Jasper Ridge Biological Preserve

Annual Report 2005–06

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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.

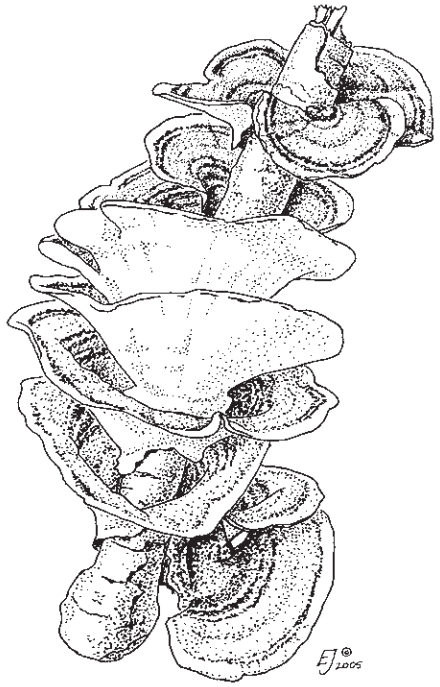
Contents

From the Faculty Director

Chris Field

My core reflection on the past year is one of gratitude—for the generous welcome to my new position, for the hard work of the staff and a multitude of volunteers, for the intense enthusiasm and curiosity of those working in and visiting the preserve, and for the opportunity to contribute to this very special place. My primary connection with Jasper Ridge is still as a researcher, but in the past year that connection has broadened and deepened, thanks to many people.

I focused my efforts this year on strengthening—or, in some cases, building from scratch—advisory structures to help implement the core recommendations of the Jasper Ridge strategic plan. The Jasper Ridge advisory committee includes Stanford faculty from four of the university's seven schools, with members representing Humanities and Sciences (Paul Ehrlich, Liz Hadly, Craig Heller, Hal Mooney, and George Somero from Biological Sciences, plus Richard White from History), Earth Sciences (Gary Ernst from Geological and Environmental Sciences), Engineering (David Freyberg from Civil and Environmental Engineering), and Law (Meg Caldwell). In addition, the committee includes two PhD students, Claire Lunch from Biological Sciences and Ron Yeh from Computer Science.



Left: Sensor arrays and photovoltaic power make up the eddy covariance station, which calculates carbon uptake and loss by the ecosystem based on relationships between air turbulence and CO_2 concentration.

The vast range of disciplines represented by the advisory committee underscores the diversity of issues facing the preserve. The advisory committee met quarterly this year and addressed key issues associated with each of the preserve's missions. A common theme in these discussions is increasing support for research, and encouraging class use of the preserve, while insuring that increased use does not lead to degradation.

At our first meeting the advisory committee discussed ways to increase research opportunities for undergraduates, both in the short term and over the long term; this led to increased participation of summer interns this year. JRBP's education program was the focus of our second meeting, and I have been following this up with meetings of staff, docents, and others. In addition, Peter Vitousek, Rachel Lotan, and I jointly submitted a proposal to the National Science Foundation for Jasper Ridge research. Rachel, a member of the faculty of the School of Education, is interested in developing new methods to increase the effectiveness of environmental education. I am also continuing efforts to increase the prominence of Jasper Ridge research in Stanford courses. One new element will be a series of field laboratories in the course I co-teach on biosphere-atmosphere interactions. These will focus on the eddy covariance station on Jasper Ridge, which is part of a network of 90 active stations contributing data for studies of global carbon balance.

The third meeting of the advisory committee focused on guidance for ongoing initiatives. One of these initiatives is a new effort to assess the "state of the preserve," a core goal of the strategic plan. In developing the strategic plan, we realized that all of our goals for effective research, conservation, and education depend on a clear and complete understanding of our assets, a snapshot of the preserve's natural and historical resources. In addition to providing an overview of the preserve's biotic richness, the state of the preserve assessment will highlight historical data as well as problems to solve. Nona Chiariello is coordinating the first phase of this assessment, which will be a report on the status and trends of resources in the preserve, based on available information. Eighteen individuals or groups are developing papers that review particular groups of species (e.g., plants, mammals, birds, butterflies), processes (primary production, nutrient cycling, herbivory), or specific long-term studies. Our goal is producing a report that will help guide the management of JRBP, stimulate new collaborations, and strengthen the conservation mission.

A second effort is to evaluate the condition of Jasper Ridge facilities, and to assess future facilities needs. Philippe Cohen is making a comprehensive assessment of what we have, what we need, and alternative ways of meeting those needs. Philippe's role as chair of the Jasper Ridge coordinating committee will help provide, among many other things, input from local entities sharing similar needs.

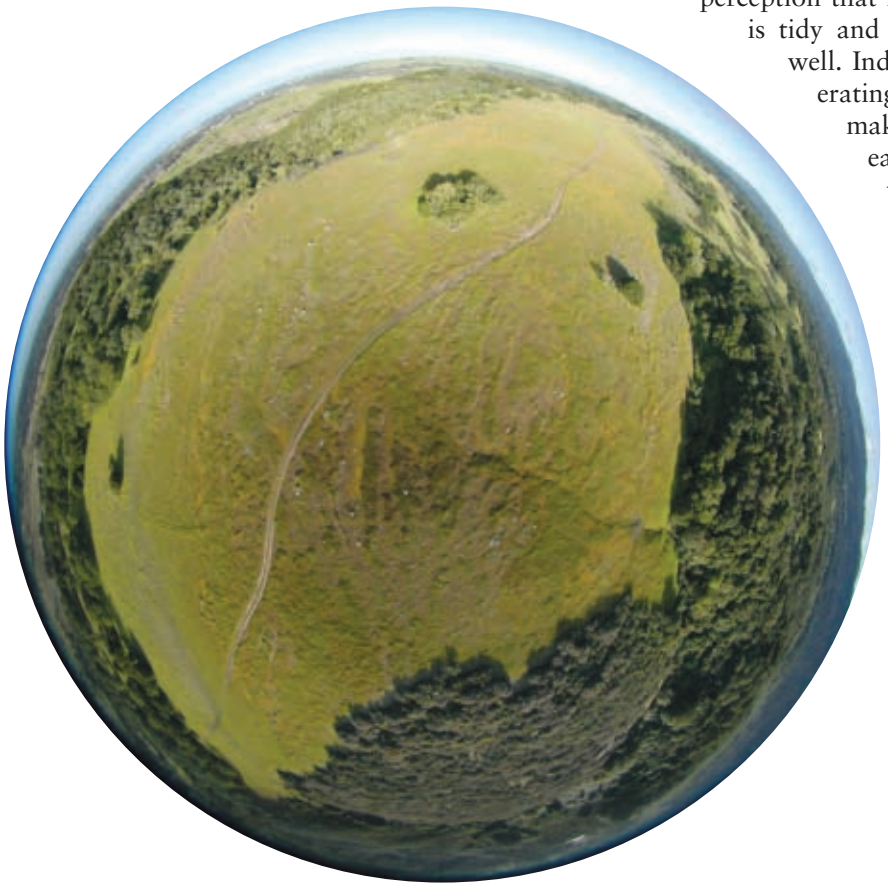
A third effort is to address a growing need for experimental studies focused on restoration. As habitat protection for sensitive species has increased at JRBP, our policy of minimally intrusive research has become even more restrictive, at the same time that conservation challenges such as invasive species are mounting. There is both a need, and a strong interest among students, for areas where more intrusive restoration experiments can address needs that are getting bigger at Jasper Ridge, and elsewhere.

All three of these efforts have benefited from the enthusiasm, creativity, and vision that the advisory committee brings to our discussions. It is tremendously rewarding to see busy people make the commitment to help the preserve realize the goals in the strategic plan.

Research at Jasper Ridge is strong and scientifically important; education is engaging and broadly inclusive. My goal remains to further strengthen these areas and their connection to the university's academic mission, and I have been gratified by the energy and willingness of the Jasper Ridge community to join me in this effort.

Management and Operations

Philippe S. Cohen



The boundaries of the preserve are strikingly visible in aerial photos. A fence line can dramatically demarcate where one type of land use begins and another ends. But while that demarcation is visible, impressing one with a wall-like solidity, it is also partly illusory. It promotes the perception that if everything inside the boundary is tidy and functioning properly, then all is well. Indeed, I sometimes find myself operating as if that is the case, because it makes managing the preserve seem easier and more clear-cut. Luckily, the shortcomings of this habit of perception are exposed when confronting actual land management challenges. Often, it isn't managing the activity on the land itself that determines future success in protecting valued resources. Rather, it is the decisions, events, and activities outside the managed land that shape the success of management objectives. This relationship is true at many scales: whether thinking about a single cell or an entire landscape, influences at the edges or just outside a boundary can have profound effects on conditions inside.

During my early years at Jasper Ridge, my efforts focused on familiarizing myself with the preserve and the people associated with it. What transpired within the confines of the preserve's boundaries and, to a lesser extent, within the university community, were front and center. As my familiarity with the challenges of managing the preserve grew, so did my appreciation for the importance of the 'away game' (as Brian O'Neill, Superintendent of the Golden Gate National Recreational, refers to it). Addressing issues such as invasive species, the future of Searsville Lake, or fire management increasingly requires JRBP to collaborate and communicate with neighbors, organizations, and local, regional, and state jurisdictions to assure the continued ecological health and well-being of the preserve.

For instance, the preserve's proximity to residential development means that fire management is a continuing and essential component of our land use policy. In addition to managing fuels at strategic locations along our border, the preserve dedicates three weeks from mid-June through early July to familiarizing fire crews with JRBP infrastructure

Left: Taken with a digital camera suspended from a kite, this photo provides a 360° view of the preserve from the west end of the serpentine grassland. One can discern several transitions: from chaparral to grassland, from serpentine grassland to grasslands dominated by non-native grasses, and from Jasper Ridge to adjacent land uses.

1. Sustainable Silicon Valley held their best-attended event to date at Jasper Ridge on June 21. The focus of the meeting was on integrated green building design.

2. Tina Sebay from the San Mateo County Mosquito Abatement District checking a CO_2 trap for adult mosquitoes. Several of these traps are distributed around Searsville Lake. Since 2004 Jasper Ridge has coordinated with the county to control mosquito larvae by spraying a targeted larvicide over Searsville Lake and associated wetlands. This effort is designed to reduce risk of exposure of adjacent residents to West Nile Virus.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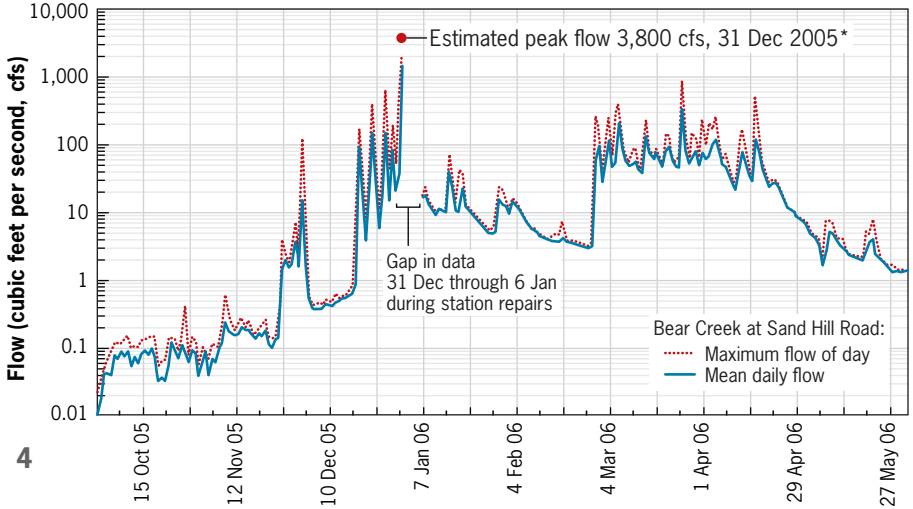
and sensitive resources, and upgrading emergency response to nonfire risks. This past year, 15 tours were provided to 19 fire crews from the Woodside Fire Protection District, California Department of Forestry, and the Palo Alto Fire Department.[1]

Recognizing the importance of being more engaged with the communities outside the preserve is one of the achievements of the strategic plan. The recommendation to create the Jasper Ridge coordinating committee (JRCC) was one result of the plan's foresight. This committee, composed of 19 members from the many outside entities with which I interact, has created a forum for exploring the challenges facing the preserve and determining how we might better collaborate with surrounding communities and agencies to meet those challenges. During 2005–06, the JRCC learned about past and current research at the preserve, and heard presentations on invasive species (by professor Deborah Gordon), Searsville Lake (by professor David Freyberg and Chris Christofferson, Stanford Associate Vice Provost for Facilities), and fire history and management (by Scott Stephens, fire ecologist at UC Berkeley). In the coming year, the committee will become even more engaged in discussing these issues and providing input to how Jasper Ridge approaches its many management challenges. (See appendix 6 for a list of JRCC members.)

The need to inform, to coordinate, and to collaborate with those outside the preserve is also evidenced by the numerous presentations I gave during the past year. Depending upon the particular group, these presentations ranged from general introductions about Jasper Ridge and its mission, to explorations of particular topics such as the ones mentioned previously. The diverse audiences included communities in Portola Valley, Woodside, and Menlo Park; Stanford parents; the USGS Open House; and Sustainable Silicon Valley.

While my focus is increasingly directed to JRBP's relationships with the outside world, much remains to attend to internally. Now that we have



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On December 31, 2005, the weather provided a demonstration of how forces outside the preserve can shape events inside. On that day, Bear Creek had the highest recorded water flow to date, which damaged an automated water-quality monitoring station. **Left:** Bear Creek water flow during the 2005–06 rainy season. (Note: the y-axis uses a logarithmic scale.) **Right:** Cary Tronson, operations steward, clears up the concrete pad that had been overturned in the flooding, in preparation for installation of a repaired monitoring station.

*Estimated by Balance Hydrologics, Inc., using high water marks.

3. The Stanford Board of Trustees chose JRBP as the venue to honor Ward and Priscilla Woods for their naming gift to Stanford's Woods Institute for the Environment on June 13. The event included tours of the Jasper Ridge global change experiment, Searsville dam, and the Sun field station.

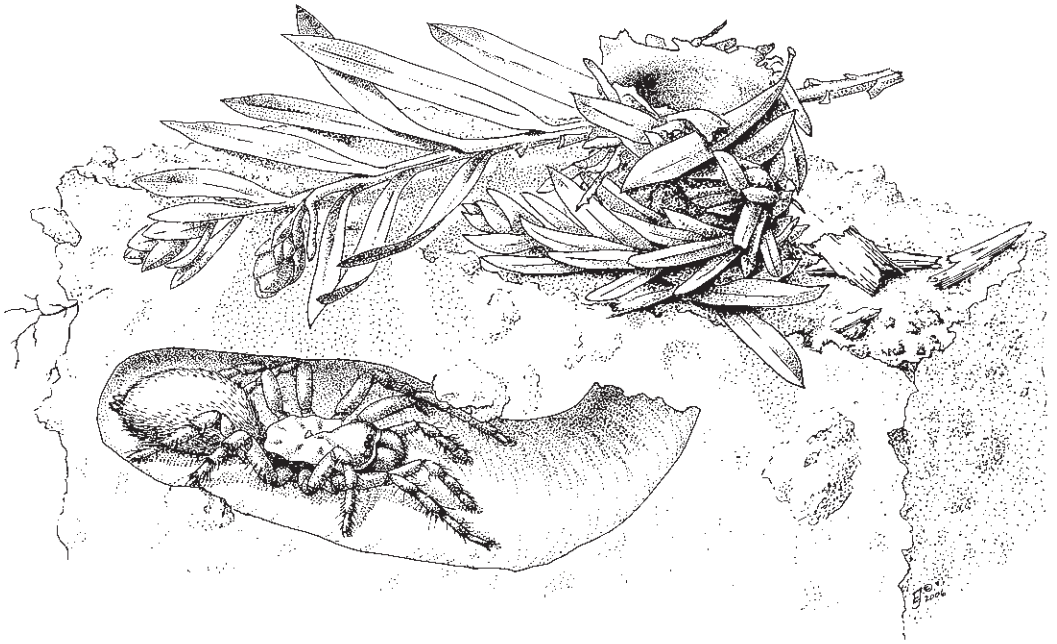
4. For Earth Day, Jasper Ridge participated in the Woodside Environment Fest: Earth and Art Day.

occupied the Leslie Shao-ming Sun Field Station for four years, I have begun to assess other infrastructure and facilities, including roads, trails, housing, communications, and equipment, and the ways these might indirectly support or hinder research, education, and land management activities. For instance, in the coming year I will be looking at the adequacy of the current roads and trails, and determining whether all of them should be regularly maintained. One reason for concern is that roads and trails are some of the primary means by which invasive species are introduced and spread throughout JRBP. Another issue to be addressed is whether the preserve should provide accommodations for visiting researchers. These questions invite important considerations about the ecological footprint of activities at JRBP and the amount of support the preserve can sustainably provide.

The interplay between inside and outside is easily overlooked in day-to-day management responsibilities—but it is a balance that must be carefully attended to lest we neglect these interactions and undermine the effectiveness of our own management objectives. One of my favorite poets, A. R. Ammons, touched on this theme eloquently:

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

(from *Tape for the Turn of the Year*, 1965)



Turret spider (*Atypoides riversi*)

David Riaño and Yen-Ben Cheng marking and mapping one of their 40 plots, in preparation for collecting vegetation samples on the day of a remote sensing flyover.

Research and Monitoring

Nona Chiariello

The past year was one in which every week seemed to include a new study, a novel collaboration, or an exciting spin-off. This perception of heightened activity reflects a measurable increase in research, both in scope and participation. Based on study plots and monitoring protocols, the spatial coverage of research rose by ten percent to more than one-eighth the area of the preserve, and several studies have nearly preserve-wide sampling designs that address JRBP in its entirety. Undergraduates participated in research in larger numbers, including a critical mass of summer interns within the global change experiment. There were also increases in volunteer efforts and in interactions between our docent and academic members. This fostered new research capabilities, particularly for the mammal-monitoring project.

These developments are real progress toward several goals identified in JRBP's strategic plan, which called for expanded research opportunities for undergraduates and greater integration of the docent and research programs. A third strategic goal, a stronger conservation mission, received support this year from two new biodiversity studies. The conservation focus is further strengthened by the increased spatial coverage and overlap of studies, which will permit us to analyze habitat changes from a multispecies perspective.

There were also some notable strides this year by several projects and individuals. Chris Field, Hal Mooney, and Peter Vitousek were awarded a new three-year grant from the US Department of Energy to continue their global change experiment; Rodolfo Dirzo's mammal-monitoring study became fully operational; and Tom Mudd expanded his bat monitoring from one station to five. Two PhD students, Hillary Young and Jessica Shors, received grants from the joint AW Mellon Foundation/Stanford University program for student research. A previous recipient of this grant, Jeannie Stamberger, completed a PhD, and three new master's degrees included research at Jasper Ridge. The profiles section (pages 18–19) has details on research associated with the year's graduate degrees.

In all, 54 scientists, 32 students, and 13 volunteers conducted more than 70 studies this year (appendix 1), and many additional people contributed to these studies as research staff or regularly participating volunteers. The 2005–06 period also produced 27 publications (appendix 2).

The following discussion provides a glimpse of the breadth and depth of the year's endeavors and discoveries. Additional information is available on the Jasper Ridge website.[2]

Biodiversity studies

Research on biodiversity expanded this year, thanks to the efforts of many volunteers and Stanford researchers, often working together. The bird monitoring program added two members, bringing the number of regular observers to 24. Our dedicated herbarium group completed their ten-year effort to identify all the specimens in the plant collection; they also took on new projects in the field, including plant community surveys for several experiments. These groups also interacted in important ways with the multidisciplinary program led by computer scientist Andreas Paepcke, called BioACT (biodiversity data acquisition, curation, and transfer).

One of this year's BioACT studies used data from the bird monitoring program to test a new species identification tool, called EcoPod, developed by Andreas and colleagues. Its purpose is to help novices and experts alike contribute to large databases with accuracy and high temporal and spatial resolution. EcoPod uses software to turn a table of diagnostic bird traits into a dynamic species key that runs on a palm-sized computer, which can easily be used in the field. When tested against the JRBP bird list, the device correctly keyed out all 110 species. Andreas's group also found that by factoring historical JRBP bird data into the algorithms, they could streamline the key, without hindering its ability to identify birds that have rarely or never been recorded at Jasper Ridge.

Ron Yeh, a PhD student in computer science, has worked on another class of tools for biologists called Interactive Gigapixel Prints, or GIGAprints.[3] One example is an "augmented paper map," a printed airphoto embedded with a barely visible pattern that transfers location information to a digital pen each time the pen touches the map. In August, ant researchers Jessica Shors and Katherine Fitzgerald provided their expertise in helping to design an early prototype. With the augmented map and digital pen, researchers will be able to simultaneously capture field notes on paper and in electronic form, with the observations linked to the coordinates of the location selected on the map. Jessica and Katherine hope to use the technology next year as a complement to their existing GPS-based data collection system.

In March, another component of BioACT became fully operational, professor Rodolfo Dirzo's camera-trap project for monitoring large and medium-sized mammals. Twelve camera traps are distributed according to a hexagonal grid that covers the entire preserve. Each trap consists of a pair of film cameras facing one another on posts 10 meters

1. Hillary Young weighing a live-captured wood rat; each new capture also receives a numbered ear tag before being released.

2. Jérôme Pellet readying his net during one of his butterfly surveys; whenever possible, he identified butterflies without catching them.

3. Tim Bonebrake examining one of his serpentine competition plots.

4. The global change experiment's summer interns. Front row, left to right: Rebecca Sorenson, Brandon Cortez, Michael Alyono, and Astasia Myers. Behind them, three of their mentors: Chris Field, Ben Houlton, and Todd Tobeck.

apart, with paired infrared beams and detectors that trigger both cameras. Many people have made a major commitment to this study, particularly docent Bill Gomez, Luis Abdala, and postdoctoral fellows Eduardo Mendoza and Yolanda Cachú, aided by a group of volunteers organized by Cindy Wilber.

The camera-trap study's first five months yielded almost 2000 photos of eight species of mammals. Capture frequency differed strikingly across species: opossums (2 photos), squirrels (37), coyotes (42), raccoons (47), skunks (77), rabbits (282), bobcats (286), and deer (1124). Some species are consistently trapped in particular sites (e.g., bobcats in chaparral), while others are widely distributed (e.g., deer). Since each animal is photographed from two sides, it may be possible to identify individuals of some species, especially bobcats, which would aid studies of behavior and population size. Ron Yeh is working on techniques for recognizing individuals.

Additional monitoring at the camera stations will expand the value of the photographic data. Each station has been characterized with a photographic analysis of the plant canopy and a detailed 100-m^2 survey of the plant community. The stations also include temperature and humidity sensors.

The breadth of data from the camera-trap study makes it a strong framework on which other studies can build. This year, Hillary Young and Rachel Adams, both PhD students, began a new pilot study of small mammals, and nested it within the hexagonal camera grid. In eight of the hexagons, they identified one or more hectare-sized patches of uniform habitat suitable for placing an array of live traps. Most arrays were radial, with traps placed along twelve 50-meter spokes, but other layouts were necessary in dense chaparral and steep woodland. During spring, they trapped for one week at each site. Hillary focused primarily on species diversity and density, while Rachel examined genetic diversity. With this pilot study as groundwork, each is developing a more focused dissertation project. Among their findings this year is the first record of *Chaetodipus californicus* (a pocket mouse) at JRBP.

A final addition to the year's developments in biodiversity was a new survey of butterflies conducted by postdoctoral fellow Jérôme Pellet. Each week during the six-month flight season, Jérôme surveyed butterflies along transects in grassland, chaparral, and woodland. In total, he observed 1242 individuals of 37 species of butterflies. Jérôme's results and detailed protocol lay the foundation for continuing the survey in future years.

Checkerspot butterflies

Researchers from five departments at Stanford made progress this year in their effort to understand and improve the recovery prospects for JRBP's most famous butterfly, the Bay checkerspot (*Euphydryas editha bayensis*). The Bay checkerspot was last seen on Jasper Ridge in 1998 and is federally listed as threatened. Professors Carol Boggs, Paul Ehrlich, Scott Fendorf, Chris Field, Buzz Thompson, and Richard White, PhD students Jon Christensen and Tim Bonebrake, and master's student Cristina Salvador are combining studies on the butterfly's ecological needs, the environmental history of the area, and legal issues relating to listed species.

This year the group's efforts were all linked to a single question: are Bay checkerspot butterflies, and the food plants their larvae depend on, restricted to grasslands on serpentine soil? The researchers are examining this question in terms of the past, present, and future.

Jon Christensen is analyzing the historical distribution of the butterfly using two lines of investigation. One is a broad examination of diverse sources of evidence, and the other focuses intensively on evidence regarding extinction or persistence of the butterfly in particular places. As part of his research, Jon has digitized numerous collection records, and

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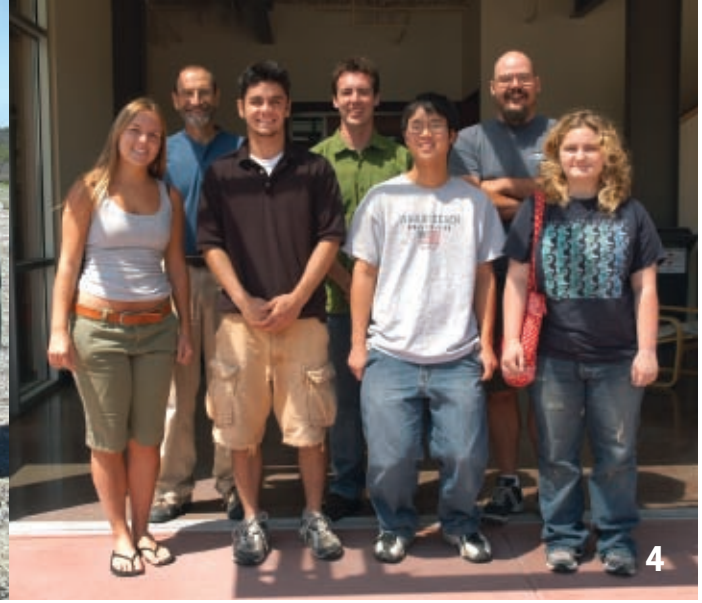

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has combined them with other digital databases, producing a geographic information system (GIS) that combines soil types, plant communities, and Bay checkerspot locations. His results have led him to an unexpected hypothesis: the Bay checkerspot's larval food plants, and the butterflies themselves, may have persisted on nonserpentine soils at various times in the past 150 years. In the coming year he will use the GIS to further refine and test this hypothesis.

If nonserpentine soils once provided habitat for Bay checkerspots and their food plants, what would it take to restore this habitat? Tim Bonebrake is examining one possibility. On nonserpentine land adjacent to JRBP, Tim is testing whether adding different soil amendments will tip the balance of competition among plants in favor of native serpentine plants and against non-natives. This year he distributed seed from both types of plants within control plots and plots where he had added serpentine rock or magnesium sulphate (which shifts the calcium: magnesium ratio toward values typical of serpentine soil). His results are slightly encouraging in that dwarf plantain (*Plantago erecta*), the primary food plant of Bay checkerspot larvae, fared better in plots that received the most magnesium. Non-native weeds, however, continued to fare best of all.

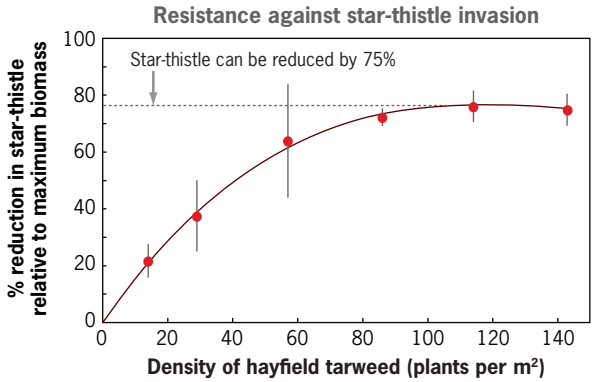
The converse question—what does it take to keep non-native plants from taking over serpentine soils?—is even more pressing, because the remaining Bay checkerspot habitat on serpentine soils is being lost to very invasive species. To assess the degree of encroachment in the last two decades, Cristina Salvador repeated a survey from the 1980s which recorded species composition along a 100-meter swath from serpentine to nonserpentine grassland. She is analyzing whether the transition in species composition has shifted or blurred.

Competition and coexistence

Questions about species coexistence and replacement are central to understanding problems ranging from biological invasions to ecosystem processes. For JRBP's woody communities, which are dominated by native species, PhD student Will Cornwell has analyzed coexistence in terms of two constraints. One constraint is a "filter" that excludes species unable to tolerate a given environment; the second is competitive exclusion of any species that is too similar to another. These constraints oppose each other, with one leading to greater similarity of coexisting species and the other to limited similarity. Will has detected both types of constraint among the 54 woody species at JRBP. For example, leaf thinness (technically, leaf area per unit mass, one of 13 traits Will studied) varies less within a community than across all communities, but within a community, leaf thinness differs among species more than would be expected by chance.

The principle of limiting similarity suggests that an invasive species might be less successful in communities where it confronts a very similar native species. For one very invasive species of grasslands, yellow star-thistle (*Centaurea solstitialis*), PhD student Kris Hulvey has used competition experiments in pots to test this mechanism of invasion resistance. Yellow star-thistle has a deep taproot and a long growing season, traits that are shared by only a few native species, such as hayfield tarweeds (*Hemizonia congesta*). Kris has found that star-thistle can establish within tarweed stands of any density, yet even a low abundance of tarweeds contributes some invasion resistance. These results suggest that adding *Hemizonia* to invaded grasslands may provide some restoration benefit, but even at high seeding densities, it is unlikely to exclude yellow star-thistle.

A third study of species interactions is under way by Rodolfo Dirzo, Yolanda Cachú, and Eduardo



Above: Kris Hulvey's results showing increasing—but never complete—invasion resistance against yellow star-thistle as a function of increasing tarweed planting density. Invasion resistance is defined here as the percent reduction in star-thistle biomass relative to its maximum. (Kris Hulvey, unpubl.)

Mendoza. They and docent Ann Lambrecht have collected seed from four pairs of species, each pair consisting of a native and a non-native species within the same genus. Their experiment in a campus greenhouse will use a design that has been a cornerstone of ecology for many decades—a "replacement series" in which paired species are grown together in varying proportions but with overall density held constant. In addition, their study will examine the effect of herbivory on the competitive interactions between the paired species. Either the native banana slug (*Ariolimax columbianus*), a non-native slug (*Deroceras reticulatus*, from Europe), or no slug will be added to each pot.

Watershed studies

Searsville Lake and dam are a growing focus of studies concerned with the future of the San Francisquito watershed. PhD student Christopher Heppner is analyzing the role of the dam in the hydrologic functioning of the watershed, particularly the upstream area near the lake. This year he collected data from nine sensor arrays he installed in and near JRBP for tracking soil-water content, permeability, and sediment concentration, and is using those data in a comprehensive model of the upstream watershed. Chris's model is working well, simulating key features of the watershed, including seasonal changes in groundwater and sediment trapping by the dam. Chris's goal is to characterize the hydrologic behavior of the watershed during the predam, early dam, and current conditions, and then extend the model to predict what would happen if the dam were removed.

The heavy loads of sediment and organic material entering Searsville Lake have long been its trademarks. They constrained use of the lake water historically, even for irrigation, and have implications for its future usage. For two years, chemist Ted Mill has been studying the processes and constituents that control the lake's clarity. He has found that the clarity of lake water is determined primarily by the amounts of suspended mineral and organic particles, which reach very high concentrations (>30mg/L) following heavy rain and runoff. These particles affect water clarity both directly, by absorbing and scattering light entering the water, and indirectly, by reducing the amount of light available for breaking down dissolved organic compounds.

The quantity, quality, and timing of flow over the dam can have significant effects on species of concern in San Francisquito Creek. This year's unusually long rainy season produced high flows in late spring which dispersed largemouth bass (*Micropterus salmoides*, a non-native predator) and disrupted steelhead trout (*Oncorhynchus mykiss*, a threatened native species). Campus biologist Alan Launer discovered that young-of-the-year largemouth bass, which typically remain in the lake and a pool below the dam, spread ten kilometers downstream to the Stanford Shopping Center—a first in Alan's ten years of surveys. For steelhead trout, the late-season storms apparently disrupted redds (nests) or washed away fry. Alan expects these effects will reverse in coming years, without lasting impact to the steelhead population.

Although San Francisquito Creek within Jasper Ridge is more protected than most portions of local creeks, two sensitive species have been declining for some time. In this year's survey, red-legged frogs (*Rana aurora draytonii*, a threatened species) and western pond turtles (*Clemmys marmorata*, a possible future candidate for listing) were down in number, with only a single individual of each species observed.

The waterways also provide important habitat for bats, especially Yuma Myotis (*Myotis yumanensis*), the species most frequently detected by the acoustical monitoring station next to Searsville Lake. This year Tom Mudd analyzed five years of echolocation data (over eight million calls) in relation to environmental parameters, and found that correlations between bat activity and air temperature switched for temperatures above and below 14°C. The resulting seasonal pattern is that in fall and winter, bat activity increases with air temperature, presumably because bats arouse from torpor on warmer nights. In summer, however, bat calls decline as nighttime temperature increases, suggesting that bats satisfy their prey requirements more quickly on warm nights. Tom recently added a new monitoring station upstream of the lake, one on the dam, and two along San Francisquito Creek.

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Global Change

The Jasper Ridge global change experiment (JRGCE) conducted a major new study this year alongside the ongoing field experiment, which completed its ninth year. Both studies examine grassland responses to four globally important environmental changes: warming, and elevated levels of CO_2, nitrogen, and precipitation. Chris Field directs the project with co-investigators Brendan Bohannan, Hal Mooney, Peter Vitousek, and Jim Tiedje.

One goal of the experiment has been to understand whether, and how, elevated CO_2 or increased nitrogen deposition will stimulate uptake and storage of carbon by ecosystems. A major focus of the year's work was testing the hypothesis that the environmental changes applied in the field experiment have tipped the ecosystem towards limitation by phosphorus, which might then constrain carbon uptake and storage under elevated CO_2. If this were the case, global environmental changes might be exacerbating what is already a constraint in many ecosystems.

Based on results from the year's new experiment, the picture is not so simple. Plant communities were grown in deep pots (mesocosms) receiving factorial combinations of CO_2, nitrogen, and phosphorus in order to test whether responses to elevated CO_2 and nitrogen differed depending on whether phosphorus was also added. Surprisingly, elevated CO_2 had no effect on growth by the plant community, with or without supplemental nitrogen and/or phosphorus.

This unexpected result deepens the mystery of the lack of CO_2 sensitivity, yet there are clues that nutrient interactions are at its root. Postdoctoral fellow Ben Houlton discovered that under elevated CO_2 there is a reduced amount of phosphatase, an enzyme that plant roots excrete into the soil that makes phosphorus available for uptake. This decline in phosphatase reinforces the idea that elevated CO_2 worsens phosphorus deficiency, or it may indicate that plants switch to alternative strategies for acquiring nutrients when CO_2 is in excess. Ben did see an increase in phosphatase under one condition, however—when legumes were present. Because legumes fix nitrogen symbiotically, while nonlegumes acquire it from the soil, this finding suggests that interacting nutritional strategies regarding nitrogen and phosphorus may mediate ecosystem responses to global change through changes in species composition and nitrogen fixation. To further probe this lead, postdoctoral fellows Noel Gurwick and Halton Peters, and PhD student Claire Lunch made a comprehensive survey of the predominant legume in the JRGCE, common vetch (*Vicia sativa*).

Changes in the composition of the soil microbial community may have equal significance. Postdoctoral fellow Stephan Gantner has found effects of global change factors on the bacterial communities that live in very close association with plant roots. Stephan's results include changes in the abundance and composition of these rhizosphere bacteria, as well as in their functional capability for adaptation, especially under elevated CO_2 and nitrogen.

There were also accomplishments this year in developing the technology to refine the ecosystem carbon budget through new measurements of inputs, outputs, and storage. Claire Lunch completed the first measurements of carbon uptake by the ecosystem through an entire growing season. Noel Gurwick measured the amount of organic carbon in water leaching through the mesocosms. This pathway for carbon loss is impractical to measure in the field because it requires precise tracking of water flow belowground. Noel and senior scientist Ted Raab also explored new techniques for better characterizing carbon storage in soil organic matter, the component of soil derived from living things.


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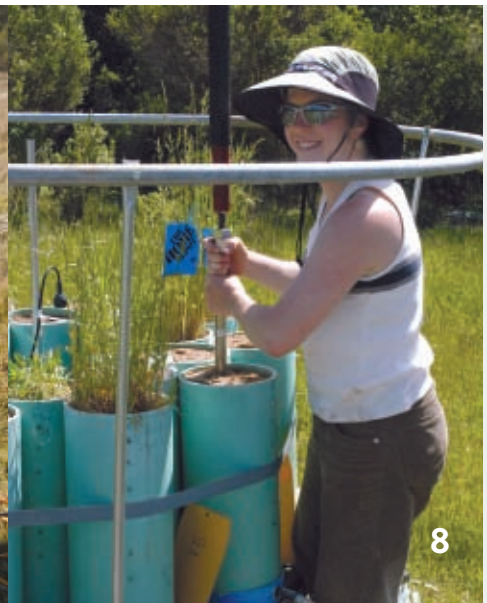
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5. Postdoctoral fellow Jacky Ng sampling water from Searsville Lake in order to isolate bacteria that form a symbiosis with nitrogen-fixing cyanobacteria.

6. Chris Heppner adding water to a tensiometer to replace water that has infiltrated the soil. The device is used to measure soil water potential (the pressure necessary to extract water from the soil).

7. Claire Lunch with her equipment for monitoring photosynthesis and respiration in the field plots of the global change experiment.

8. Alison Appling, a technician on the global change experiment, coring one of the mesocosms to get a soil sample.

9. Roland Pieruschka and the LIFT instrument, which monitors oak, lichens, and grasses from an east window of the Sun field station.


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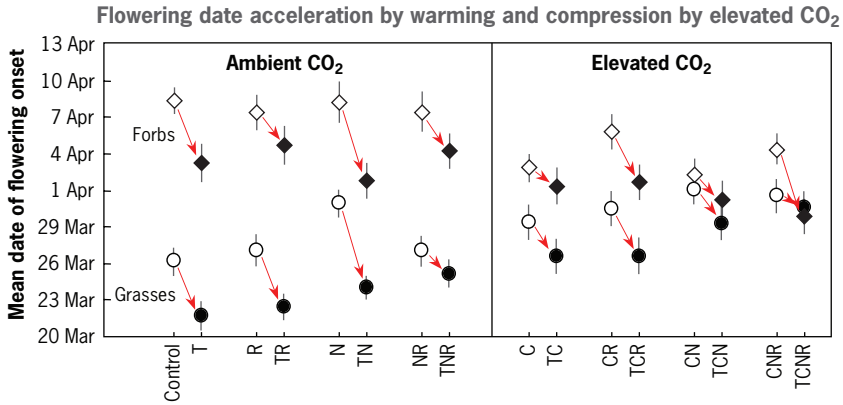

Left: Downward arrows show that warmed treatments (filled symbols) flower earlier than matched, unwarmed treatments (unfilled symbols). Convergence in flowering date of grasses (circles) and wildflowers (diamonds) is seen under elevated CO_2 (right panel) as compared with ambient CO_2 (left panel). The JRGCE's 16 treatments represent all possible combinations of added rain (R), nitrogen (N), warming (T), and CO_2 (C). (Redrawn from Cleland et al., 2006[4])

In an important publication this year, Elsa Cleland (a former PhD student) and others reported that treatment effects on flowering date and other developmental events may also play a role in carbon balance. The investigators found that warming accelerated flowering by both grasses and wildflowers (forbs), regardless of what other treatments were applied. This is consistent with reports that global warming has accelerated various biological activities. Elevated CO_2 compounded the response of forbs but, surprisingly, reversed it in grasses. This led to a compression in the flowering period which may be a factor in CO_2 effects on plant production.

In spring, Chris Field, Peter Vitousek, and Hal Mooney received a new three-year grant for an experiment that is expected to conclude the JRGCE. The study will further examine plant community changes as mediators of ecosystem response, focusing on legumes, woody plants, and invasives. In the coming year, preliminary studies will test methods for introducing these species into experimental plots in a controlled, reversible manner. Only species already abundant at JRBP will be used.

Scaling up

Two new studies examined aspects of carbon balance at large spatial scales. Professor Joe Berry and postdoctoral fellow Roland Pieruschka tested a new device for remote monitoring of photosynthetic efficiency of vegetation during stress cycles and seasonal changes. They used the Sun field station as a base for the laser-induced chlorophyll fluorescence transient (LIFT) device. The instrument was programmed to emit eye-safe laser pulses and continuously measure the induced chlorophyll fluorescence from targeted leaves up to 50 meters away. The device rotated automatically among various species and was able to detect both daily and seasonal patterns in photosynthetic processes.

This year JRBP was also a calibration site for remote sensing studies aimed at global monitoring of the water content of vegetation. The studies were conducted by professor Susan Ustin, postdoctoral fellows David Riaño and Yen-Ben Cheng, and PhD student Marco Trombetti. Coinciding with remote sensing flyovers in spring and summer, the research team mapped and measured the water content of vegetation at 40 sites within JRBP, and will correlate their measures with the remotely sensed data for the corresponding pixels. The correlations will help calibrate images from a satellite-based instrument, MODIS, for use in global models of canopy water content. These models have applications in assessing primary production, drought, risk of wildfire, and other important processes within the global carbon budget.

Viewed as a whole, research at Jasper Ridge not only expanded this year but also carried a sense of momentum in pursuing the goals of the JRBP strategic plan. Undergraduate research increased significantly, especially summer internships, which provided relatively open-ended pathways for participating in experiments. New studies of biodiversity, and explicit attention to nesting and cross-linking studies, are helping to strengthen our conservation efforts. Greater integration of the docent and research programs, and the contributions of many volunteers, were indispensable to several studies and enhanced others. These developments fostered one another, and provided new opportunities for thinking about, conducting, and communicating our research. They also created new relationships—mentoring relationships, collaborations, and friendships—each of which brought an important and refreshing alchemy of new talents and perspectives to the year's studies.

GIS and GPS Trevor Hébert

One of the most exciting new developments for researchers and geographic information systems (GIS) professionals is "mobile GIS" technology: handheld devices that integrate GIS, databases and other software, and global positioning system (GPS) receivers on a single personal digital assistant (PDA) platform. With mobile GIS, many of the powerful map display and data integration capabilities of desktop computers are available in the field.

In January, the preserve purchased a new Trimble GeoXT handheld, a submeter-accurate GPS receiver integrated with a waterproof, rugged Windows Mobile handheld computer. It has quickly become indispensable for supporting mapping activities at JRBP.

Mobile GIS Case Study: Argentine Ant Project

One project that has put the GeoXT to good use is the long-term study of invasion by the Argentine ant, *Linepithema humile*, and its effect on native ant populations. PhD students in Stanford professor Deborah Gordon's lab, most recently Jessica Shors and Katherine Fitzgerald, have monitored the invasion every May and September since 1993.

Up until this summer, the work was done using a large printed, laminated map of survey points over an aerial photograph of the preserve upon which observations for each point were written with alcohol-soluble markers. While the laminated map approach was adequate in the past, there were significant drawbacks. "In order to analyze and map our data, we matched the species data for each point to the point's geographic coordinates," said Jessica and Katherine. "It was a complicated and time-intensive process to transfer the data from the laminated map to GIS.... The tediousness and the excessive complexity of this data transfer made [the process] unnecessarily prone to human error." Also, locating the correct point in the field could be difficult. "Using only the aerial photograph for navigation, we often could not find the stake marking our survey points. Some of the survey points are located in mixed tree/grasslands with no visible landmarks."

Below: *Katherine Fitzgerald and Jessica Shors navigating to an ant survey point using the GeoXT.*

Above: *The GeoXT in use; at left, a view of the screen showing the aerial photo overlaid with trails and data points, plus the window for data entry.*

The GeoXT provided an effective solution to both the data-entry and navigation issues. Its ArcPad software allows the display of the mapped ant survey points over the 2005 color aerial photo of the preserve, along with trails and topo lines. The GeoXT's integrated GPS displays the user's current location and direction of travel on the map, helping the user to navigate to the survey points. Since the map is fully interactive, the user can zoom in or out to see more or less detail on the aerial photo.

To facilitate data collection for the ant survey on the GeoXT, I wrote a custom ArcPad software application using ArcPad Studio and Visual Basic. After navigating to an ant survey point in the field, the user clicks on the point with the device's stylus pen, and the application opens a custom data entry form. The form has a pull-down menu displaying all the possible combinations of ant species for the user to select from so that observations do not have to be typed in by hand, thus reducing the possibility of human error and greatly speeding up the data entry process. There is also a comment field where observations can be entered by soft keypad. The form automatically fills in the date and time.

The immediate results produced for the Argentine ant study by a relatively simple implementation of mobile GIS technology on JRBP's Trimble GeoXT suggests that this technology can benefit most researchers who collect data in the field. The preserve hopes to purchase an additional GeoXT in the near future to provide similar support for more projects. I have been experimenting with ArcPad with a relatively inexpensive PDA and a recreational-grade Garmin GPS to see to what extent we can lower the cost of deploying this technology to as many researchers as possible.

Looking Ahead

I am currently testing new software, GPS-Photo Link, which allows photographers to automatically map the locations of photos they take in the field. Associating a site or specimen photo with map coordinates will greatly enhance the usefulness of archived digital imagery to researchers and students and has great potential to expand docent involvement in research activities at the preserve.

Education

Cynthia J. Wilber

During academic year 2005–06, the JRBP education program of classes, fieldwork, lectures, teacher workshops, and community outreach provided multifaceted learning to a diverse audience. Stanford University classes included Jasper Ridge Docent Training, Core Experimental Laboratory for Ecology, Science of Soils, Introduction to Earth Systems, Sophomore College, Freshman Seminar on Climate Change, Introduction to Prehistoric Archaeology, Water Resources and Water Hazards, General Botany, and many others.

Jasper Ridge affiliates participated in numerous educational opportunities as well. One of the highlights of the year was the October field trip to the White Mountain Research Station (WMRS) during which affiliates visited the Owens Valley Lab (elevation 4,000 feet), as well as the WMRS montane station at Crooked Creek (elevation 10,200 feet), and the alpine station at Barcroft (elevation 12,500 feet). While in the field with John Weyhausen, a bighorn sheep researcher, the group was fortunate to sight several of these magnificent animals on the steep, rocky slopes. During fall quarter, JR hosted a class on the life of the young Charles Darwin taught by Léo Laporte as well as the 2005–06 monthly brown bag lunch lecture series that covered a broad range of topics presented by speakers from the Stanford faculty, other universities, and JRBP researchers. Additionally, numerous K–12 science outreach programs brought together docents, researchers, and students from local schools including Eastside College Prep, Woodside High School, Castilleja School, and Woodside Priory School. For a complete list of instructional use of the preserve, see appendix 3.

BioSci 96, the Jasper Ridge docent training class, provides core curriculum as well as initial access to the preserve, after which affiliates find their niche within the community. Tours and field teaching for classes and the public remain a vital part of the preserve's education program, but each year our affiliates are finding innovative ways to contribute while at the same time discovering their own areas of interest. In the past year they have dedicated their efforts to the preserve in new and invaluable ways, participating in unique research projects and building much-needed teaching collections.

Camera-Trapping Project

The camera-trapping project is an outstanding example of how effectively our affiliates have collaborated in research efforts. Led by professor Rodolfo Dirzo, the project includes 24 cameras located at 12 sites within the preserve, monitoring mammal activity. Each site is visited weekly to download data, change cameras, and service the units. Vegetation analysis of each site is completed quarterly and temperature and relative humidity data are also collected. Affiliates Bill Gomez, Gary and Liz Nielsen, Susan Gold, Ardis Walling, Léo Laporte, and Don Mason have worked together with JRBP staff and members of Rodolfo's lab Luis Abdala, Eduardo Mendoza, and Yolanda Cachú to maintain this labor-intensive project. In addition,

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1. Bighorn sheep researcher John Weyhausen pointing out several animals visible on the ridgeline to Jasper Ridge visitors as he discusses his work at the White Mountain Research Station.

2. Chris Field discussing the global change experiment in the field during his winter quarter freshman seminar, Climate Change: Drivers, Impacts and Solutions.

3

4

5

the herbarium crew provided their botanical expertise for the often-grueling vegetation studies at each site, and Gary Nielsen is leading an effort aimed at replacing the film cameras with digital.

The challenges of having a large and diverse group of individuals acting as a single researcher have been daunting, but the success of this collaboration indicates that large scale monitoring projects can indeed be implemented and maintained by committed volunteers.

Oakmead Herbarium

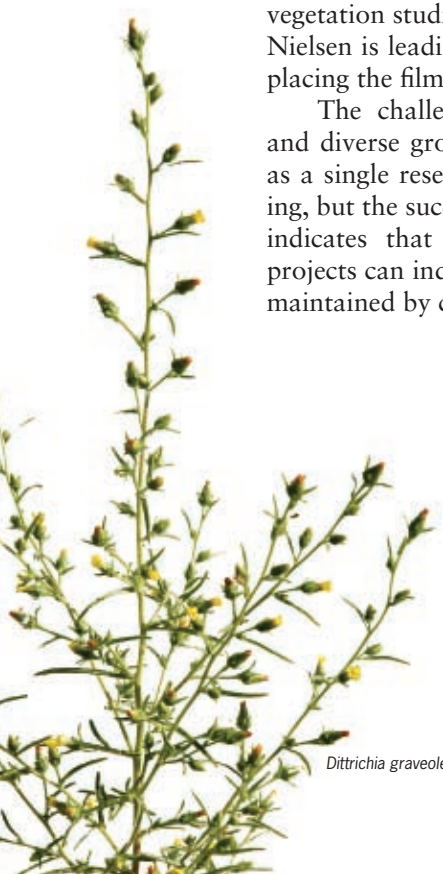
In the past year affiliates working in the Oakmead Herbarium have added greatly to this invaluable teaching resource. Since the publication of the last JRBP Vascular Plant List in 2002, almost 40 additional plant species have been added. This has contributed to our knowledge about species that are present, were historically present, and are new to the preserve. Many invasive plants new to the preserve have been found, and one example, stinkwort (*Dittrichia graveolens*), is thought to have entered the preserve in just the last two to three years.

The herbarium crew, Toni Corelli, Ann Lambrecht, Ruth Porter, John Rawlings, Carol Zabel, and newcomer Liz Schwerer Duffie worked side by side this year with multiple researchers on vegetation transects and plant identification. This collaboration, valuable in its own right, has also yielded significant botanical information and new plant species for the herbarium collection.

New Teaching Collections

This year Jasper Ridge has had two significant additions to its teaching collections. In 2005, entomologist Paul Arnaud of the California Academy of Sciences donated a collection cabinet to the preserve, an important beginning to building a much-needed insect teaching collection.

Insects are extraordinarily abundant and diverse. In California alone, close to 30,000 species



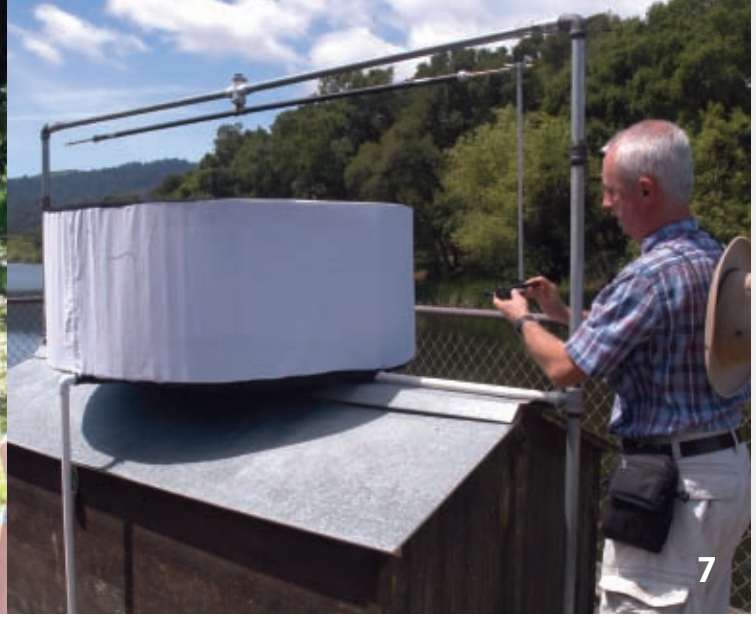
Dittrichia graveolens

Hydrophilidae

Sphingidae

Libellulidae

Bombyliidae



3. Eastside School field studies students identifying benthic invertebrates gathered in leaf traps placed in the creek, with the guidance of teacher Ben Graves, a Stanford student and docent.

4. The annual Conservation Strategy Fund (CSF) training course brings participants from many countries and organizations to Jasper Ridge; here they are discussing bark and tree defenses at the grown-over "no swimming" sign on the trail above the dam.

5. Bobcat and deer, as captured by the camera-trapping project.

6. BioSci 96 students Seth Silverman and Matt Velasco learning to use a pressure chamber to measure water potential in various chaparral plant species.

7. Pierre Martineau setting up his minimal-impact light trap for a night insect-collecting session. Insects are attracted to the bright light, land on the sheet, and are periodically recorded by a rotating video camera; they may then be collected or allowed to fly away.

have been named, spanning a vast range of morphological and behavioral adaptations. They are found in every ecological niche, and are relevant to the natural history of virtually every life form present on the preserve, either as predator, prey, herbivore, or parasite. Insects constitute an abundant and readily accessible learning resource. However, the sheer number of their species, the diversity and complexity of their morphology and life forms, and their small size make insect identification more difficult than that of groups such as birds, mammals, or vascular plants.

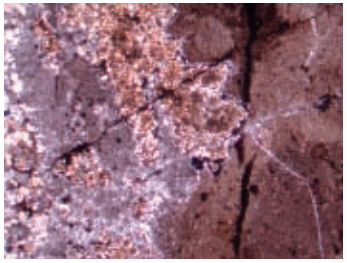
To make insect identification easier, Pierre Martineau, a 2006 graduate of BioSci 96, has assembled a core insect collection documenting more than 110 of the most common insect families present at the preserve. Although this represents only a small fraction of the preserve's entomofauna, this is an ongoing project that will be expanded and developed with the aim of documenting as many families of insects as possible. The collection combines drawer specimens with digital pictures, videos, line drawings, and text documenting key identification characteristics.

This year also brought the addition of a geology teaching collection thanks to the efforts of Léo Laporte and Jamie Cundiff, another 2006 BioSci 96 graduate, whose class project yielded a set of thin sections for the classroom. The thin sections show in polarized light at 16x to 50x magnification the constituent minerals and texture of each of the major Jasper Ridge rock types, making their distinctive differences much clearer than when the rocks are seen in their heavily weathered state in the field. The collection also contains many specimens of the major rock types of the preserve, as well as related soil samples derived from each of the rock types. Geologic and hydrologic maps relevant to JRBP are available, as well as science and news articles of geologic interest.

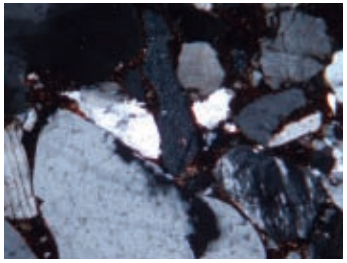
Below: Left, *Dittrichia graveolens*, an invasive plant. Middle, a selection of Jasper Ridge insects from the new teaching collection, with family name indicated. Right, photomicrographs of geology thin sections as viewed under crossed polarized light.

Acrididae

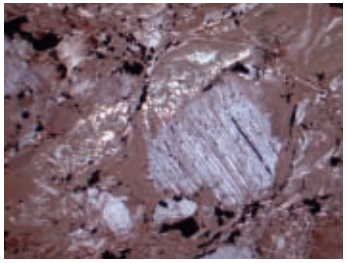
Corydalidae



Red chert (jasper)

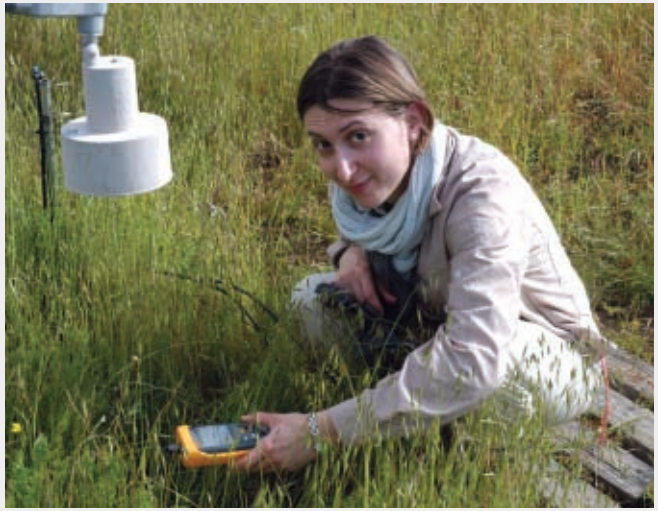


Graywacke



Serpentinite

Profiles academic milestones and accomplishments



Audrey Niboyet

Since the Jasper Ridge global change experiment (JRGCE) began in 1997, it has welcomed researchers from many universities to conduct studies that complement those of the core research program. Audrey Niboyet is one of five students who have visited the preserve to carry out graduate research within the JRGCE. This year she completed her master's degree from the Université Paris-Sud. For her thesis she examined two components of the nitrogen cycle: nitrification, which is the conversion of ammonium to nitrate in the soil, and denitrification, the conversion of nitrate to gaseous forms of nitrogen. These processes reveal important aspects of ecosystem function because nitrate is one of the main forms of nitrogen utilized by plants and bacteria; it is also easily leached from the soil. Audrey found that these nitrogen transformations were altered by simulated nitrogen deposition, and in the presence of added nitrogen, other global change factors also had effects. This is one of many examples from the JRGCE in which the effects of one global change factor depend on the presence or absence of another. Audrey is now pursuing her PhD.

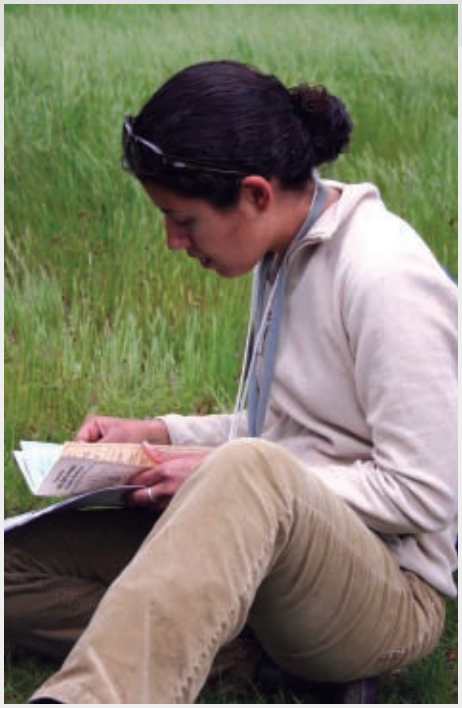
Jeannie Stamberger

Jeannie Stamberger received her PhD this year for research she conducted at the Rocky Mountain Biological Laboratory and at Jasper Ridge. She studied relationships between butterflies and their thermal environments, and especially, the capacity of butterflies to use existing adaptations to modulate changes in climate. At Jasper Ridge, Jeannie focused on the strategies that a common butterfly of grasslands, the common ringlet (*Coenonympha tullia*), may use to buffer earlier senescence of its larval food plant, which would be expected with climate warming. While a PhD student, Jeannie was also a member of the BioACT group (see page 7), and she contributed to the development of Eco-Pod and other field tools. This aspect of her work now includes international collaborations on basic research and further tool development with conservation biologists, park rangers, and agricultural inspectors, as well as working with software developers to bring this technology to the public.

Common ringlet, *Coenonympha tullia*

John Juarez

For more than four years, John Juarez incorporated Jasper Ridge in multiple aspects of his studies in the Earth Systems Program. This year he completed his coterminal master's degree, which is an integrated academic program in which students simultaneously pursue both a bachelor's and master's degree. John's connection to Jasper Ridge began in the summer of 2002 when he became an intern with the JRGCE. This developed into a master's study in which he tracked the amount and movement of carbon in the soil of the global change treatments. His research has shown that the amount of carbon in the JRGCE soil does not change over time, but open pathways allow new carbon to enter and cycle through multiple soil carbon pools. The accessible pools range from the most labile to the most recalcitrant components of the soil system. Alongside his research, John broadened his role at Jasper Ridge as he became a docent and took the field studies class. He is committed to making a difference in the area of global climate change, and is now pursuing a career in the renewable energy sector.



Cristina Salvador

Jasper Ridge has benefited from a growing number of students undertaking the master's program in biological sciences, and this year, Cristina Salvador took advantage of the program's flexibility and opportunities by participating in all aspects of JRBP's mission. During her one year at Stanford obtaining her master's, Cristina completed the docent training course, taught in the Eastside Field Studies program for sixth graders, assisted in David Freyberg's studies of groundwater dynamics, and conducted a vegetation survey. Her survey re-examined a 1980s vegetation transect from serpentine to non-serpentine grassland to see if changes had occurred in the boundary between the two grassland communities. Cristina found that although there were many changes in community composition, including a number of new species, the vegetation boundary had not shifted. Her work contributed to the multidisciplinary case study evaluating the reintroduction of Bay checkerspot butterflies to Stanford lands.

Bay checkerspot, *Euphydryas editha bayensis*

Carol Boggs

This year Carol Boggs was named Director of the Program in Human Biology (HumBio), which is Stanford's largest undergraduate major. HumBio is an interdisciplinary program, melding biological sciences with the social and behavioral sciences to address problems facing humanity. Carol has taught and advised in this program since 1987, including core courses on evolution, ecology, and environmental policy. In addition she teaches an upper division conservation biology course which visits Jasper Ridge each year. As director of HumBio, Carol is responsible for the overall direction and health of the program. One of her goals is to maintain HumBio's strengths in health and human development, while providing more focus on the environment, including interactions between human health and the environment. Carol is a professor (teaching) in the department of biological sciences and her research focuses on evolutionary and ecological patterns in butterflies. In addition to conducting studies in central California and the Rocky Mountain Biological Laboratory, she is a principal investigator in the multidisciplinary study of the feasibility of reintroducing Bay checkerspot butterflies to Stanford lands. This photo was taken during one of her continuing spring surveys to check for possible Bay checkerspot migrants to Jasper Ridge, an increasingly unlikely possibility since other local populations are also extinct.

2006 Docent Class

The Jasper Ridge Biological Preserve docent training class of 2006 after a day in the field searching for reptiles and amphibians with instructor Rich Seymour. The class of 2006 includes new docents Rachel Adams, Alison Appling, Matthew Bahls, Boyce Burge, Jamie Cundiff, Liz Schwerer Duffie, Valentina Fontiveros, Pierre Martineau, Robin Pam, Chloe Pinkerton, Andy Rominger, Alison Rountree, Cristina Salvador, Seth Silverman, Marguerite Stevens, Matt Velasco, Susan Walz, and Alex Williamson.

Appendix 1: Research Projects

Project	Principal Investigator(s)	Department or Division	Institution
Comparative ecology and life history of chaparral shrub species	David Ackerly	Fac, Integrative Biology	UC Berkeley
Functional diversity of California woody plant communities	Will Cornwell	GS, Biological Sciences	Stanford University
Transition from the understory to the canopy by *Prunus ilicifolia*	Reyes Tirado	PD, Integrative Biology	UC Berkeley
Mycorrhizal networks and invasion by yellow star-thistle	Krikor Andonian	GS, Ecol. and Evol. Biol.	UC Santa Cruz
Biosystematics of Hilara, Medetera, and Tachinidae	Paul Arnaud	SS, Entomology	Cal. Academy of Sciences
Broadband seismic monitoring	Greg Beroza	Fac, Geophysics	Stanford University
	Bill Karavas	SS, Berkeley Digital Seismic Net.	UC Berkeley
Test application of the laser-induced chlorophyll fluorescence transient (LIFT) instrument	Joe Berry	Fac, Global Ecology	Carnegie Institution
	Roland Pieruschka	PD, Global Ecology	CIW & Forschungszentrum Jülich (Germany)
Population biology of the butterfly *Euphydryas chalcedona*	Irene Brown	Vol, JRBP	
Evolution of edaphic races in *Lasthenia californica*	Gina Choe	GS, Botany	Univ. Brit. Columbia (Canada)
Collection and mapping of the flora of Jasper Ridge	Toni Corelli, Ann Lambrecht, Ruth Porter, John Rawlings, Carol Zabel	Vol, JRBP	
Mammalian herbivores as mediators of community structure and soil fertility	Hall Cushman	Fac, Biology	Sonoma State Univ.
Mammalian diversity, abundance, and activity	Rodolfo Dirzo	Fac, Biological Sciences	Stanford University
Camera-trap monitoring of large and medium-sized mammals	Yolanda Cachú, Eduardo Mendoza, Luis Abdala	PD, Biological Sciences	Stanford University
	Bill Gomez	Vol, JRBP	
Small mammal diversity and density across habitats	Hillary Young	GS, Biological Sciences	Stanford University
Population genetics of *Microtus californicus*	Rachel Adams	GS, Biological Sciences	Stanford University
Dissection and analysis of raptor pellets	Elizabeth Callaway	UG, Biological Sciences	Stanford University
Herbivory and competition between native and exotic plant species	Rodolfo Dirzo	Fac, Biological Sciences	Stanford University
	Eduardo Mendoza, Yolanda Cachú	PD, Biological Sciences	Stanford University

Botta's pocket gopher (*Thomomys bottae*)

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)	Department or Division	Institution
Long-term studies of *Euphydryas editha bayensis* and feasibility of reintroduction	Paul Ehrlich	Fac, Biological Sciences	Stanford University
	Carol Boggs	Fac, Biological Sciences	Stanford University
	Scott Fendorf	Fac, Geol. & Environ. Sciences	Stanford University
	Chris Field	Fac, Global Ecology	Carnegie Institution
	Buzz Thompson	Fac, Law School	Carnegie Institution
	Richard White	Fac, History	Stanford University
Feasibility study of serpentine habitat creation	Tim Bonebrake	GS, Biological Sciences	Stanford University
Historical distribution of the Bay checkerspot butterfly and its food plants	Jon Christensen	GS, History	Stanford University
Resurvey of preinvasion serpentine vegetation plots	Cristina Salvador	GS, Biological Sciences	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
	Brendan Bohannan, Hal Mooney, Peter Vitousek	Fac, Biological Sciences	Stanford University
	Jim Tiedje	Fac, Ctr. for Microbial Ecology	Michigan State Univ.
Fixer vs. nonfixer incorporation of biologically fixed nitrogen	Michael Alyono	UG	Stanford University
Response of soil bacterial communities to global change	Sharon Avrahami	PD, Biological Sciences	Stanford University
Impacts of global change on soil microbial community	Teri Balser; Jessica Mentzer	Fac; GS, Soil Science	Univ. of Wisconsin, Madison
Effects of global change on methane oxidation	Joey Blankinship	GS, Biological Sciences	Northern Arizona Univ.
Biochemical indices of leaf and canopy responses to global changes	Natalie Boelman	PD, Global Ecology	Carnegie Institution
Spectral measurement of aboveground vegetation dynamics	Nona Chiariello	SS, Biological Sciences	Stanford University
Carbon storage as measured by carbon mineralization in soil cores	Brandon Cortez	UG, Biological Sciences	Stanford University
Trace gas fluxes under simulated global changes	Paul Dijkstra	SS, Biological Sciences	Northern Arizona Univ.
Microbial diversity and breakdown of polyaromatic compounds in soil	Stephan Gantner	PD, Ctr. for Microbial Ecology	Michigan State Univ.
Changes in nitrogen cycling in response to global change treatments	Noel Gurwick	GS, Biol. Sci. & Global Ecol.	Stanford Univ. & Carnegie Inst.
UV degradation of litter	Hugh Henry	Fac, Biology	Univ. Western Ontario (Canada)
Carbon, nitrogen, and phosphorus interactions and global change	Ben Houlton	PD, Global Ecology	Carnegie Institution
Effects of global change on soil nitrogen cycling	Bruce Hungate	Fac, Biological Sciences	Northern Arizona Univ.
Responses of soil carbon to global change	John Juarez	GS, Earth Sys. & Global Ecol.	Stanford Univ. & Carnegie Inst.
Whole-system gas exchange of the JRGCE	Claire Lunch	GS, Biol. Sci. & Global Ecol.	Stanford Univ. & Carnegie Inst.
Nitrification and denitrification under altered climate	Paul Leadley; Audrey Niboyet	Fac; GS, Ecol., Systém, Evol.	Université Paris-Sud (France)
Response of yellow star-thistle to global change and competition	Emily Pollina	GS, Biol. Sci. & Global Ecol.	Stanford University
Chemical characterization of soil organic matter responses to global change	Ted Raab; Noel Gurwick	SS; PD, Biological Sciences	Stanford University
Effects of maternal growth environment on seed mass and C and N contents	Rebecca Sorenson	UG, Biological Sciences	Stanford University
Changes in gene expression in *Geranium dissectum* and *Avena barbata*	Sue Thayer	SS, Plant Biology	Carnegie Institution
Brittle deformation in thrust fault–related folds	Patricia Fiore	GS, Geol. & Environ. Sciences	Stanford University

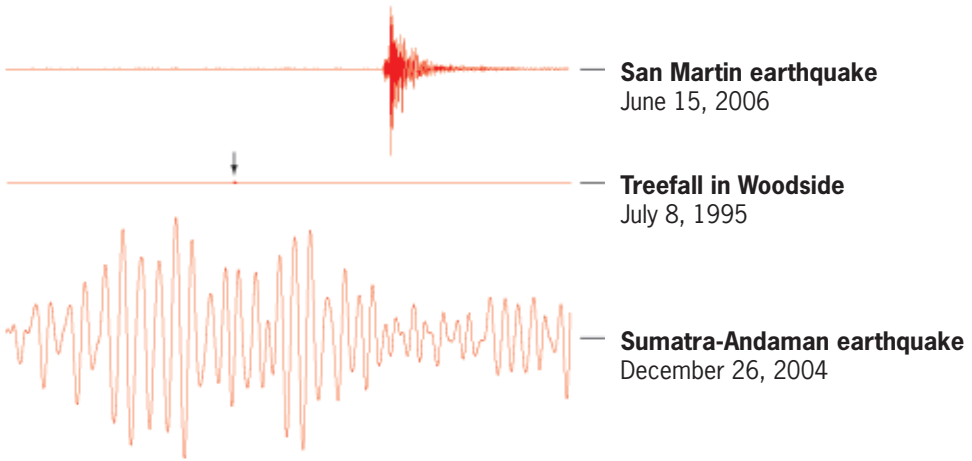




Project	Principal Investigator(s)	Department or Division	Institution
Surface- and groundwater interactions in the Searsville Reservoir sediments	David Freyberg	Fac, Civil & Envir. Engineering	Stanford University
Numerical modeling of subsurface water flow in Searsville sediments	May Chui	UG, Civil & Envir. Engineering	Stanford University
Groundwater flow in lake sediments and lake-groundwater exchange	Donghyun Kim	GS, Civil & Envir. Engineering	Stanford University
Climate data synthesis for hydrologic modeling	Michael Li	UG, Civil & Envir. Engineering	Stanford University
Pan evaporation monitoring	Matthew Sylvester	GS, Civil & Envir. Engineering	Stanford University
Argentine ant *(Linepithema humile)* invasion and the response of native ants	Deborah Gordon	Fac, Biological Sciences	Stanford University
Population dynamics of the Argentine ant in JRBP	Jessica Shors, Katherine Fitzgerald	GS, Biological Sciences	Stanford University
Effects of Argentine and native ants on Lycaenid butterflies	Jessica Shors	GS, Biological Sciences	Stanford University
Determinants of the distribution and reproductive success of *Dirca occidentalis*	William Graves	Fac, Botany	Iowa State Univ.
Monitoring of water flow and quality	Barry Hecht, Jonathan Owens, Chris White		Balance Hydrologics, Inc.
Simulation of the upstream effects of dams and dam removal on hydrologic response and sediment transport	Christopher Heppner	GS, Geol. & Environ. Sciences	Stanford University
Fate of perfluorochemicals in lake sediments	Chris Higgins	GS, Civil & Envir. Engineering	Stanford University
Effects of rainfall variability and gopher removal on serpentine grassland	Richard Hobbs	Fac, Wildlife & Ecol.	CSIRO (Australia)
Native species as a control on grassland invasion by yellow star-thistle	Kris Hulvey	GS, Ecol. and Evol. Biology	UC Santa Cruz
GPS mapping for the San Francisquito archaeological research project GIS	Laura Jones	SS, Campus Archaeology	Stanford University
Earthquake prediction from precursory electromagnetic anomalies	Simon Klemperer	Fac, Geophysics	Stanford University
	Darcy McPhee, Jonathan Glen	Geophysical Unit, Menlo Park	US Geological Survey
	Sheila Bijoor; Todd Lewandowski	GS; UG, Electrical Engineering	Stanford University
Regional surveys of annual acorn production and oak phenology	Walter Koenig	Fac, Hastings Natural Hist. Res.	UC Berkeley
	William Carmen		Ctr. for Environ. Citizenship
Repeat of a 1976 analysis of lead in the lichen *Ramalina menziesii*	Léo Laporte	Vol, JRBP	

Project	Principal Investigator(s)	Department or Division	Institution
Long-term monitoring of birds	Phil Leighton, Peter LaTourrette, Marion Smith; Trevor Hébert	Vol; SS, JRBP	
Survey of San Francisquito Creek and removal of exotics	Alan Launer	SS, Univ. Land & Buildings	Stanford University
Restoration, monitoring, student & public outreach in San Francisquito Creek Watershed	Alan Launer Ryan Navratil	SS, Univ. Land & Buildings SS	Stanford University San Francisquito Watershed Council
Biocontrol insects of thistles and their distribution at JRBP	Anna Lee	UG, Biological Sciences	Stanford University
Monitoring and collection of insects	Pierre Martineau	Vol, JRBP	
Photochemical changes in natural organics in Searsville Lake water	Ted Mill	SS, Chemistry	SRI International
World herbivory project	Angela Moles Will Cornwell	PD, Biological Sciences GS, Biological Sciences	Macquarie Univ. (Australia) Stanford University
Effect of dew on water relations of *Hemizonia* capitula	Suzanne Morse	Fac, Botany	College of the Atlantic
Long-term acoustical monitoring of bat activity	Tom Mudd	Vol, JRBP	
Bacterial-cyanobacterial symbioses in Searsville Lake	Wing-On Jacky Ng	PD, Civil & Envir. Engineering	Stanford University
Computing support for acquisition, collaborative curation, and dissemination in biodiversity research	Andreas Paepcke	SS, Computer Sciences	Stanford University
Data capture (ButterflyNet) and interactive gigapixel prints (GIGAprints)	Ron Yeh	GS, Computer Science	Stanford University
Survey and monitoring of the butterflies of JRBP	Jérôme Pellet	PD, Biological Sciences	Stanford University
Energy performance of the Leslie Shao-ming Sun Field Station	John Scofield	Fac, Physics & Astronomy	Oberlin College
Analysis and mapping of vegetation water content from remote and ground-based measures	Susan Ustin David Riaño, Yen-Ben Cheng Marco Trombetti	Fac, Land, Air & Water Res. PD, CSTARS GS	UC Davis UC Davis UC Davis & Univ. Basilicata (Italy)

Right: Just before dawn on June 15th, the Jasper Ridge seismic station (JRSC) registered the year's largest local earthquake. Bob Uhrhammer of the Berkeley Seismological Laboratory reports that the magnitude 4.67 quake near San Martin produced more than ten times the ground motion of any other local quake this year. The top seismogram shows the relative ground motion registered by the JRSC along the north-south axis. For comparison, ground motion at JRSC due to two other events is shown at the same scale, also for north-south motion. The middle seismogram was recorded when one of the largest *Eucalyptus* trees in the US fell over in Woodside on the night of July 8, 1995 (July 9, UTC). The bottom seismogram was recorded by the JRSC during the December 26, 2004 magnitude 9+ earthquake that triggered devastating tsunamis in the Indian Ocean. All three JRSC seismograms were extracted from the "make your own seismogram" tool on the website of the Northern California Earthquake Data Center.[5] The Jasper Ridge website has a link to this site, as well as more information about the JRSC.



Appendix 2: Publications

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Cleland, E.E., Chiariello, N.R., Loarie, S.R., Mooney, H.A., and Field, C.B. (2006) Diverse responses of phenology to global changes in a grassland ecosystem. Proceedings of the National Academy of Sciences (USA) 103: 13740–13744.

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Cornwell, W.K., Schwilk, D.W., and Ackerly, D.D. (2006) A trait-based test for habitat filtering: convex hull volume. Ecology 87: 1465–1471.

Dukes, J.S., Chiariello, N.R., Cleland, E.E., Moore, L.A., Shaw, M.R., Thayer, S., Tobeck, T., Mooney, H.A., and Field, C.B. (2005) Responses of grassland production to single and multiple global environmental changes. PLoS Biology 3(10): e319.

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Graves, W.R. (2005) Distribution and reproduction of *Dirca occidentalis* (Western Leatherwood). The Four Seasons 12: 54–61.

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Henry, H.A.L., Cleland, E.E., Field, C.B., and Vitousek, P.M. (2005) Interactive effects of elevated CO_2, N deposition and climate change on plant litter quality in a California annual grassland. Oecologia 142: 465–473.

Henry, H.A.L., Juarez, J.D., Field, C.B., and Vitousek, P.M. (2005) Interactive effects of elevated CO_2, N deposition and climate change on extracellular enzyme activity and soil density fractionation in a California annual grassland. Global Change Biology 11: 1–8.

Horz, H.-P., Rich, V., Avrahami, S., and Bohannan, B.J.M. (2005) Methane-oxidizing bacteria in a California upland grassland soil: diversity and response to simulated global change. Applied and Environmental Microbiology 71: 2642–2652.

Hu, S., Wu, J., Burkey, K.O., and Firestone, M.K. (2005) Plant and microbial N acquisition under elevated atmospheric CO_2 in two mesocosm experiments with annual grasses. Global Change Biology 11: 213–223.

Koenig, W.D., and Knops, J.M.H. (2005) The mystery of masting in trees. American Scientist 93: 340–347.

Moore, L.A., and Field, C.B. (2005) A technique for identifying the roots of different species in mixed samples using nuclear ribosomal DNA. Journal of Vegetation Science, 16: 131–134.

Moore, L.A., and Field, C.B. (2006) The effects of elevated atmospheric CO_2 on the amount and depth distribution of plant water uptake in a California annual grassland. Global Change Biology 12: 578–587.

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Peters, H.A., Cleland, E.E., Mooney, H.A., and Field, C.B. (2006) Herbivore control of annual grassland composition in current and future environments. Ecology Letters 9: 86–94.

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Stephens, S.L., and Fry, D.L. (2005) Fire history in coast redwood stands in the northeastern Santa Cruz Mountains, California. Fire Ecology 1: 2–19.

Wang, Y.P., Houlton, B.Z., and Field, C.B. A model of biogeochemical cycles of carbon, nitrogen and phosphorus including symbiotic nitrogen fixation and root phosphatase production. Global Biogeochemical Cycles (in press).

Zavaleta, E.S. (2006) Shrub establishment under experimental global changes in a California grassland. Plant Ecology 184: 53–63.

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Zavaleta, E.S., and Kettley, L.S. (2006) Ecosystem change along a woody invasion chronosequence in a California annual grassland. Journal of Arid Environments 66: 290–306.

Appendix 3: Educational Use

Stanford University Classes (1450*)

ANTHSCI 3	Introduction to Prehistoric Archaeology (Rick)
APPPHYS 79Q	Energy Choices for the 21st Century (Fox, Geballe)
BIOSCI 6N	Climate Change: Drivers, Impacts, and Solutions (Field)
BIOSCI 96	Jasper Ridge Docent Training Class (Wilber, Vitousek)
BIOSCI 44	Core Experimental Laboratory for Ecology (Yelton)
BIOSCI 101	Ecology (Vitousek and Bohannan)
BIOSCI 117	Biology and Global Change (Vitousek)
BIOSCI 120	General Botany (Preston)
CEE 10SC	Green Buildings (Masters)
CEE 166D	Water Resources and Water Hazards Field Trips (Freyberg)
CEE 169	Environmental and Water Resources Engineering Design (Freyberg)
CEE 242A	Sustainable Development (Levitt, Christensen)
EARTHSYS 10	Introduction to Earth Systems (Ernst)
GEOPHYS 25	Planetary Habitability (Sleep)
GES 144	Fundamentals of Geographic Information Science (GIS) (Seto)
GES 175	Science of Soils (Fendorf)
GES 186	Geoarchaeology (Mahood)
ME 222	Beyond Green Theory: A Workshop in Ecological Design (McPherson)
PWR 2	A Planet on Edge: Rhetoric of Sustainable Energy (Moekle)

Other College and University Classes (160*)

California College of the Arts: Research Design (Franceschini)
De Anza College: Natural History of the Bay Area (West-Bourke)
Notre Dame de Namur University: Ecology (MacDonald)
Notre Dame de Namur University: General Biology (MacDonald)
San Jose State University: Plant Communities of California (Lambrecht)
Santa Clara University: Restoration Ecology (Matzek)

*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-Affiliated Groups (1350*)

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Center for Teaching and Learning, staff
Department of Biological Sciences, EcoEvo Faculty
Department of Computer Science, Paepcke Lab
Earth Systems Program, staff
Engineers for a Sustainable World
Escondido Village
Graduate School of Business, alumni
Graduate School of Business, City Management and Urban Planning, Chinese Mayors
Graduate School of Business, Impact 2005
Industry Initiatives for Science & Math Education (IISME)
Japser Ridge Darwin Class
Jasper Ridge Trimble Global Positioning System Training
Master of Liberal Arts (MLA) Alumni
School of Humanities and Sciences, Office of the Dean
Stanford Alumni Association
Stanford Board of Trustees & Woods Institute for the Environment
Stanford Club of Palo Alto
Stanford Facilities, Water Division
Stanford Linear Accelerator Center (SLAC)
Stanford Nursing Alumni
Stanford Singles
Stanford-Singapore Partnership Program
Stanford University Medical Center Alumni Association
Stanford University Medical Media and Information Technologies (SUMMIT)
Woods Institute for the Environment

K–12 Groups (870*)
Castilleja School AP Biology
Castilleja School Biology
Crystal Springs Uplands School AP Biology
Eastside School Field Studies
Environmental Volunteers
Peninsula School
Serra High School
Serra High School Ecology Club
Woodside High Environmental Biology

Other Groups (1090*)
Acterra
American Geophysical Union
American Institute of Architects,
Santa Clara Valley Chapter
Año Nuevo Docents
Carmel Unified School District
Christ Episcopal Church, Portola Valley
Conservation International
Emerging Green Builders,
US Green Building Council
Environmental Volunteers, training
Friends of Edgewood Natural Preserve
The Foundation for Global Community
Master Gardeners of Santa Clara County
National Audubon Society
National League of Cities
Rainbow Recreation
Rocky Mountain Biological Laboratory (RMBL)
Board of Trustees
San Francisco Hiking Club
San Francisquito Creek Joint Powers Authority
San Mateo County Fire Safe Committee
Santa Clara Valley Audubon Society
Silicon Valley Bank
Society for Conservation Biology
Sustainable Silicon Valley
The Terraces Retirement Community
US Army Corps of Engineers
Valley Presbyterian Church
Westridge Homeowner's Association
Woodside-Atherton Garden Club

2005–06 Brown Bag Lunch Lectures

October: **Ron Yeh**
JRBP researcher and docent; graduate student in computer science, Stanford University
"Mobile information capture and access for field biologists"

November: **Walter Boyce**
Executive director, Wildlife Health Center, UC Davis School of Veterinary Medicine
"Mountain lions in southern California: an extensive and ongoing study"

December: **Rebecca Shaw**
Director of Conservation Science and Planning, The Nature Conservancy, California Program
"Saving the island fox: Santa Cruz Island restoration program"

February: **Alan Launer**
Stanford University Campus Biologist
"Conservation at Stanford University, with a focus on San Francisquito Creek"

March: **Pamela Matson**
Chester Naramore Dean of the School of Earth Sciences and Richard and Rhoda Goldman Professor of Environmental Studies, Stanford University
"Research on how intensive agriculture affects ecosystems in the Yaqui Valley"

April: **Walter Koenig**
Research zoologist, Hastings Natural History Reservation, University of California
"Research on oak trees in California, including work at Jasper Ridge"

May: **David Ackerly**
Professor, UC Berkeley
"Convergent evolution and diversity of characteristics within communities"

Appendix 4: 2005–06 Financial Summary

A change in Jasper Ridge operations that may affect both the budget and revenues is the closing of the research-housing trailer. This past year the trailer was deemed to be unsafe and was shut down. While this has reduced revenue derived from visiting researchers, it almost certainly is offset by the elimination of costs associated with maintenance of that facility.

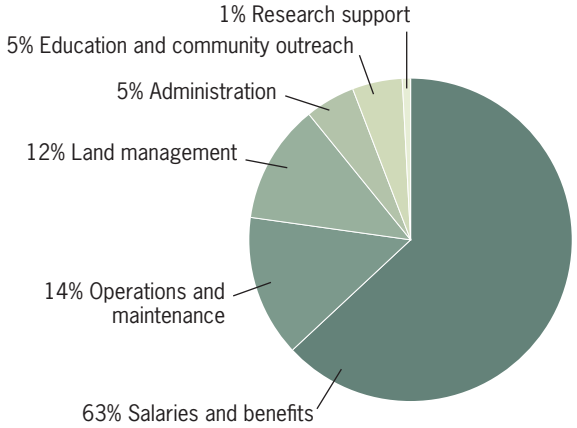
An unusual expense this past fiscal year was the replacement of the preserve dump truck with one that was newly refurbished.

It is likely that in the coming years, the fiscal picture for the preserve will brighten. This is driven by several factors. For the past three years Jasper Ridge expenses significantly exceeded revenue, in large measure due to the additional costs associated with mosquito abatement activities mandated by San Mateo County. The abatement covered the costs associated with helicopter spraying of larvicide on Searsville Lake and its associated wetlands to protect nearby residents from the arrival and presence of West Nile Virus. These costs have typically represented about 5% of the Jasper Ridge annual budget. Starting with fiscal year 2007 (September 1, 2006–August 31, 2007), the School of Humanities and Sciences facilities budget will assume the costs of mosquito abatement. This is an important change and will stabilize the preserve's operating budget so that expenses and revenues are more or less in balance. This, in turn, should increase the preserve's flexibility and allow it to use existing reserves to address other pressing needs and programmatic enhancements.

Expense Summary

Salaries and benefits	$486,911
Operations and maintenance	112,719
Land management	89,876
Administration	41,716
Education and community outreach	38,486
Research support	9,364
Total	**$779,072**

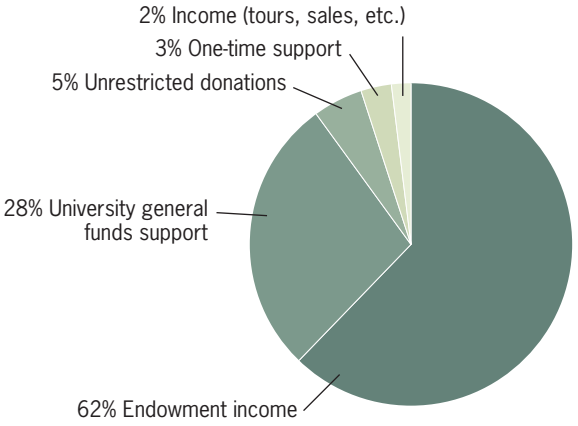
Expenditures include: charges for San Mateo County mosquito abatement activities, $38,672; one-time capital expenditure of $21,995 to replace preserve's dump truck; one-time cost of $22,683 for repairs to the Bear Creek water-quality monitoring station, which was damaged by high flows on New Year's Eve.



Revenue Summary

Endowment income	466,193
University general funds support	206,760
Unrestricted donations	35,968
One-time support	21,683
Income (tours, sales, etc.)	11,847
Total	**$742,451**

One-time support was insurance coverage for flooding damage to Bear Creek monitoring station and fenceline, $21,683. The difference between revenue and expenses was $–36,621; this difference was covered by Jasper Ridge reserves.



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 flexible approach 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, 2005 to August 31, 2006.

James B. and E. Anne Allen
Amber Foundation
Paul H., Jr., and Madeline L. Arnaud
Barbara C. Bartlett
Leonie F. Batkin
Nancy C. and Clayton W. Bavor
Monika B. and Olle Björkman
Ross D. and Joann Bright
Irene L. and Robert W. Brown
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Carolyn Clark
Elsa Eleanor Cleland
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Rigdon Currie and Trish Johnson
Robert L. and Patricia R. Dengler
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John L. and Judith Anne Doyle
Charlotte P. and W. G. Ernst
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Nancy J. and Thomas J. Fiene
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Winifred "Winkie" H. Lennihan
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Woodside-Atherton Garden Club
Jane Woodward
Nancy K. Woodward
John W. Working
Lysbeth Warren Working
Richard I. Yankwich and Megan McCaslin

Patty and Eff Martin next to the recently installed sign naming the Jasper Ridge library in honor of their generous gift to the Leslie Shao-ming Sun Field Station.

Appendix 6: The JRBP Community

Luis Abdala
David Ackerly
Rachel Adams
Kali Albright
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Nico Grundmann
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Trevor Hébert
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Craig Heller
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Nona Chiariello, PhD, research coordinator
Cindy Wilber, education coordinator
Trevor Hébert, GIS and data manager
Alison Rountree, administrative assistant
Susan Lacoste, temporary administrative assistant
Cary Tronson, operations steward
Leonard Robinson, resident caretaker
Brooke Fabricant, resident ranger
Deanna Messinger, resident ranger

Endnotes

1. Jasper Ridge fire management: http://jrbp.stanford.edu/fire.php
2. JRBP research projects: http://jrbp.stanford.edu/db/projects/index.php
3. Interactive Gigapixel Prints: http://hci.stanford.edu/gigaprints/
4. Cleland, E.E., et al. (2006) Diverse responses of phenology to global changes in a grassland ecosystem. Proc Natl Acad Sci USA 103(37):13740–4.
5. Northern California Earthquake Data Center: http://www.ncedc.org/bdsn/make_seismogram.html
6. Jasper Ridge watershed management: http://jrbp.stanford.edu/watershed.php

For more information about Jasper Ridge Biological Preserve:
Administrative director
Jasper Ridge Biological Preserve
Stanford University
Stanford, CA 94305-5020
Email: philippe.cohen@stanford.edu
Website: http://jrbp.stanford.edu
Phone: (650) 851-6814
Fax: (650) 851-7334

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

Photographs

Nona Chiariello: 2, 6, 8, 9, 10, 11, 13 (top right, bottom), 15 (2), 16 (bottom left), 17 (7), 18 (top left, top right), 19 (top right), 20 (bottom), 22 (far left, middle, middle right, far right), 25 (left)
Philippe Cohen: 4, 5, 7, 15 (1), 20 (top), 22 (middle left), 29
Dirzo lab and volunteers: 16 (5)
Scott Haefner and Sheldon Breiner: 3 (bottom)
Trevor Hébert: 13 (top left), back cover
Justin Holl: 18 (middle)
Gerry Jennings: 24 (bottom middle)
Alan Launer: cover, 19 (middle inset)
Don Mason: inside front cover, 1, 3 (top), 14, 15 (top), 16 (bottom middle/right series), 17 (bottom left/middle series), 19 (bottom), 24 (bottom right), 25 (right), 26, 27, 28, 31, 32, inside back cover
Judy Mason: 24 (top, bottom left), 30
Jérôme Pellet: 18 (bottom inset)
Kelly Rollefson: 25 (middle)
Hilde Schwartz: 17 (bottom right series)
Gary Smith: 15 (bottom right inset)
Cindy Wilber: 16 (3, 4), 17 (6), 19 (top left)

Illustrations

Chris Andrews: 12
Eliza Jewett: 1, 5, inside back cover

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In Memoriam

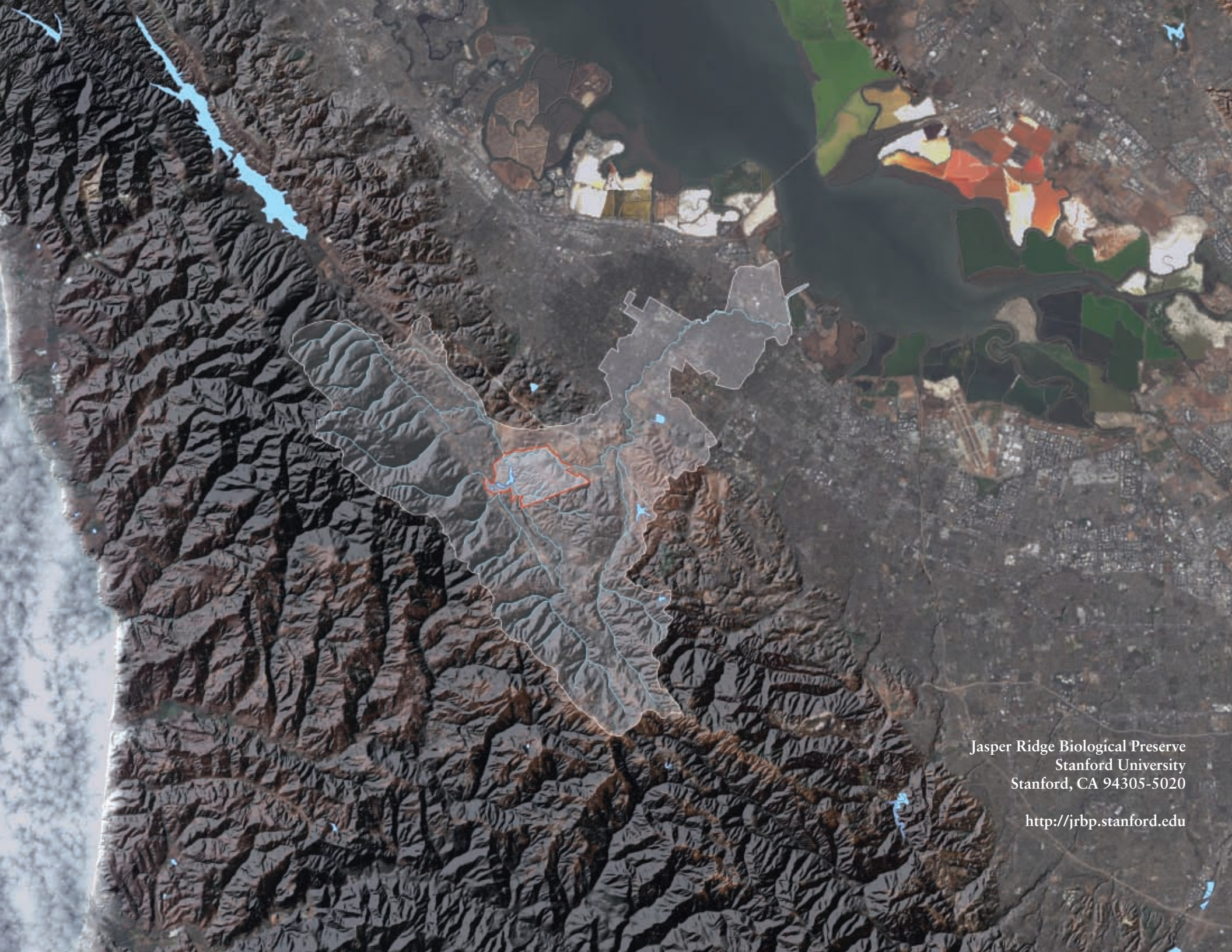
Alan Weiss
1925–2006

Member of the docent class of 1995, who followed his sons to Jasper Ridge, and walked the trails measuring wheel in hand so that we might know how far we have come already and how far we have yet to go.

About the covers

Front cover: The photographer, Alan Launer, writes, "I took the image in San Francisquito Creek on August 18, 2006. The site is in Jasper Ridge, approximately 750 meters downstream from the cement crossing, at a depth of about one meter. There are young-of-the-year Sacramento suckers in the middle of the image; the crayfish are signal crayfish, a very abundant species that is not native to this part of California. This species apparently/supposedly replaced a native crayfish around a century ago, and has also been widely introduced across temperate zones of the world."

Back cover: By Trevor Hébert. The image shows the boundary of Jasper Ridge Biological Preserve (red) within the San Francisquito Creek watershed (white; from USGS). The background is a 2002 Landsat 7 color satellite image combined with shaded relief from USGS elevation data. For more information on watershed management at JRBP, visit the website.[6]



Jasper Ridge Biological Preserve
Stanford University
Stanford, CA 94305-5020

http://jrbp.stanford.edu