity among the 62 animals analyzed is high—on average every 6th individual represents a new genetic variant. The distribution of variants across the trapping arrays has led Rachel to conclude that "voles are quite mobile, in essence making Jasper Ridge one … genetic population, covering both serpentine and greenstone grasslands."

A second view of the diversity of small mammals has come from raptor pellets gathered near trapping areas. The pellets contained a different mix of mammals than the trapping survey, and included shrews (*Sorex* spp.), broad-footed moles (*Scapanus latimanus*), and pocket gophers (*Thomomys bottae*). In a parallel study, docent Targe Lindsay has collected raptor pellets weekly from beneath multiple roosts in order to study seasonal variation in prey selection by raptors. In twelve months he has collected 424 pellets.

Large and medium-sized mammals

Visitors to Jasper Ridge cannot help but sense the abundance and importance of larger mammals.

6. Docent Bill Clark, founder of monthly bird monitoring at JRBP.

7. Master's student Laura Saunders measuring the height of hundreds of flagged oak seedlings, while Kay Fox records data. Laura is comparing plots with and without mammalian browsers to determine their effect on oak regeneration.

8. Coyotes (*Canis latrans*) passing through a camera station late in the afternoon during midsummer.

The young oaks shaped like hour-glasses are evidence enough that deer (*Odocoileus hemionus*) are plentiful and hungry, and for many animals there are trails, tracks, feces, and carcasses, in addition to actual sightings. Until 2006, however, studies of these animals and their effects were rare. In a chapter of the state of the preserve assessment, professor Rodolfo Dirzo, postdoctoral fellows Yolanda Cachú and Eduardo Mendoza, and docent Bill Gomez reviewed the half-dozen reports on diversity of large and medium-sized mammals and characterized the reports as "anecdotal, sporadic and of very short duration."

This is not surprising. Many of the larger mammals are scarce, wary, cryptic, or nocturnal, and studying them can be dangerous, both to the researcher and to the animal. For the Dirzo team, which includes researchers, volunteers, and students, the solution was camera trapping. In 2006 they began a formal study with 12 camera stations regularly spaced across JRBP. As of August 2008 the study has produced over 15,000 photographs of large and medium-sized mammals representing ten non-rodent species.

The team's chapter for the state of the preserve assessment summarizes the first nine months of the study, or 4,209 photographs. Their report describes a strikingly non-uniform spatial distribution of mammal activity, with a 45-fold range in the number of mammal photographs across the 12 camera stations. The variation in numbers is not driven by the abundance pattern of deer, even though deer account for two thirds of all photographs, nor is it driven by simple features of the habitat such as trail and road density or proximity to water. Somewhat surprisingly, bobcats (*Lynx rufus*) were the second most abundant species on average and were photographed at ten stations. The photographs also document the presence of a native rabbit, *Sylvilagus audubonii*, which was previously unrecorded at Jasper Ridge.

The camera project illustrates how a monitoring program can lead to new research opportunities. PhD student Eric Abelson decided to "observe the observer" with a more cryptic, near-video camera focused on several of the camera stations. This has enabled him to study behavioral patterns such as the camera-shyness of coyotes (*Canis latrans*) and the apparent "cameraphilia" of bobcats. His work has implications for interpreting results from the camera traps, and also illuminates how animals perceive human artifacts in their environment. Another new project is aimed at identifying individual bobcats in the photographs in order to break down the camera station data into estimates of population size and travel patterns of individual bobcats. Recently, members have also become intrigued by an unexpected 100+ photographs of Great Horned Owls (*Bubo virginianus*) apparently foraging on the ground. The list of research offshoots will undoubtedly grow as the team continues to analyze this remarkable data set.

Argentine ants

While Jasper Ridge is abundantly rich in natural and cultural resources, its major distinction has been the history and quality of research by scientists from Stanford and other institutions. A hallmark of this research is the focus on species that have become model systems, such as Argentine ants (*Linepithema humile*) or Bay checkerspot butterflies (*Euphydryas editha bayensis*). Chapters on these focal species have a dual role in the state of the preserve assessment. In addition to summarizing a body of research, these chapters address opportunities to develop basic scientific knowledge that ultimately may have very broad and fundamental conservation value.

The chapter on Argentine ants covers 16 years of research and is authored by PhD students Jessica Shors and Katherine Fitzgerald, professor Deborah Gordon, and former students Nicole Heller and Nathan Sanders. Throughout the chapter are reminders that invasion involves not just taking over an area but also interacting with whatever was already there. Jessica Shors has been studying whether Argentine ants, after they have displaced native ants, are good substitute tenders of the larvae of Acmon blue butterflies (*Plebejus acmon*). Tending entails defending the larvae in exchange for feeding on larval secretions. Jessica has found that Argentine ants are better tenders than some native ants and worse

9. PhD student Katherine Fitzgerald examining an ant trail etched in a moss-covered tree trunk by the velvety tree ant (*Liometopum occidentale*).

than others. Paradoxically, Argentine ants devour the adult butterflies.

The chapter stresses the value of Argentine ants as a case study for the role in invasions of "edge effects, genetics, seasonality, precipitation, interference and exploitative competition, jump dispersal...budding, and cascading indirect effects." A surprising conclusion of the chapter is the need for predictions on the ants' eventual spread. Katherine Fitzgerald's dissertation addresses this need. Her approach combines mathematical models and empirical observations at Jasper Ridge and two other natural areas, Pulgas Ridge and Fremont Older.

The authors also think ahead to the likely arrival of fire ants. Will we try to intervene, or should we view this as a unique opportunity to study whether Argentine ants will stave off the incursion? This is the kind of decision that JRBP, thanks to its mission and history of research, is able to debate. Like Katherine's dissertation work, the answer may rest on thinking beyond Jasper Ridge in order to envision what can uniquely be done within Jasper Ridge.

On the horizon

Since the state of the preserve assessment began, research at Jasper Ridge has shifted more toward the kinds of questions that motivated the assessment. Some of this was probably good timing, but the assessment itself was also a factor. For example, Bill Anderegg's repeat of Dave DeSante's 1972 study was suggested by Tim Bonebrake as a result of his work on the bird chapter. But this raises the question of where the assessment should stop, and even, for some chapters, where to begin. As a result, the advisory committee endorsed the idea of an evolving assessment with chapters posted on the Jasper Ridge website as they become available. This will encourage additional chapters and insure that chapters are widely available. To facilitate broad participation, we are encouraging authors when possible to submit versions of their chapters for publication in scientific journals. Two have been accepted by journals so far.

The chapters described here are just under half the current number. For reptiles and amphibians, PhD student Sarah McMenamin summarized previous studies, and a much-needed field survey was started by Doug McCauley, also a PhD student. The late Tom Mudd prepared a chapter on bat diversity based on his six years of acoustical monitoring. University archaeologist Laura Jones is contributing a chapter on cultural resources. Tim Bonebrake and professor Carol Boggs are summarizing the outlook for studies and conservation of Bay checkerspot butterflies. Ben Houlton (a former postdoctoral fellow, now UC Davis professor) and professor Chris Field examined nutrient cycling. The list continues.[8]

The assessment has demonstrated that knowledge of the preserve's resources rests with all parts of the community—researchers, students, docents, and other volunteers, such as the birders. In particular, volunteers play a vital role in gathering and maintaining long-term data. Those data, however, have tended to be underutilized scientifically, relative to the long-term studies organized by research groups. This suggests there is enormous value in community-wide collaborations such as the chapters on mammals and birds. Undergraduate research also contributes to our knowledge of JRBP and is sometimes the forerunner to more conclusive studies.

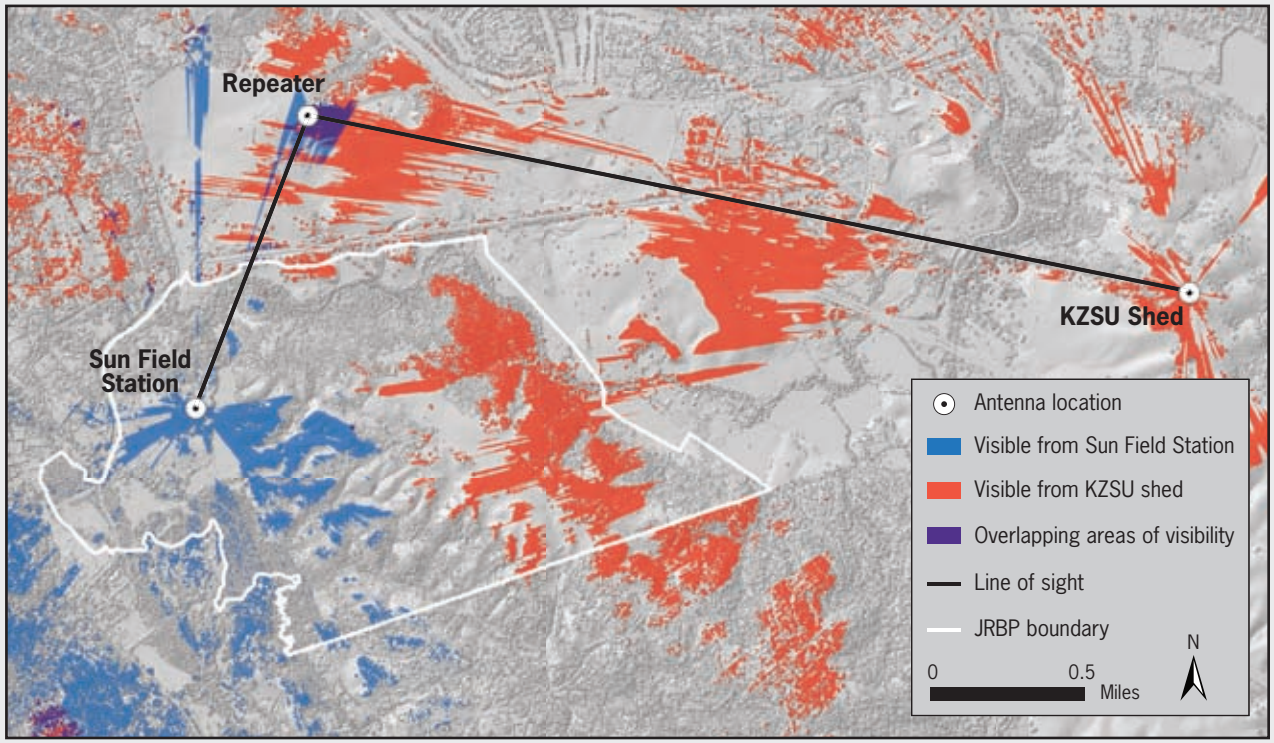
Historical reference points exist for almost every chapter of the assessment. For some chapters, explicit historical comparisons have been constrained by the often narrow focus of prior work and by the difficulty of finding and sifting through old data, but there is no doubt that JRBP's history of research is an irreplaceable asset. Rediscovering old studies can suggest unique opportunities for examining the effects of many kinds of change—rising atmospheric carbon dioxide, declining atmospheric lead pollution, removal of grazing, or accumulation of sediment in the lake. As one student author of the assessment remarked, "I only wish I had written this chapter before I started my dissertation research!"

In addition to the papers and dissertations that were examined for these chapters, there are many others that relate to topics that have not yet been addressed by the assessment. There are also other sources of information, such as the archived files of individuals. The state of the preserve assessment provides a new impetus for retrieving, mapping, and posting selected historical data. Doing so will renew the value of prior studies, build on the chapters of the assessment, strengthen our conservation efforts, and provide new research opportunities. For every interested member of the community, there are opportunities to contribute to this effort.

One of the preserve's infrastructure improvement priorities is upgrading wireless network connectivity to the Sun Field Station. Geographic Information Systems (GIS) have played a key role in the planning and decision-making process.

Since the construction of the field station, JRBP's primary connection to the Internet and the Stanford campus network has been provided by wireless equipment located on the SLAC National Accelerator Laboratory property. The signal is sent wirelessly from a communications tower at the eastern end of SLAC along the length of the accelerator property to a network device at the western end. From there, the signal is transmitted to and from the field station. This system has been problematic for several reasons. There have been a number of construction and maintenance-related power outages at the equipment locations, which have interrupted network service at JRBP for hours or even days at a time. Also, JRBP and Stanford information technology staff have limited access to the equipment on SLAC property, because it is a secure US Department of Energy facility. Moreover, the line of sight from SLAC to the field station is less than optimal due to nearby trees, resulting in signal degradation.

To address the limitations of the current wireless connection from campus to the Sun Field Station, we investigated alternative sources of high-bandwidth Internet service. A comparable high-bandwidth fiber connection into the preserve from a commercial telecommunications provider was prohibitively expensive. The next option was to look for facilities on Stanford property that are connected to the high-bandwidth campus network, and on high ground with generally unobstructed views westward towards Jasper Ridge. I identified several viable sites in the Dish hill area, including the KZSU (Stanford's radio station) shed. The KZSU site was the best candidate, since it already had a high-bandwidth fiber-optic network connection and an unused pole where we can attach a wireless antenna. Jasper Ridge proper blocks any direct line of sight to the field station from east of I-280 so we also needed to locate an intermediate site on Stanford property where we could place a repeater. With lines of sight to both the KZSU location and the Sun Field Station, the wireless repeater would serve as a bridge between both ends of the network connection.



I used a GIS technique known as viewshed analysis to select the best location for the repeater site. Viewshed analysis is performed with GIS software and topographic data to determine all nearby areas of the Earth's surface that are visible from a specified geographic location. The user inputs the exact coordinates and height above ground of an observer point into the GIS software; the software then generates a map marking all the visible surfaces in the specified range and field of view. With JRBP's high-resolution LiDAR elevation data, I was able to perform the viewshed analysis using an elevation surface that included vertical obstructions such as buildings and trees, resulting in a more accurate viewshed model. Once I had generated the viewsheds for the Sun Field Station and the KZSU facility, I checked them for areas where they overlapped each other. To select the final repeater site within the overlapping viewshed areas, I factored in other considerations such as whether or not the site was on Stanford property, its proximity to power supply, and ease of access to it.

The new wireless bridging system will increase the bandwidth and reliability of the network to and from the preserve. It will also expand JRBP's ability to share data and provide remote access to on-site resources, including wirelessly connected research sites in the field. We anticipate that the new system will be operational within the next year.

Rodolfo Dirzo and Cindy Wilber demonstrating to Bio 96 students how to sample vegetation with quadrats in the mammal exclosures.

Education and Outreach

Cynthia J. Wilber

The steady stream of achievements and growing educational opportunities of the Jasper Ridge education program reflect the skilled and generous hard work of JRBP affiliates, who further the mission of the preserve in a multitude of ways. They share their knowledge by teaching in our 1,200-acre classroom, leading tours, and lending their expertise with classes ranging from university to K–12, both at the preserve and in the local community. Affiliates also conduct bird censuses, teach unique preserve-based classes, contribute to research, manage the Oakmead Herbarium and other teaching collections, and enthusiastically provide many essential services that benefit the preserve.

During academic year 2007–08, Stanford University classes at Jasper Ridge Biological Preserve included Jasper Ridge Docent Training, Core Experimental Laboratory, The Ecology of Invasions, Global Warming: Good Science or Bad Politics?, Water Resources and Water Hazards, Plant Genetics, Science of Soils, Introduction to Earth Systems, Sophomore College, Introduction to Prehistoric Archaeology, and others. For a complete list of classes see appendix 3.

In 2007–08, the Jasper Ridge community participated in numerous educational opportunities. The JRBP brown bag lunch lecture series filled the classroom once each month from October to May with topics that ranged from ocean acidification, the San Francisquito Creek watershed, and global warming, to the current Stanford archaeological excavation of the men's gymnasium destroyed by the 1906 earthquake. During spring quarter, Pierre Martineau's class, Observation and Identification of Bees, combined hands-on learning of field collection techniques with lab-based insect identification for many in the Jasper Ridge community.

The annual field trip in October 2007 went to the UC Davis McLaughlin Reserve located in Napa, Yolo, and Lake Counties. Participants received a glimpse into the work of the 6,940-acre reserve from researchers, insight into the history of the reserve, including the Homestake Mining Company, and the opportunity to go on spectacular hikes through serpentine and nonserpentine ecosystems.

Each year, Bio 96 students complete projects as part of their course requirement and this past year's projects were exceptionally diverse. In 2008, some of the docent class projects included vegetation mapping of the chaparral community, transects of oaks along the north side of the preserve, an analysis of high frequency water table data at Searsville Lake, a survey of freshwater mussels in the San Francisquito Creek, an illustrated guide to preserve mammals related to Rodolfo Dirzo's camera trapping research, and a series of extraordinary photos that capture the astounding beauty of Jasper Ridge across the seasons. In addition, Stanford student Leon Peralto worked together with chairwoman Rosemary Cambra, vice chairwoman Monica Arellano, and

1. Bio 96 student Lauren Norwood taking the last of her group's vegetation data points before analyzing and comparing the data.

2. Biology undergraduates Sheppard Peng and Caitlin Roake with a jar of insects they will sort for Bio 44Y.

3. Docent Ruth Buneman identifying insects during Pierre Martineau's Observation and Identification of Bees class.

4. David Freyberg teaching Yu-Jin Lee how to measure groundwater level in one of his piezometers.

RAWWEN
Soap Plant
Chlorogalum pomeridianum

Traditional Uses

- **Soap:** *Toroowi* (bulb) of the Rawwen pounded to make a detergent foam which was used as a *hawwon* (soap) for washing and as a shampoo to reduce dandruff.
- **Fish poison:** *Toroowi* (bulb) of the Rawwen pounded and used as a *háamuy* (fish) poison to stun and catch *háamuy* (fish).
- **Brushes:** Fibers covering the *toroowi* (bulb) of the Rawwen were bundled up into brushes which were used to clean acorn meal from mortars and baskets.
- **Food:** Leaves of the young, immature Rawwen were *'ammaakne 'áššote* (eaten raw). After overnight cooking the *toroowi* (bulb) is also edible.
- **Glue:** *Toroowi* (Bulb) of the Rawwen was roasted to make a glue which could be used to attach arrowheads to shafts, or to glue the handle of the Rawwen brush.
- **Medicine:** Uncooked juice of the *toroowi* (bulb) was used to relieve the itch from poison oak.

5

5. Excerpt from the collaborative booklet begun as Leon Peralto's docent project, "*Siská'E Héemeteya Puichon Wolwoólum*, Plant Life of the Puichon Ohlone."

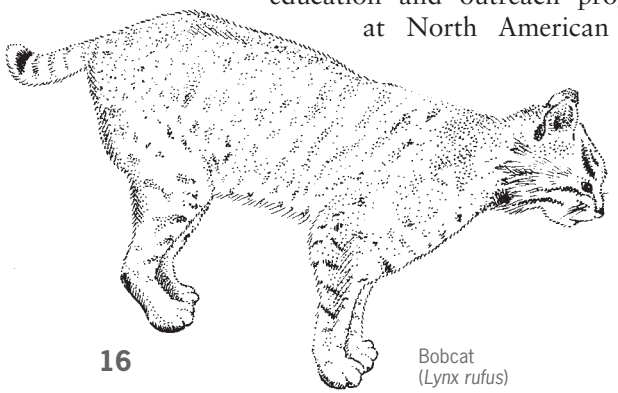
6. Bio 96 students learning to identify spring wildflowers in early April.

ethnohistorian Alan Leventhal of the Muwekma Ohlone Tribe, as well as The Muwekma Language Committee, to produce a booklet entitled "*Siská'E Héemeteya Puichon Wolwoólum*, Plant Life of the Puichon Ohlone." The booklet includes tribal history and plant information in both English and Chochenyo and is a collaborative work in progress with the Muwekma Ohlone Tribe, to be expanded following upcoming plant workshops in 2008–09.

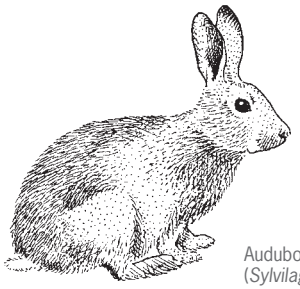
In August, the Jasper Ridge education program was represented in a symposium at the annual meeting of the Ecological Society of America in Milwaukee, Wisconsin, whose 2008 meeting theme was "Enhancing ecological thought by linking research and education." The symposium, "Ecology education and outreach programs at North American Field Stations," focused on biological field stations as natural resource islands uniquely able to provide critical early ecology education, improved ecological literacy, and experiential learning across ages for a new, more diverse generation of ecologists and science educators. Also at the meeting were Leon Peralto and Mattias Lanas (Jasper Ridge 2008 docent class) who participated in the Strategies for Ecology Education, Development and Sustainability (SEEDS) program,[9] and Hilary Rollins, high school intern and Jasper Ridge docent, who presented her work on *Dirca occidentalis* with mentor Bill Graves of Iowa State University.

During the past ten years the Jasper Ridge education program has grown significantly, and now encompasses, in addition to Stanford classes, a broad range of learning opportunities and programs for those from the very young to the lifelong learner. This seems like the ideal time to question what we know about what students have learned and to ask what we have learned about field-based education. We know that students of all ages thrive in situations where they are actively participating in scientific inquiry. We know that promoting scientific literacy and inclusion in the preserve's community supports scholarly observation and promotes inquiry across all ages, and that student self-identification as someone who "is good at science" changes dramatically.

With an extensive program and a small staff we have also learned which education strategies work for Jasper Ridge. First and foremost, we support and sustain the JRBP docent community, a highly trained and motivated volunteer community, and

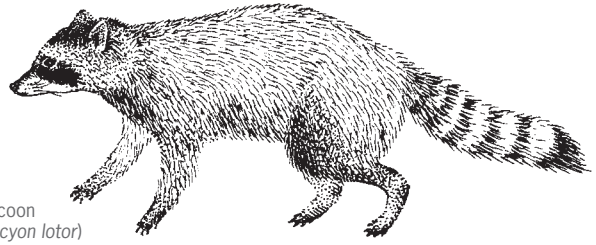


Bobcat
(*Lynx rufus*)



Audubon's cottontail
(*Sylvilagus audubonii*)

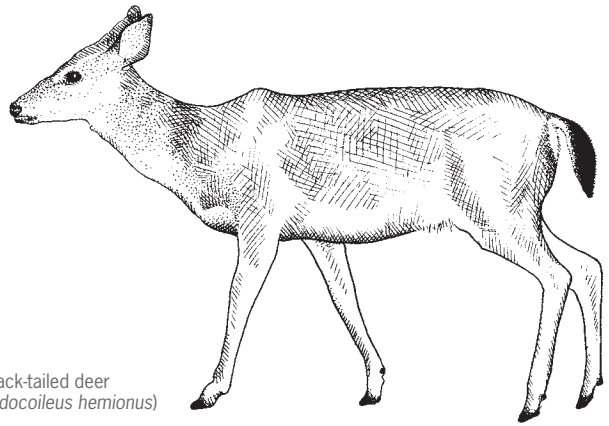
Common large mammals from the camera-trap study, illustrated by Mattias Lanas



Raccoon
(*Procyon lotor*)

build strong relationships with partner schools. Collaborating with the Stanford School of Education, especially the Stanford Teacher Education Program (STEP), to create models for teacher professional development in order to provide ecology-based experiences for local high school science teachers has reached thousands of students over the past ten years. We also continue to work with local, national and international partners to provide educational opportunities for the greater learning community.

But, our most important strategy in the end is to take students outside. The natural world is our best classroom.



Black-tailed deer
(*Odocoileus hemionus*)

K–12 Programs

2007–08 was a banner year for K–12 programs at Jasper Ridge. In addition to ongoing programs with local elementary and high schools, community organizations, and mentoring programs, the spotlight was on two programs: The Stanford K–12 Initiative REAL program and Eastside Field Studies.

• In December 2007, the Stanford K–12 Initiative funded the Ecology: Learning by Doing project, headed by Rodolfo Dirzo and Cindy Wilber. The project is a collaborative outreach program with the Dirzo lab, Jasper Ridge Biological Preserve, the School of Earth Sciences, the Stanford SEEDS chapter and Redwood High School, the continuation high school in the Sequoia Union School District. The project began in spring quarter with the creation of the Redwood Environmental Academy of Leadership (REAL) and is an interdisciplinary ecology class focused on the Cordilleras Creek riparian ecosystem located on the high school campus.

In the program, students learn science by doing real ecology projects, side by side with Stanford faculty, students, and JRBP affiliates. During spring quarter, students learned how to conduct vegetation sampling and forest transects working with Rodolfo Dirzo and docent Toni Corelli. Raynelle Rino, the REAL program project manager (and JRBP researcher) guided the students through eight weeks that included watershed dynamics, plant-animal interactions, ecosystem services, plant reproduction and fitness, and environmental justice. Stanford students Kate Lowry and Mattias Lanas (also SEEDS members and JRBP docents) worked each week with the students, and Stanford director of heritage services Laura Jones taught a class session on archaeology. During 2008–09 students from the REAL program will visit Jasper Ridge in small groups to learn about JRBP research, to compare the preserve's riparian community to their own campus wetland, and to work on plant defenses to herbivory.

• In May 2008, the Jasper Ridge/Eastside Field Studies class was honored by the Stanford Office of Public Affairs at the 2008 Community Partnership Awards annual luncheon.[10]

The event celebrates programs that benefit the local community and represent successful partnerships between Stanford and its neighbors. The Eastside[11] Field Studies class, now in its tenth year, focuses on sixth-grade student researchers working in small groups taught by JRBP-trained Stanford student mentors during spring quarter. The highlight of the awards ceremony was the arrival of the sixth graders and their JRBP team, Stanford students Brandon Cortez, Hannah Larkin, Samantha Staley, Ben Graves, Dave Bernstein, Matt Velasco, Ron Yeh, and JRBP docents Susan Gold and Mary Baron, fresh from their Jasper Ridge fieldwork in time to share the honor.

Left: Rodolfo Dirzo teaching REAL program students at Redwood High School. **Right:** Eastside students at the Community Partnership Awards ceremony.

Profiles

Academic Milestones and Accomplishments

Bill Anderegg came to Stanford with the well-trained ear of an accomplished pianist, and later found that his musical ability was key to his honors thesis in biology. Bill became interested in species' responses to environmental change, and decided in his junior year to revisit a 35-year-old survey of the bird diversity of Searsville wetland. Bill's knack for bird call recognition was indispensable for identifying birds in dense willow thickets, and his senior thesis became a detailed then-and-now comparison of the wetland avifauna and environment. Bill's thesis was awarded a 2008 Firestone Medal for excellence in undergraduate research, and launched him into two new projects on climate change, as well as the PhD program at Stanford.

Members of the 2008 docent training class in the serpentine grassland in early January. The class of 2008 includes new docents Dave Bernstein, Lisa Brown, Brandon Cortez, Allison Dedrick, Catherine Fong, Mattias Lanas, Hannah Larkin, Crystal Lee, Yu-Jin Lee, Melissa Lewis, Kate Lowry, Lauren Norwood, Leon No'eau Peralto, Ariana Poursartip, Dan Quinn, Diane Renshaw, Sarah Truebe, and Peter Wright.

Yolanda Cachú came to Stanford after receiving her PhD from Lancaster University, UK, where she studied responses of herbaceous plants to herbivory and to infection by fungi such as rusts. During her two-year postdoctoral fellowship in Rodolfo Dirzo's lab, Yolanda collaborated on the camera-trap project, which is the first formal study that has compiled a list of mammal species present at JRBP. She also contributed to studies of competition and herbivory comparing native plants and closely related, non-native plants. Yolanda is currently in Mexico developing a career in environmental policy.

Eduardo Mendoza joined Rodolfo Dirzo's lab as a postdoctoral fellow after completing his PhD in tropical ecology and conservation biology at UNAM in Mexico. At JRBP, he collaborated on the camera-trapping study of temporal and spatial variation in mammal abundance and activity, helping to produce one of the largest photographic databases of mammals currently available. Eduardo also conducted experiments on seed predation on the buckeye tree, and on the interaction between invertebrate herbivores and invasive plants. Now as a researcher in Mexico, Eduardo is continuing his collaboration with the Dirzo lab and also applying his knowledge of camera trapping to study and conserve tropical forest mammals in southeast Mexico.

Darcy McRose fell in love with Jasper Ridge through the docent training course, and realized it was the perfect place to combine her interests in soils and sustainability. She began an internship with the Jasper Ridge global change experiment in which she added to and analyzed an eight-year time series of soil samples. Darcy was specifically interested in the effects of global environmental changes on the rate at which carbon is stored in soil or decomposed. Her internship led to a senior honors thesis, "Understanding carbon dynamics in California grassland soils," which won a 2008 Firestone Medal for excellence in undergraduate research. Darcy is continuing her work on biogeochemical cycling as a master's student at Stanford.

Noel Gurwick came to the Carnegie Institution and Stanford after a series of positions at the science-policy interface, including a PhD from Cornell on nutrient cycles in streamside soils. The Jasper Ridge global change experiment (JRGCE) interested him as a chance to study feedbacks between climate change and terrestrial ecosystems, and to explore policy-related questions in ecosystem science in a collaborative environment. In the JRGCE's long-term data sets he found surprising interactions among precipitation, atmospheric CO_2, and plant growth. Noel is now a AAAS fellow at the US Department of State working on US international energy policy.

Michael Tom finished his major in biology by researching the ecological impacts of managing French broom, an idea he developed in the Field Studies in Earth Systems course. Mike examined population dynamics, hydrology, and nutrient cycling in dozens of plots that were first weeded of broom or left intact, and then shaded or treated in other ways. He found that broom-pulling triggers more recruitment from the seedbank but does not immediately alter nitrogen dynamics, so persistent followup should succeed in removing broom without favoring other invasives. Mike has returned to his native Hawai`i to pursue a career in medicine.

Ron Yeh completed his PhD in December 2007 in Stanford's computer science department. At Jasper Ridge he studied how digital pen technology could help scientists capture field data more effectively and collaborate with each other remotely. For his dissertation, he developed a suite of software tools that could help programmers rapidly build software to digitize, recognize, and share handwritten input. Ron's projects—ButterflyNet and PaperToolkit—have been field-tested with over 100 users in various disciplines, including many at Jasper Ridge. Ron has also taught field biology to sixth graders in the Eastside field studies class. Currently "on sabbatical" from academia, Ron is exploring novel web interfaces for information visualization at Cooliris, a Palo Alto startup.

Appendix 1: Research Projects

Project	Principal Investigator(s) or Coordinator	Department or Division	Institution
Spectral imaging and waveform light detection and ranging (wLiDAR)	Greg Asner, Chris Field	Fac, Global Ecology	Carnegie Institution
Remote sensing and field measurement of vegetation and aboveground biomass	Kyla Dahlin	GS, Biology	Stanford University
Wildfire fuel load monitoring	Chris Fedor	UG, Earth Systems	Stanford University
Monitoring for management: remote sensing of sudden oak death	Sara Maatta	UG, Earth Systems	Stanford University
Broadband seismic monitoring	Greg Beroza	Fac, Geophysics	Stanford University
	Bill Karavas	SS, Berkeley Dig. Seismic Net.	UC Berkeley
Population biology of the butterfly *Euphydryas chalcedona*	Irene Brown	Vol, JRBP	
Collection and mapping of the flora of Jasper Ridge by volunteers	Nona Chiariello	SS, JRBP	Stanford University
Multiple resource limitation, and top-down versus bottom-up controls on plant community structure	Elsa Cleland	Fac, Ecology, Behavior & Evol.	UC San Diego
Nationwide grassland soils survey	Joseph Craine	Fac, Biology	Kansas State University
Effects of mammalian herbivory on growth and reproduction of oaks	Hall Cushman	Fac, Biology	Sonoma State University
	Laura Saunders	GS, Biology	Sonoma State University
Survey for presence of the light brown apple moth	Allison Dedrick	UG, Earth Systems	Stanford University

Key to abbreviations used:

Fac = faculty
GS = graduate student
PD = postdoctoral fellow
SS = staff or senior scientist
UG = undergraduate
Vol = docent and/or volunteer

Project	Principal Investigator(s) or Coordinator	Department or Division	Institution
Mammalian diversity, abundance, and activity	Rodolfo Dirzo	Fac, Biology	Stanford University
Behavioral response to camera traps via a comparative study of two methods	Eric Abelson	GS, Biology	Stanford University
Population genetics of *Microtus californicus*	Rachel Adams	GS, Biology	Stanford University
Camera-trap monitoring of large and medium-sized mammals	Yolanda Cachú, Eduardo Mendoza	PD, Biology	Stanford University
Small mammal diversity and density across habitats	Hillary Young	GS, Biology	Stanford University
Herbivory and seed predation on Jasper Ridge plants	Rodolfo Dirzo	Fac, Biology	Stanford University
Herbivory and competition between native and exotic plant species	Eduardo Mendoza, Yolanda Cachú	PD, Biology	Stanford University
Consequences of non-lethal seed predation on seeds of California buckeye	Eduardo Mendoza	PD, Biology	Stanford University
Long-term studies of *Euphydryas editha bayensis* and feasibility of reintroduction	Paul Ehrlich	Fac, Biology	Stanford University
	Carol Boggs	Fac, Biology	Stanford University
	Scott Fendorf	Fac, Env. Earth System Science	Stanford University
	Chris Field	Fac, Global Ecology	Carnegie Institution
	Buzz Thompson	Fac, Law School	Stanford University
	Richard White	Fac, History	Stanford University
Feasibility study of serpentine habitat creation	Tim Bonebrake	GS, Biology	Stanford University
Historical distribution of the Bay checkerspot butterfly and its food plants	Jon Christensen	GS, History	Stanford University
Long-term monitoring of ecosystem processes by eddy covariance	Chris Field, Joe Berry	Fac, Global Ecology	Carnegie Institution
Jasper Ridge global change experiment (JRGCE)	Chris Field	Fac, Global Ecology	Carnegie Institution
	Hal Mooney, Peter Vitousek	Fac, Biology	Stanford University
Effects of global change on methane oxidation	Joey Blankinship	GS, Biological Sciences	Northern Arizona Univ.
Spectral measurement of aboveground vegetation dynamics	Nona Chiariello	SS, Biology	Stanford University
Trace gas fluxes under simulated global changes	Paul Dijkstra	SS, Biological Sciences	Northern Arizona Univ.
Changes in nitrogen cycling in response to global change treatments	Noel Gurwick	PD, Biology & Global Ecol.	Stanford Univ. & Carnegie Inst.
Effects of global change on soil nitrogen cycling	Bruce Hungate	Fac, Biological Sciences	Northern Arizona Univ.
Nitrification and denitrification under altered climate	Paul Leadley; Audrey Niboyet	Fac; GS, Ecol., Systém, Evol.	Université Paris-Sud (France)
Disturbance and global change effects on yellow star-thistle invasions	Annie Lindseth	UG, Earth Systems	Stanford University
Whole-system gas exchange of the JRGCE	Claire Lunch	GS, Biology & Global Ecol.	Stanford Univ. & Carnegie Inst.
Soil carbon dynamics	Darcy McRose	UG, Earth Systems	Stanford University
Role of fungal community composition in soil carbon dynamics	Rebecca Mueller	GS, Ctr. for Ecol. & Evol. Biol.	University of Oregon
Chemical characterization of soil organic matter responses to global change	Ted Raab; Noel Gurwick	SS; PD, Biology	Stanford University
Effect of global change on root demography	Briana Swette	UG, Earth Systems	Stanford University

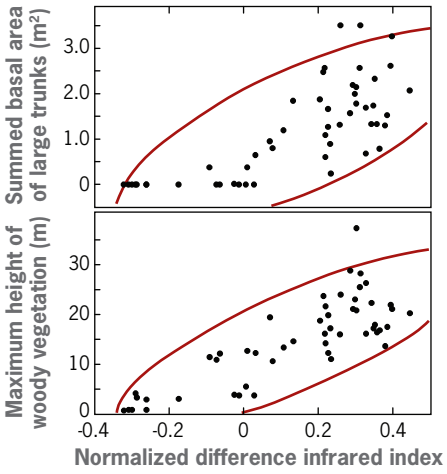


Project	Principal Investigator(s) or Coordinator	Department or Division	Institution
Characterization of freshwater ammonia-oxidizing communities	Chris Francis	Fac, Geol. & Environ. Sciences	Stanford University
	Augusta Dibbell	GS, Geol. & Environ. Sciences	Stanford University
The water balance of Searsville Lake and its sediments under existing and possible future conditions	David Freyberg	Fac, Civil & Envir. Engineering	Stanford University
Numerical modeling of surface-subsurface water flow	May Chui	GS, Civil & Envir. Engineering	Stanford University
Evaporation measurement and estimation	Jun Young Kim	GS, Civil & Envir. Engineering	Stanford University
Monitoring groundwater pressure in the Searsville complex	Gabrielle Puz	GS, Civil & Envir. Engineering	Stanford University
Argentine ant *(Linepithema humile)* invasion and the response of native ants	Deborah Gordon	Fac, Biology	Stanford University
Seasonal polydomy, budding, and the spread of the Argentine ant	Katherine Fitzgerald	GS, Biology	Stanford University
Effects of Argentine and native ants on Lycaenid butterflies	Jessica Shors	GS, Biology	Stanford University
Determinants of the distribution and reproductive success of *Dirca occidentalis*	William Graves	Fac, Horticulture	Iowa State University
Ground survey of sediment deposition in Searsville Lake and wetlands	Brad Hall	SS	Northwest Hydraulic Consultants
Long-term monitoring of birds by volunteers	Trevor Hébert	SS, JRBP	Stanford University
Monitoring of water flow and quality	Barry Hecht, Jonathan Owens, Chris White	SS	Balance Hydrologics, Inc.
Effects of rainfall variability and gopher removal on serpentine grassland	Richard Hobbs	Fac, Wildlife & Ecol.	Murdoch University (Australia)
Post-fire survey of historical and prehistoric artifacts	Laura Jones	SS, Univ. Land & Buildings	Stanford University
	Julia Hammett	Fac, Anthropology	Truckee Meadows Comm. Coll.
Earthquake prediction from precursory electromagnetic anomalies	Simon Klemperer	Fac, Geophysics	Stanford University
	Darcy McPhee, Jonathan Glen	Geophysical Unit, Menlo Park	US Geological Survey
Regional surveys of annual acorn production and oak phenology	Walter Koenig William Carmen	SS, Cornell Lab. Ornithology	Cornell University Ctr. for Environ. Citizenship
Repeat of a 1976 analysis of lead in the lichen *Ramalina menziesii*	Léo Laporte	Vol, JRBP	
Survey of San Francisquito Creek and removal of exotics	Alan Launer	SS, Univ. Land & Buildings	Stanford University

Project	Principal Investigator(s) or Coordinator	Department or Division	Institution
Restoration, monitoring, student & public outreach in San Francisquito Creek Watershed	Alan Launer Ryan Navratil	SS, Univ. Land & Buildings SS	Stanford University San Francisquito Wtrshd. Counc.
San Francisquito Creek habitat characterization	Paul Rich, Stuart Weiss	SS	Creekside Ctr. for Earth Observ.
Seasonality of eating habits and prey selection of raptors in serpentine grassland	Targe Lindsay	Vol, JRBP	
Synergistic anthropogenic effects on riparian avian communities	William Love Anderegg	UG, Human Biology	Stanford University
Monitoring and collection of insects	Pierre Martineau, Ted Mill	Vol, JRBP	
Biodiversity and abundance of snakes in California grassland	Doug McCauley	GS, Biology	Stanford University
Photochemical changes in natural organics in Searsville Lake water	Ted Mill	SS, Chemistry	SRI International
Microbially mediated transformations of arsenic and selenium in lake sediments	Larry Miller	SS, Water Resources	US Geological Survey
Wetland delineation for Stanford University	Jeff Olberding	SS	Olberding Environmental
Computing support for acquisition, collaborative curation, and dissemination in biodiversity research (BioACT)	Andreas Paepcke	SS, Computer Sciences	Stanford University
Data capture (ButterflyNet) and interactive gigapixel prints (GIGAprints)	Ron Yeh	GS, Computer Science	Stanford University
Legume-rhizobial interactions in *Lotus wrangelianus* on and off serpentine soils	Stephanie Porter	GS, Population Biology	UC Davis
Paleoseismic study of the peninsula San Andreas fault	Carol Prentice	SS, Western Earthquake Hazards	US Geological Survey
Associations among ants, aphids, and leaf galls on arroyo willow	Raynelle Rino	GS, Biology	San Francisco State University
Ecological impacts of French broom invasion management	Mike Tom	UG, Biology	Stanford University
Distribution of *Leptosiphon* on serpentine and sandstone soil	Lorna Watt	GS, Plant Biology	Michigan State University

PhD student Kyla Dahlin measuring tree heights to compare with tree height data collected by the Carnegie Airborne Observatory's light detection and ranging (LiDAR) system.

Kyla's research at Jasper Ridge seeks to use airborne remote sensing to measure and map important ecosystem properties such as the amount of carbon stored in the wood and leaves of plants. Along with tree height, the remote sensing data provide measurements of reflected sunlight at hundreds of wavelengths for every 2.7 m by 2.7 m patch of vegetation. Kyla correlates ground-based measurements such as the basal area of tree trunks, or aircraft-based measurements of tree height, with various wavelengths of reflected light. The graph shown here illustrates one such correlation.



Appendix 2: Publications and senior theses

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Amatangelo KL, Dukes JS, Field CB. 2008. Responses of a California annual grassland to litter manipulation. Journal of Vegetation Science 19: 605–612.

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Henry HAL, Brizgys K, Field CB. 2008. Litter decomposition in a California annual grassland: interactions between photodegradation and litter layer thickness. Ecosystems 11: 545–554.

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Houlton BZ, Field CB. Nutrient cycling, limitation and global change in Jasper Ridge rangelands. Rangeland Ecology and Management (in press).

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Manoharan A, Stamberger J, Yu YY, Paepcke A. 2008. Optimizations for the EcoPod field identification tool. BMC Bioinformatics 9:150.

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Peters HA. 2007. The significance of small herbivores in structuring annual grassland. Journal of Vegetation Science 18: 175–182.

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Pieruschka R, Klimov D, Rascher U, Kolber ZS, Berry JA. 2007. Remote monitoring of photosynthetic efficiency using laser induced fluorescence transient (LIFT) technique. Proceedings of the 14th International Congress on Photosynthesis. Glasgow.

Rawlings J. 2008. Native grass viewing at Jasper Ridge Biological Preserve's serpentine grassland. Grasslands 18: 10–13.

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Wang Y-P, Houlton BZ, Field CB. 2007. A model of biogeochemical cycles of carbon, nitrogen, and phosphorus including symbiotic nitrogen fixation and phosphatase production. Global Biogeochemical Cycles 21: 1–15.

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Appendix 3: Educational Use

Stanford University Classes (1160*)

ANTHRO 3	Introduction to Prehistoric Archaeology (Robertson)
APPPHYS 79Q	Energy Choices for the 21st Century (Fox, Geballe)
BIO 11SC	The Ecology of Invasions (Gordon)
BIO 33N	Conservation Science and Practice (Daily)
BIO 44Y	Core Experimental Laboratory (Malladi)
BIO 96A,B	Jasper Ridge Docent Training (Wilber, Dirzo)
BIO 101	Ecology (Dirzo, Vitousek)
BIO 137/237	Plant Genetics (Walbot)
BIO 344	Advanced Seminar in Cellular Biology (Cyert)
CEE 166D/266D	Water Resources and Water Hazards Field Trips (Freyberg)
EARTHSYS 10	Introduction to Earth Systems (Ernst)
GEOPHYS 25	Hands-on Introduction to Astrobiology (Sleep)
GES 175	Science of Soils (Fendorf)
GSB SGSI	Global Warming: Good Science or Bad Politics? (Schneider, Root)

Stanford Continuing Education Classes (150*)

BOT 55	California Native Plants (Duvall) (Stanford Continuing Studies)
JRBP	Observation and Identification of Bees (Martineau)
GSB Back To School	Reduce Your Ecological Footprint: Choose Environmentally Sustainable Business Practices (Richter)

Other College and University Classes (110*)

De Anza College: Natural History of the Bay Area
Santa Clara University: Civil Engineering
San Jose State University: Plant Communities of California

*Number of visits. One visit = one person entering preserve on one day. These numbers represent an underestimate; they do not include informal use or research use.

Stanford and Affiliated Groups (960*)

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BioACT
Biological Impacts of Climate Change in California
Center for Advanced Study in the Behavioral Sciences
Controller's Office
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First Nations' Futures Institute
Graduate School of Business, alumni association
Green Living Council Leadership Team
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Office of Undergraduate Admissions
Outdoor Education Program
Physics Department faculty
School of Education
Stanford Management Company
Stanford News Service
Stanford-Singapore Partnership Program (SSP)
Woods Institute for the Environment

Right: In March, US Treasury Secretary Henry M. Paulson Jr. (center, in cap) visited Jasper Ridge, accompanied by students from the Department of Biology and the Graduate School of Business. Later the same day, he delivered the keynote address on campus at the 2008 Stanford Institute for Economic Policy Research (SIEPR) Economic Summit.

K–12 Groups (760*)
East Palo Alto High School
East Palo Alto Tennis and Tutoring
Eastside College Preparatory School
Environmental Volunteers
Gunn High School
Menlo School Knight School
Palo Alto High School
Redwood High School
Woodside High School
Youth Community Service

Other Groups (1100*)
A Sense Of Place
California Fish and Game
California Native Plant Society
Canopy
Chewonki Organization
Christ Church of Portola Valley
Conservation Strategy Fund
Exploratorium
Garden Club of Palo Alto
Gray Hawks
Kamehameha School faculty and trustees
Muwekma Ohlone Tribe
Pepperwood Reserve
PG&E Energy Center
Portola Valley Nature and Science Committee
San Francisco Bay Bird Observatory
San Francisquito Watershed Council
San Mateo County Fire Safe Committee
Sequoia Audubon Society
Silicon Valley Audubon Society
Society for Conservation Biology, Central California Coast Chapter
Society for Environmental Journalists
Stevens and Permanente Creek Watershed Council
Stevenson House
Walter Hays Elementary School Faculty
Woodside-Atherton Garden Club

2007–08 Brown Bag Lunch Lectures

October: **Ryan Navratil**
Field Coordinator, San Francisquito Watershed Council
"Monitoring/managing resources in urban landscapes"

November: **Ken Caldeira**
Department of Global Ecology, Carnegie Institution of Washington
"Ocean acidification: carbon dioxide from fossil-fuel burning threatens marine biota; biophysical and carbon-cycle effects of forests"

December: **Susan Frankel**
Sudden Oak Death Research Program Manager, USDA Forest Service, Pacific Southwest Research Station
"An update on sudden oak death/*Phytophthora ramorum* and other Phytophthoras"

January: **Hal Mooney**
Paul S. Achilles Professor of Environmental Biology, Stanford University
"Conserving biological diversity—the enormous challenge"

February: **Stephen Schneider**
Melvin and Joan Lane Professor for Interdisciplinary Environmental Studies and Professor of Biology, Stanford University
"Global warming: Is the science settled enough for policy?"

March: **Claire Lunch**
Graduate student, Stanford University
"Seasonal and interannual variation of plant responses in the Jasper Ridge global change experiment"

April: **Laura Jones**
Director of Heritage Services in Land Use and Environmental Planning and University Archaeologist, Stanford University
"Current excavation of the men's gymnasium, destroyed in the 1906 earthquake"

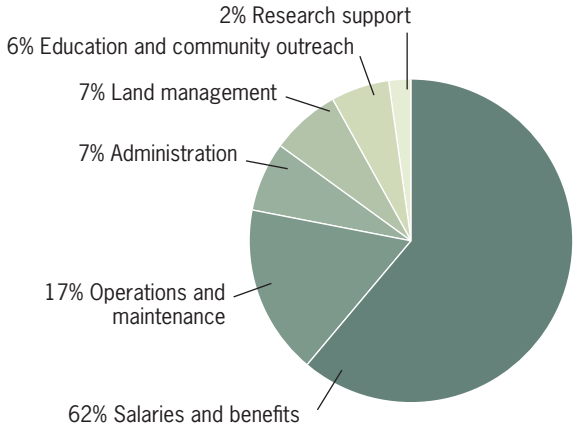
May: **Ralph Larson**
Professor, San Francisco State University
"The effect of climate variation on California nearshore fishes, and the myth of sustainability."

Appendix 4: 2007–08 Financial Summary

Expense summary

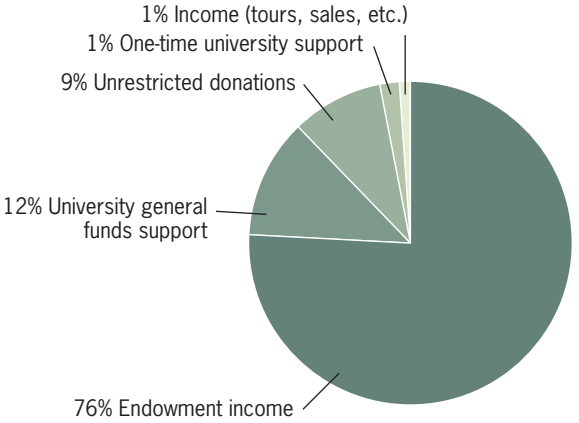
Salaries and benefits	$539,069
Operations and maintenance	144,432
Administration	60,512
Land management	57,660
Education and community outreach	51,808
Research support	14,981
Total	**$868,462**

Education and community outreach expenses included the purchase of audio-visual equipment for recording presentations.



Revenue summary

Endowment income	$714,758
University general funds support	117,260
Unrestricted donations	85,723
One-time university support	13,237
Income (tours, sales, etc.)	11,133
Total	**$942,111**



Appendix 5: Donors

Through most of its history, Jasper Ridge has been able to manage unanticipated challenges and respond in innovative and nimble fashion while supporting a high level of research and educational productivity. That flexibility rests upon the support the community of donors has provided over the years. We offer our sincere gratitude to our donors for your continuing generosity. The following is a list of those who made unrestricted gifts to the preserve from September 1, 2007 to August 31, 2008.

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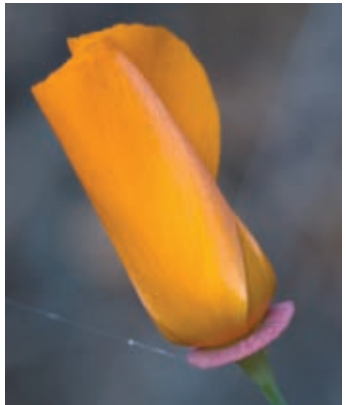

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Cindy Wilber, education coordinator
Trevor Hébert, GIS and data manager
Carolyn Taylor, administrative assistant
Cary Tronson, operations steward
Leonard Robinson, resident caretaker (retired)
Brooke Fabricant, resident ranger
Chandra Nicola, temporary maintenance assistant

Endnotes

1. MROSD: http://www.openspace.org
2. Community Partnership Award: http://jrbp.stanford.edu/cp_award.php
3. Cuthbertson Award: http://news-service.stanford.edu/news/2008/june11/awards-061108.html
4. Fire research: Westerling AL, Hidalgo HG, Cayan DR, Swetman TW. 2006. Warming and earlier spring increase western US forest wildfire activity. Science: 313; Westerling A, Bryant B. 2006. Climate change and wildfire in and around California: Fire modeling and loss modeling. Public Interest Energy Research, California Energy Commission, CEC-500-2005-190-SF.
5. Chartwell School: http://www.chartwell.org
6. First Nations: http://fnfp.org/web/guest/home
7. JRBP strategic plan: http://jrbp.stanford.edu/stratplan.php
8. State of the preserve assessment: http://jrbp.stanford.edu/sop.php
9. ESA SEEDS: http://www.esa.org/seeds
10. Community Partnership Award: http://jrbp.stanford.edu/cp_award.php
11. Eastside College Preparatory School: http://www.eastside.org

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6–8 NC **9** TC, NC, DQ **10** CC, NC
11 RD **12** *top* NC; *bottom* CA **13** TH
14 DQ **15** *top* DQ; *bottom* DQ, NC, NC
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22 DQ **23** NC, NC/EJ **24** *top* DQ; *bottom* DM, DM, TL **25** DQ, DQ, TC
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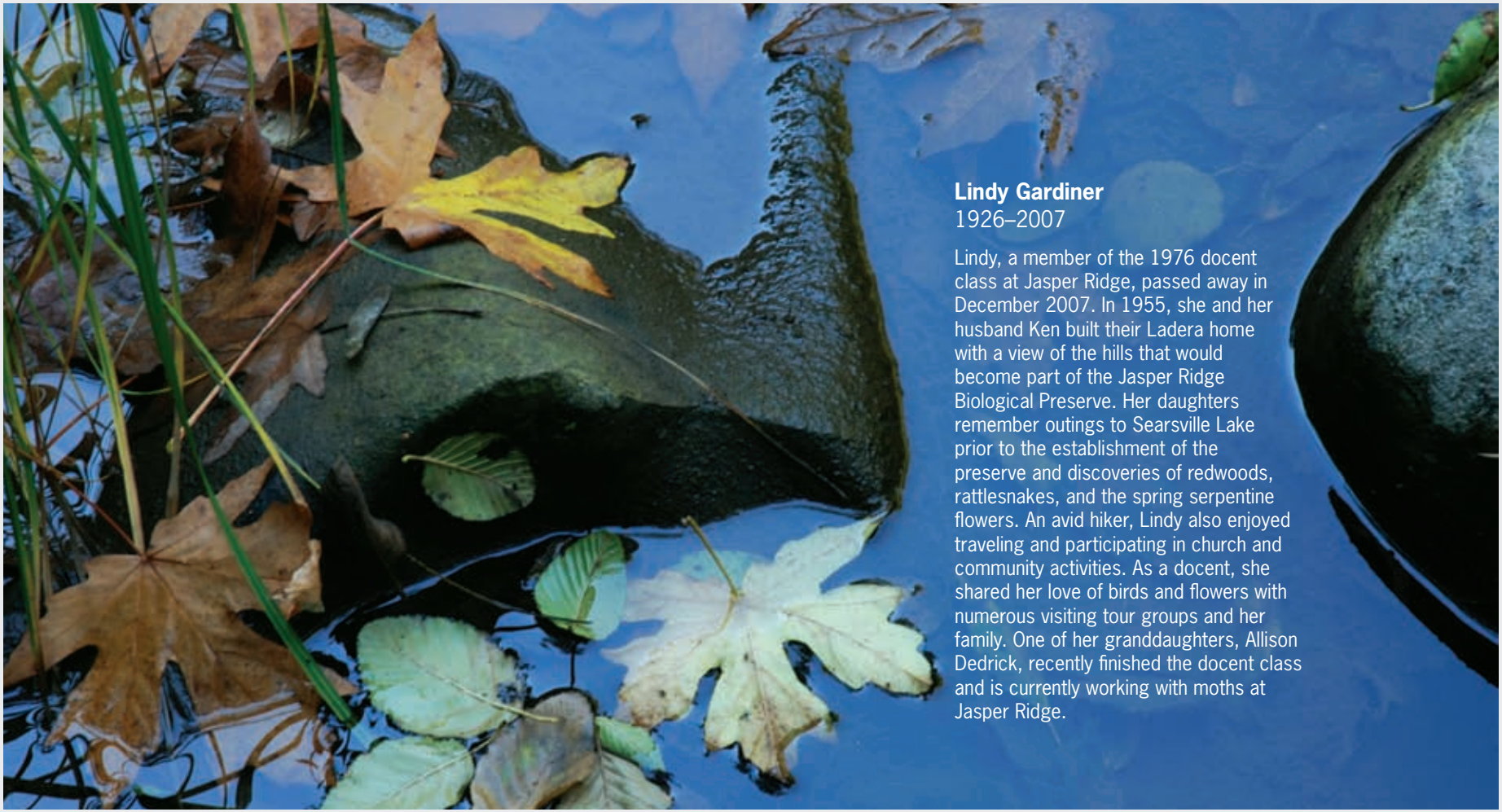
In Memoriam



Lindy Gardiner
1926–2007

Lindy, a member of the 1976 docent class at Jasper Ridge, passed away in December 2007. In 1955, she and her husband Ken built their Ladera home with a view of the hills that would become part of the Jasper Ridge Biological Preserve. Her daughters remember outings to Searsville Lake prior to the establishment of the preserve and discoveries of redwoods, rattlesnakes, and the spring serpentine flowers. An avid hiker, Lindy also enjoyed traveling and participating in church and community activities. As a docent, she shared her love of birds and flowers with numerous visiting tour groups and her family. One of her granddaughters, Allison Dedrick, recently finished the docent class and is currently working with moths at Jasper Ridge.

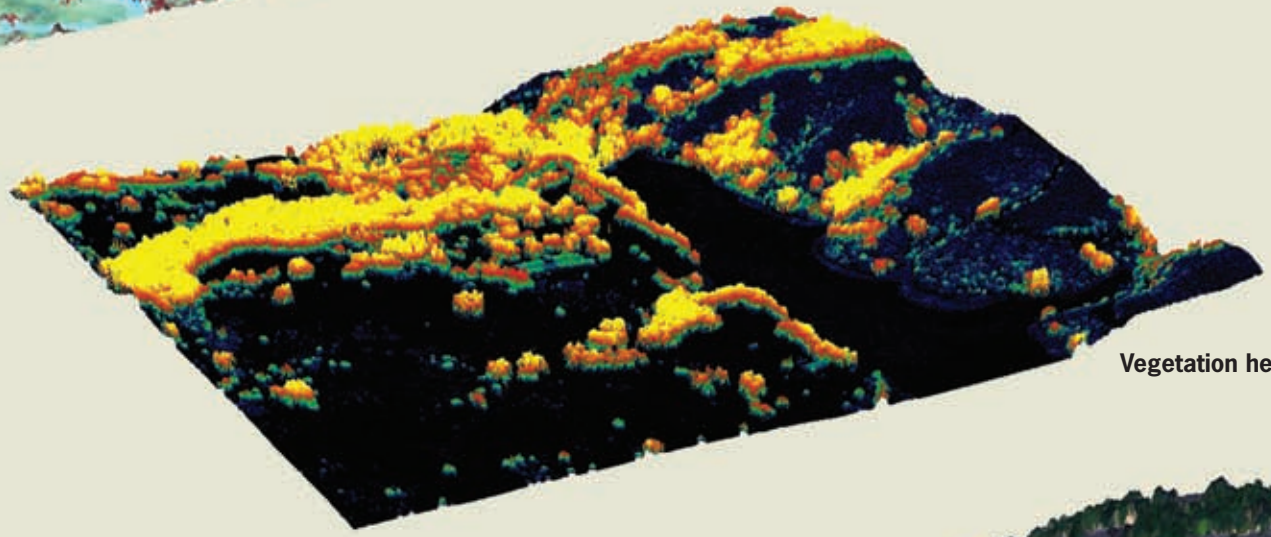
About the covers

Front cover: Western Grass Stem Sawfly (*Cephus clavatus*; family Cephidae, order Hymenoptera) and smaller click beetle (family Elateridae, order Coleoptera) together on the blossom of a California buttercup (*Ranunculus californicus*). Photographed near the Sun Field Station in April 2008 by Dan Quinn.

Back cover: Images of Jasper Ridge from the Carnegie Airborne Observatory's Beta system, a combination of light detection and ranging (LiDAR), NASA's Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) and a high-fidelity navigational system. These three images show how hyperspectral data from AVIRIS can be combined with topographic data from LiDAR to create three-dimensional maps of the landscape. Hyperspectral data (e.g., color-infrared and true color images, shown on the top and bottom, respectively) and vegetation height (middle) are being used by researcher Kyla Dahlin and others to address landscape-level questions about plant distribution, fire fuel loads, and carbon sequestration. For example, variations in infrared data can indicate changes in species diversity and in the amount of green vegetation in a pixel. Source: Carnegie Airborne Observatory, Carnegie Institution of Science (http://cao.stanford.edu); images created by Kyla Dahlin.

860 nm (infrared)
650 nm
550 nm

Color-infrared data



>15 m
0 m

Vegetation height

True-color landscape

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Stanford University
Stanford, CA 94305-5020

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