University of California
Natural Reserve System

2006 MATHIAS SYMPOSIUM
Bodega Marine Laboratory/Reserve
February 24-26, 2006

This symposium is supported by the Kenneth S. Norris endowment fund for the California environment provided to the Natural Reserve System by the David and Lucile Packard Foundation
Welcome

Participating Bodega Marine Laboratory (BML)/Reserve Staff

Claudia Luke (PhD, Zoology, University of California, Berkeley, 1989)
   – Reserve Manager

Peter Connors (PhD, Biophysics, University of Wisconsin)
   – Former Reserve Manager

Accommodations, Meals and Socials

Dorms
It may be convenient for participants to move their belongings into the dorms before nightfall. Good times are before lunch and from 4:20-5:00 p.m. before the laboratory tour.

Locations where Meals and Events will be Hosted

Breakfast will be in the Dormitory Dining Hall.

Lunch, Dinner, and Socials will be in the BML Lounge.

Lectures will be in the BML Lecture Hall.
Carole Hickman (PhD, Stanford University, 1975) is Professor of Integrative Biology at UCB. Her research “strives to understand how the building blocks of life come together to produce distinctive structural patterns, and thinks about how these patterns are grown — starting with a single cell even in very complex multicellular organisms — and how they change and evolve.”

Overview of Research Interests

“My research seeks new understanding of the diversity of structure and function in living and fossil organisms by integrating formal (morphogenetic) historical (phylogenetic) and functional (adaptive) explanations. Theoretical, constructional, evolutionary, and developmental morphology provide the conceptual and practical tools that I use to analyze structure and function. Molluscs are the primary subject organisms for defining principles of structure. I have developed new model systems: the gastropod radula, suspension feeding devices, and the gastropod larval shell, as well as novel tools that include design spaces, ecospaces, ethospaces, and developmental spaces in which phylogenetic trajectories illustrate macroevolutionary trends and patterns.

As paleobiologist and geologist, I am investigating the taphonomic assembly and patterning of shell beds in the fossil record and the responses of community architecture to global climate change during the Cenozoic Era. Recently completed projects include an astrobiological theory of the role of microbial-metazoan interactions in extreme environments, an analysis of the “problem of similarity,” and an analysis of changes in shell biomineralization at metamorphosis that are reflected in funeous composite bioinorganic materials.”

Kaustuv Roy (PhD, University of Chicago, 1994) is Associate Professor of Biology at UCSD. His research interests include macroevolution and macroecology, marine conservation, and biotic effects of climate change. His research is described at [http://ib.berkeley.edu/research/interests/research_profile.php?person=183] and at [http://www-biology.ucsd.edu/labs/roy/RLresearch.html]

Overview of Research Interests

“Research in my lab is focused on understanding the processes that determine the spatial and temporal distribution of biological diversity in the sea, emphasizing not just the traditional counts of species, but also functional groups and morphological diversity. In particular we are using marine mollusks as a focal group to (i) test hypotheses about the origin and maintenance of the spatial patterns of species diversity in the ocean; (ii) better understand the effects of climatic and environmental change on shallow marine species and communities; and (iii) quantify spatial patterns of morphological diversity in marine invertebrates and explore the ecological and evolutionary basis of these patterns. In addition, we have just initiated a large research project quantifying the effects of human impacts on the rocky intertidal biota of southern California. Research in my lab is interdisciplinary in nature and combines ecological and biogeographic data from living populations with the deep time perspective afforded by the rich fossil record of mollusks, as well as collaborative work on molecular phylogeny and population structures of selected clades.”

[http://ib.berkeley.edu/research/interests/research_profile.php?person=183]
### 2006 Mathias Symposium
Bodega Marine Laboratory/Reserve  
February 24-26, 2006

#### Friday, February 24, 2006

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<td>12:00-1:20 p.m.</td>
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| 1:30-2:00 p.m.    | Introduction to Bodega Marine Laboratory and Reserve  
Claudia Luke   |
| 2:00-2:20 p.m.    | Demographic study of the intertidal alga *Pelvetiopsis limitata*  
Jennifer A. Skene, Department of Integrative Biology, UCB |
| 2:20-2:40 p.m.    | The larval export of a harvested intertidal limpet, *Lottia gigantea*,  
from marine protected areas in California  
Robin Pelc, Department of Ecology, Evolution and Marine Biology, UCSB |
| 2:40-3:00 p.m.    | Factors controlling the early stages of macroalgal growth and  
removal in Carpinteria Salt Marsh Reserve, Santa Barbara, California  
Rachel Kennison, Department of Ecology and Evolutionary Biology, UCLA |
| 3:00-3:20 p.m.    | Time to eat: Measuring at-sea feeding events to understand foraging  
behavior of the northern elephant seal (*Mirounga angustirostris*)  
Carey E. Kuhn, Department of Ecology and Evolutionary Biology, UCSC |
| 3:20-3:40 p.m.    | Break                                                                     |
| 3:40-4:00 p.m.    | Bacterial-algal interactions and stream biofilm composition: the role of  
resource availability and network position  
Maria L. Goodrich, Department of Integrative Biology, UCB |
| 4:00-4:20 p.m.    | Interannual variability in the Net Ecosystem Exchange of CO$_2$ and the  
Normalized Difference Vegetation Index (NDVI) at the San Joaquin  
Freshwater Marsh  
Adrian V. Rocha, Department of Earth Systems Science, UCI |
| 5:00-6:00 p.m.    | Tour of Laboratory  
Claudia Luke and Peter Connors |
| 6:15-7:45 p.m.    | Dinner (Food service 6:15-7:00 p.m.)                                    |
| 8:00-9:00 p.m.    | Structural and functional innovations for metazoan life in seagrass ecosystems  
Carole Hickman |
| 9:00-10:00 p.m.   | Social                                                                    |
## Saturday, February 25, 2006

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<tr>
<td>7:30-8:30 a.m.</td>
<td>Breakfast (Food service 7:30-8:15 a.m.)</td>
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| 9:00-9:20 a.m. | **A sensor network for semi-automated remote data collection at McLaughlin Reserve**  
Leo Szumel, Department of Electrical and Computer Engineering, UCD |
| 9:20-9:40 a.m. | **Understanding shifts of species ranges in response to climate change: A case study in the Sierra Nevada mountains**  
Teresa Chuang, Department of Environmental Science, Policy and Management, UCB |
| 9:40-10:00 a.m.| **Bio-Heritage of Coal Oil Point: The Experiments of Frederic E. Clements**  
Donald R. Burnette, Department of History, UCSB                                                                 |
| 10:00-10:20 a.m.| **Bringing a rancher’s diary into the digital age: modeling historical land use with GIS**  
Jeff Howarth, Department of Geography, UCSB                                                                         |
| 10:20-11:00 a.m.| Break                                                                                                           |
| 11:00-11:20 a.m.| **Effects of mate attractiveness on maternal investment in Dark-eyed Juncos**  
Elise Ferree, Department of Ecology and Evolutionary Biology, UCSC                                                     |
| 11:20-11:40 a.m.| **The role of nest predation in shaping nest site selection and clutch size in open-cup nesting songbirds**  
Susana I. Peluc, Department of Biology, UCR                                                                        |
| 11:40-12:00 noon| **Avian response to ecological gradients: variation in bird-habitat relationships along an elevational gradient**  
Lori Hargrove, Department of Biology, UCD                                                                            |
| 12:15-1:30 p.m.| Lunch (Food service 12:15-1:00 p.m.)                                                                              |
| 1:30-3:30 p.m. | **Tour of the Reserve**  
Claudia Luke and Peter Connors                                                                                       |
| 4:00-4:20 p.m. | **The cost of hover-feeding as a function of altitude and temperature in migratory rufous hummingbirds, *Selasphorus rufus***  
Kenneth Welch, Department of Ecology, Evolution and Marine Biology, UCSB                                                |
Saturday, February 25, 2006

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<tr>
<td>4:20-4:40 p.m.</td>
<td><strong>Competitive mechanisms driving the <em>Holcus lanatus</em> invasion</strong>&lt;br&gt;Adrianna A. Muir, Department of Evolution and Ecology, UCD</td>
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<td>4:40-5:00 p.m.</td>
<td><strong>Understanding the link between environmental heterogeneity and seed dispersal in the invasive annual, <em>Erodium cicutarium</em></strong>&lt;br&gt;Brooke Baythavong, Population Biology Graduate Group, UCD</td>
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<td>5:00-5:20 p.m.</td>
<td><strong>Effects of nutrient enrichment on the relationship between a parasitic plant and its hosts</strong>&lt;br&gt;Julie Simpson, Department of Ecology, Evolution, and Marine Biology, UCSB</td>
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<td>6:15-7:45 p.m.</td>
<td>Dinner (Food service 6:15-7:00 p.m.)</td>
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<td>8:00-9:00 p.m.</td>
<td><strong>Climate change, human impacts and coastal ecosystems: past, present and (?) future</strong>&lt;br&gt;Kaustuv Roy</td>
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<td>9:00-10:00 p.m.</td>
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| 9:00-9:20 p.m.  | The opposing effects of competition and facilitation on preservation of genetic diversity in an annual plant (*Plantago erecta*)  
                  Erin K. Espeland, Ecology Graduate Group, Department of Plant Sciences, UCD |
| 9:20-9:40 a.m.  | Geographic variation in a species interaction network: Interactions between *Greya* and *Lithophragma* in California  
                  Kate Horjus, Department of Ecology and Evolutionary Biology, UCSC |
| 9:40-10:00 a.m. | A latitudinal comparison of thermal tolerance and gene expression patterns in *Nucella* larvae  
                  Mackenzie Zippay, Department of Ecology, Evolution and Marine Biology, UCSB |
| 10:00-10:30 a.m.| Break                                                                |
| 10:30-12:00 noon| Forum: Future issues and career choices in environmental science     |
| 12:10-1:30 p.m. | Lunch [End of symposium]                                            |
Demographic study of the intertidal alga Pelvetiopsis limitata
Jennifer A. Skene, Department of Integrative Biology
University of California, Berkeley

Climate change is affecting species’ ranges, phenology, and population structure. The intertidal fucoid alga Pelvetiopsis limitata occupies the zone at the highest tidal elevation on the shore and will therefore experience increased physiological stress due to climate change. A demographic study of this alga was begun in July 2004, at the Bodega Marine Reserve in Sonoma County, California. Growth rate and mortality are monitored for marked individuals growing at high and low tidal elevations, in sites differing in exposure to wave action. Environmental conditions, including wave forces and air and rock temperature, are monitored throughout the year at all sites. These data are used to construct a matrix model to better understand how demographic processes vary with tidal elevation, wave exposure, air and rock temperature and season. Preliminary results suggest that mortality is highest in the winter, presumably because powerful waves rip the algae from the rock. Future research will examine the distribution and morphological variation of P. limitata. Several populations along the coast have hairs on their fronds that may facilitate the uptake of nutrients, or ameliorate desiccation stress. Physiological studies will seek to explain the role of surface pubescence. Laboratory experiments and phylogenetic analyses will be conducted to determine whether this unique trait is phenotypically plastic or attributable to hybridization with a related species of fucoid algae.

The larval export of a harvested intertidal limpet, Lottia gigantea, from marine protected areas in California
Robin Pelc, Department of Ecology, Evolution and Marine Biology
University of California, Santa Barbara

Human activities have been shown to reduce the density and average size of many exploited intertidal species. In well-protected areas, reproductive output is likely to be greatly enhanced, both because of higher abundances and because the individuals are larger and therefore more fecund. Protected sites may act as islands of high production, providing a source of larvae for harvested areas outside reserve boundaries. Near these areas of high reproductive output, patterns of recruitment can help elucidate the realized dispersal distance of larvae from dense populations to surrounding areas, providing insight on the scale of population connectivity through larval dispersal. Prior studies have demonstrated that the limpet Lottia gigantea is impacted by size-selective harvesting in California. In this preliminary study, I measured size structure and density of Lottia gigantea at a set of protected and comparable harvested sites, including sites inside and near the Kenneth S. Norris Rancho Marino reserve. I measured gonad mass for limpets over a range of sizes and used this size-fecundity relationship, size frequency data, and density data to estimate production at each site. Protected sites generally had larger sizes and higher estimated production than harvested sites. This collection of sites may be useful for tracking the movement of larvae from protected sites to outside areas by measuring recruitment patterns at various distances inside and outside reserve boundaries. The next challenge of the project is to collect and identify newly settled limpets to determine relative recruitment rates.
Factors controlling the early stages of macroalgal growth and removal in Carpinteria Salt Marsh Reserve, Santa Barbara, California
Rachel Kennison, Department of Ecology and Evolutionary Biology
University of California, Los Angeles

Macroalgae are a natural component of estuaries, yet their excessive proliferation due to nutrient enrichment is not and reduces habitat quality. Worldwide, studies have found that increased nutrient enrichment has led to macroalgal blooms, which has also been true in southern California estuaries. However, within estuary spatial patterns of blooms were patchy. This suggested that while nutrient availability is important, other factors, such as recruitment, water flow regimes, sediment stability and herbivory must be investigated to explain the variability of macroalgal accumulation. This year, I studied recruitment in Carpinteria Salt Marsh Reserve and I hypothesized that recruitment of Enteromorpha intestinalis is neither density nor flow dependent. Alternatively, recruitment of zoospores may be higher where there is higher adult macroalgal biomass (HA1) and recruitment may be positively related to water flow (HA2). Settlement tiles were placed along the main channel of the estuary and dissolution of Plaster of Paris clod cards measured bulk flow. A 0.25 m² quadrat was used to measure percent cover of adults. Results supported the hypothesis that spore densities varied along the main channel. As expected, neither alternative hypothesis was supported; there was no relationship between adult biomass vs. recruitment, and water flow vs. recruitment. Results demonstrated a spatial gradient for water flow with higher rates at the mouth of the estuary, decreasing toward the head. These results suggest that recruitment of zoospores does not control spatial patterns of blooms in Carpinteria Salt Marsh Reserve, and that other factors must be investigated.

Time to eat: Measuring at-sea feeding events to understand foraging behavior of the northern elephant seal (Mirounga angustirostris)
Carey E. Kuhn¹, Daniel E. Crocker ², Daniel P. Costa ³
¹ Department of Ecology and Evolutionary Biology, University of California, Santa Cruz
² Department of Biology, Sonoma State University
³ Center for Ocean Health, University of California, Santa Cruz

Understanding the foraging ecology of marine predators presents a unique challenge as most feeding occurs underwater and therefore outside the scope of observational studies. For the northern elephant seal, a great amount of information has been gathered on at-sea behavior through the use of satellite telemetry and time-depth (dive) recorders. However, there are limitations when using these technologies to understand foraging ecology. Dive records and satellite locations lead to assumptions about where prey are found, but definitive evidence of feeding is crucial to truly understand foraging. New technology used to measure stomach temperature can provide direct measures of feeding in free-ranging marine mammals and make it possible to elucidate the foraging behavior of these animals. This research combined data collected from dive recorders, satellite transmitters, and the first recorded stomach temperature measurements from 13 adult females to investigate the foraging behavior of northern elephant seals. Specifically, we examined when animals locate prey, the accuracy of using dive types to identify foraging, and the behavioral factors that are associated with feeding. Although much is known about diving and movement patterns in this species, this is the first study to directly measure at-sea foraging.
Abstracts

Measuring feeding events is a significant step, not only towards understanding the ecology of northern elephant seals but also to address foraging ecology of other marine mammals. In addition, the ability to identify specific foraging locations provides researchers with data necessary to more accurately define critical foraging habitat for this species as well as other elusive marine predators.

Bacterial-algal interactions and stream biofilm composition: the role of resource availability and network position
Maria L. Goodrich, Department of Integrative Biology
University of California, Berkeley

Biofilms play an important role in nutrient and carbon cycling in stream ecosystems and also link directly to higher trophic levels through periphyton grazers. Stream biofilms on rock surfaces consist mainly of algae and bacteria. In aquatic ecosystems interactions among bacteria and algae change as a function of light, nutrient, and carbon availability. Nutrient-limited algae may exude excess labile carbon. Bacteria are often carbon-limited and can exploit these algal exudates (commensalism or parasitism). Aquatic bacteria may also outcompete algae for inorganic nutrients if there is an alternative carbon source (competition). Light, nutrients, and allochthonous carbon inputs change in a partially predictable way down drainage networks, so different interactions may take place at different network positions. For the past two years I have been studying these interactions using solute-diffusing substrates in the streams of the South Fork Eel River drainage network at the Angelo Coast Range reserve. Field experiments with nutrient and carbon supplementation from 2004 suggested that bacteria are carbon limited and possibly dependent on algae, and that under high light conditions carbon supplementation could facilitate resource competition between algae and bacteria. I am investigating these hypothesized interactions by analyzing samples from 2005 for biofilm biomass and composition in treatments where bacteria or algae were removed with selective biocides. This will allow me to quantify interaction strength and make predictions about the boundaries where these microbial interactions change in the landscape.

Interannual variability in the Net Ecosystem Exchange of CO₂ and NDVI at the San Joaquin Freshwater Marsh
Adrian V. Rocha, Department of Earth Systems Science
University of California, Irvine

Determining the magnitude of interannual variation in ecosystem functioning against the backdrop of changes in climate is important in understanding how ecosystems will respond to climate change. This study was conducted at the San Joaquin Freshwater Marsh UC reserve (SJFM) and its goals were to: 1) determine the magnitude of interannual variability in the Net Ecosystem Exchange of CO₂ (NEE) in a freshwater marsh, 2) determine the relationship between variations in NEE and the Normalized Difference Vegetation Index (NDVI), and 3) understand the physical controls on these variations. An eddy covariance tower was assembled at the SJFM and used to continuously measure NEE (i.e. carbon uptake) at half hourly intervals from 1999-present. Remote sensing data from the Landsat TM satellite allowed for the calculation of NDVI and no less than one Landsat TM NDVI image per growing season (June-August) was acquired for the time period between 1984-
2004. NDVI in each year was normalized (NDVImax) based on an empirical relationship describing the seasonal phenology of NDVI in 1992 to allow for interannual comparison of NDVI. Data from 1999-2003 demonstrated that interannual variability in NEE and NDVImax was large. Variations NEE and NDVImax were correlated indicating that: 1) high rates of carbon uptake were associated with high NDVImax and 2) variations in NDVImax can be used to understand interannual variability in NEE. Variations in NDVImax from 1984-2003 had a periodicity of ~3 and ~6 years and were not correlated with temperature or precipitation, suggesting that mechanisms other than weather control NEE at the SJFM. Spectral unmixing of the Landsat images suggests that the abundance of litter plays an important role in regulating the interannual patterns of NDVImax. It is hypothesized that high litter production imparts a negative feedback on NEE and NDVI, leading to the oscillatory behavior of NEE and NDVImax at the SJFM.

A sensor network for semi-automated remote data collection at McLaughlin Reserve
Leo Szumel, Department of Electrical and Computer Engineering
University of California, Davis

A wireless sensor network is formed out of nodes, each of which has a small computer, sensing abilities, and a radio; nodes are typically battery powered. The potential advantages of using a wireless sensor network, as compared to traditional methods of manual sampling or remote data logging, include: more timely data, reduction or elimination of routine field visits, less-invasive measurements, and increased sample rates. We are designing such a network for McLaughlin Reserve, with the specific initial goal of supporting a study on the growth of an invasive plant species (Erodium). Ultimately, the system can be used for other studies. The project is currently in a prototype phase and has taken longer than expected to develop. The main challenges in implementing this system have been practical ones, not the least of which is how to deliver data from a very remote location using inexpensive, yet reliable, mechanisms. Current work focuses on a “store and forward” technique in which data at the field site is collected and stored automatically, but a human is involved in transporting the data over the “last hop” (from the site to the Internet). The invasive species study at McLaughlin is an ideal initial application for this network because the quantities to be measured (soil moisture and temperature) are affordable and well understood. System integration issues provide the main challenge, and potential reward, of this system. Once delivered, McLaughlin reserve will have a system capable of measuring humidity and three temperature probes from each of seven nodes, with the possibility of adding more nodes later.

Understanding shifts of species ranges in response to climate change:
A case study in the Sierra Nevada mountains
Teresa Chuang, Department of Environmental Science, Policy and Management
University of California, Berkeley

There is an acute need to understand how species may shift their geographic ranges in response to climate change, as such shifts have crucial implications for both long-term conservation planning and climate models that incorporate climate-ecosystem feedbacks.
Current bioclimate models predict range shifts upwards in elevation or towards the poles across species, yet remarkably little fieldwork has been done to support these predictions. My research at the Sagehen Creek Field Station is therefore designed to directly test the predictions of such models in an upper montane forest ecosystem. My focus is on seedling dynamics, as the only way in which species shifts in this system could occur would be through successful seed dispersal, recruitment, and regeneration in novel environments. Over the last year, my work has centered on 1) developing climate manipulations that mimic the decreased winter snowpack forecast for the region, 2) transplanting seedlings into novel environments outside of their current range, and 3) monitoring seedling dynamics in situ in response to natural climate variability. Beginning this winter, I plan to combine these three efforts to develop a more mechanistic understanding of how climate change-induced species shifts in this system are likely to occur.

Bio-Heritage of Coal Oil Point: The Experiments of Frederic E. Clements
Donald R. Burnette, Department of History
University of California, Santa Barbara

From 1927 through 1940, the “father of ecology,” Frederic E. Clements (1874-1945), conducted a series of ecological and botanical experiments in and around what is now known as Devereux Slough, minutes north of Santa Barbara, California. During this era, Clements introduced hundreds of species into the coastal dunes and wetlands to carry out his research on adaptation and competition, including exotics such as Machaeranthera canescensw, Nassella pulchra, and Verbascum blattaria. However, he also installed a number of species native to the region including Abronia maritima, Abronia umbellata, Encelia californica, and Eschscholtzia californica, which were transplanted from a number of peripheral sources. This study reveals a unique environment with a distinctive bio-heritage and complex ecosystem in which natural and artificial variation exist simultaneously. The bio-heritage of species and the biota in which they exist is an essential component of understanding and preserving biodiversity. Variation profoundly impacts the study and scope of biodiversity, but the source of such diversity is of equal or greater importance. This research explores the impact of “place” upon both the content and context of science and reveals that non-traditional approaches can assist our understanding of local intraspecific variation. Additionally, interdisciplinary research can be of immense value to traditional biological and ecological research as well as influencing issues surrounding environmental preservation efforts. In addition to the intrinsic value in identifying and recognizing the impact of Clements’s involvement from a historical standpoint, the disclosure of this history enriches the research opportunities at Coal Oil Point Natural Reserve and the overall merit of the University of California Natural Reserve System as a valuable resource for researchers from a range of disciplines.

Bringing a rancher’s diary into the digital age: modeling historical land use with GIS
Jeff Howarth, Department of Geography, University of California, Santa Barbara

Land use is a general term for how people purposefully organize space. As such, land use is an interface between human goals and the natural environment. It is a subject relevant to both ecological scientists and stewards, as historical uses often remain embedded in the
present structure and function of natural ecosystems, while the management programs that respond to these ecological legacies themselves entail the ongoing use of space to achieve conservation goals. Incorporating knowledge of human land use into both ecological research and planning is presently limited by how we represent land use in spatio-temporal databases, which in turn constrains what kinds of information that we can bring into these databases. Our goal is to develop a Geographic Information System (GIS) that can store, retrieve, and integrate land use data from both traditional and non-traditional materials, including maps, global positioning systems, and written texts. We are developing a general framework to model the human use of space based on how natural language and written texts represent human actions and activities. Our data model organizes and stores data based on a small number of semantic roles that have been identified in both computational and cognitive linguistics. We are also developing tools to facilitate bringing textual information into the database. These tools consist of methods to parse texts for specific syntactic constituents that then map to semantic roles. Over the last year, we have been populating the GIS with data derived from various records of historical ranching activities on the Santa Cruz Island Reserve. These records include a rancher’s diary, a historical pasture map, and field surveys of ranching features. By linking the written information in the rancher’s diary to the cartographic data, the GIS allows us to examine patterns of land use that are not depicted on the map. This includes the appearance and disappearance of pastures and other land use features, in addition to spatio-temporal patterns of ranching activities, such as when, where, and why animals were present or moved between certain areas. The availability of written, cartographic, and field data related to the human use of space has made the Santa Cruz Island Reserve an ideal laboratory to develop and evaluate this GIS.

Effects of mate attractiveness on maternal investment in Dark-eyed Juncos
Elise Ferree, Department of Ecology and Evolutionary Biology
University of California, Santa Cruz

To optimize lifetime reproductive success, breeding females should theoretically invest relatively little energy when mated to unattractive males to save energy for later and more beneficial attempts with better males. This variation is predicted by the Differential Allocation Hypothesis (DAH) and is usually measured in terms of clutch size and parental care. Tests in birds have generally supported the DAH, yet these studies failed to measure other potentially essential female responses, specifically, brood sex ratio and extra-pair paternity. I tested the DAH by studying a sexually-selected trait, number of white tail feathers (“tail white”) in Dark-eyed Juncos at Sagehen Creek Field Station. I studied natural trait variation from 2003-2005 and experimentally increased tail white in 2004 and 2005. Based on the DAH, I predicted that females mated to males with high tail white would have larger clutches, provide more care, have more sons (who will benefit from high tail white), and less extra-pair paternity relative to controls. I found no strong differences in clutch size or parental care but did find other interesting patterns. Regarding sex ratio, in my population female and male natural tail white strongly predicted the proportion of sons in a nest. There was also a non-significant trend for increased sons in nests of experimentally enhanced males. Extra-pair paternity probably occurs in around 30% of nests at Sagehen, yet these analyses are still underway. Finally, I found morphological and behavioral patterns that could be related to snowfall variation in the Sierras over the past few years.
Nest predation is the major source of nestling mortality in passerines and should therefore be a prime determinant of traits such as nest site selection and clutch size. I compared these traits between populations of the Orange-crowned Warbler (OCWA) breeding on Santa Cruz and Santa Catalina Islands. Contrary to mainland breeding OCWAs, which are exclusive ground nesters, OCWA breeding on these islands show an unusual plasticity in nest site selection, nesting over a wide range of vegetation strata. Moreover, the islands populations are exposed to different nest predator communities; Santa Cruz is the only Channel Island where the Island Scrub-Jay, a major nest predator, breeds; while Jays are absent from Catalina and avian nest predators are very uncommon. This scenario yields two naturally dissimilar nest predation risks for OCWAs which should result in differences in their nest placement and clutch size. Our preliminary results show that as expected, OCWAs on Santa Cruz Island exposed to the visually oriented avian predators, preferentially nest on the ground and tend to have smaller clutches. On Catalina Island, warblers exposed to lower predation risk and where jays are absent, preferentially nest above the ground and tend to have larger clutches. In addition to providing valuable information on how nest predation affects avian productivity through its effects on nest site selection and clutch size, the present study generated useful information on the breeding biology of a poorly known endemic subspecies of the Orange-crowned Warbler.

Avian response to ecological gradients: variation in bird-habitat relationships along an elevational gradient
Lori Hargrove, Department of Biology
University of California, Riverside

The causes and consequences of the spatial distribution of a species are fundamental issues in ecology and evolution. In vagile organisms such as birds, the behaviors of habitat selection and territoriality largely determine spatial distribution, and are expected to link adaptive traits of individuals to suitable habitat. If the distribution of a species reflects its adaptive niche, then there should be predictable environmental associations, and there should be behavioral and fitness consequences for individuals at distribution margins. My objective is to elucidate the nature of distribution limits by studying species-habitat relationships along an environmental gradient. The Philip L. Boyd Deep Canyon Desert Research Center offers an elevational gradient from 9 to 2,657 meters, along which bird distributions have been documented since 1978. Current distributions and habitat associations will be quantified at Deep Canyon and other similar sites in the region, and compared to historical data at Deep Canyon. In spring 2005, a total of 226 point-transect counts were completed, and 13,233 birds and 126 bird species were detected. Breeding was confirmed for 259 pairs of birds. Distributions will be analyzed over multiple spatial and temporal scales, and within this population-level context, individual-level predictions will be tested. Individuals in marginal areas are predicted to have reduced territorial defense, and reduced foraging and reproductive success. Ultimately, we hope to predict species distributions and response to environmental changes. Results from this study will apply to predictive modeling of bird distributions in response to vegetation and climate change.
The cost of hover-feeding as a function of altitude and temperature in migratory rufous hummingbirds, *Selasphorus rufus*
Kenneth Welch, Department of Ecology, Evolution and Marine Biology
University of California, Santa Barbara

Because of their small size and energetically expensive mode of locomotion, hummingbirds display high rates of energy metabolism. Thus, hummingbirds represent an ideal system in which to gain understanding of how animals achieve energy balance. Migratory rufous hummingbirds (*Selasphorus rufus*) arrive in flowering meadows throughout the Eastern Sierra in the summer and spend a few weeks gaining mass in preparation for the next period of migratory flight. During refueling, *S. rufus* achieve high rates of net energy intake and mass gain, despite the fact that they are often foraging at high altitudes and low ambient temperatures. In order to determine the combined as well as independent effects of increasing altitude and decreasing ambient temperature on hover-feeding metabolic rate, I measured oxygen consumption rate on captive *S. rufus* at several locations along an altitudinal gradient and at a variety of ambient temperatures. Among *S. rufus* in general, decreasing ambient temperature significantly increases hover-feeding metabolic rate. Additionally, increasing altitude also significantly increases metabolic rate during hover-feeding. Data indicate that the effects of these two environmental variables are additive. The additional energetic costs incurred as temperature decreases are relatively greater than the energetic costs incurred as altitude increases over the range of temperatures and altitudes these birds are likely to experience. These results support the hypothesis that the evolution of larger hummingbird body size in those species that are found at higher altitudes is the result of selection for greater thermoregulatory capability rather than for aerodynamic constraints.

Competitive mechanisms driving the *Holcus lanatus* invasion
Adrianna A. Muir, Department of Evolution and Ecology
University of California, Davis

Explanatory mechanisms underlying the competitive invasiveness of invasive plants and the resulting displacement or coexistence of native plants are an understudied facet of invasion ecology. Release from natural enemies and soil biota-mediated processes are both theoretical hypotheses that offer testable predictions for invasion processes and competitive contexts. This research uses the *Holcus lanatus* invasion at Bodega Marine Reserve as a model study system in which to test these hypotheses. Above ground insect and fungi enemies were manipulated by spraying insecticide and fungicide in field plots. As expected, preliminary results from the first year of this experiment showed no significant release for *H. lanatus* in neither cover nor height. The second year of this field experiment may show an increase in magnitude. In addition, there was a significant increase in the height of one native competitor plant species. Exploration of soil-biota mediated processes will take place through greenhouse manipulations to be completed during the winter of 2005-06. Results from this experiment will clarify whether the coexistence or exclusion of competitive species is due to interactions between *H. lanatus* and soil biota. Future greenhouse experiments will explore the potential of *H. lanatus* acting as a selective agent on competitive species in the coastal prairie. Research that explores underlying competitive mechanisms can directly aid selection of effective control strategies for invasive plant management.
Understanding the link between environmental heterogeneity and seed dispersal in the invasive annual, *Erodium cicutarium*
Brooke Baythavong, Population Biology Graduate Group
University of California, Davis

Plant distributions are, in part, determined by environmental heterogeneity on both large (landscape) and small (several meters) spatial scales. Plant populations can respond to environmental heterogeneity via genetic differentiation between large distinct patches, and phenotypic plasticity in response to heterogeneity occurring at small scales relative to dispersal distance. *Erodium cicutarium* has partially invaded serpentine soils in Northern California, which impose variable and harsh abiotic stress on plants growing there. I have measured the extent of heterogeneity in soil chemistry, above-ground competitor biomass, water availability, and con specific competition on a spatial scale relevant to the dispersal of individual seeds of *E. cicutarium*, as well as their influence on offspring fitness when dispersed 0, 0.5, 1 and 10 meters from a maternal home site in serpentine and non-serpentine soil patches. Preliminary analyses indicate a distinct fitness peak when seeds are dispersed 0.5 meters from their maternal home site on serpentine patches, while in non-serpentine patches fitness is uniformly higher any distance away from the maternal home site. These results indicate the potential for differential selection on dispersal distance both on small spatial scales (0.5 meters) and large spatial scales (50 to 100 meters) between patches of serpentine and non-serpentine soils at the UC McLaughlin reserve.

Effects of nutrient enrichment on the relationship between a parasitic plant and its hosts
Julie Simpson, Department of Ecology, Evolution, and Marine Biology
University of California, Santa Barbara
Steve Pennings, University of Houston

The supply of biologically available nitrogen is increasing dramatically worldwide, particularly in coastal habitats. Increases in N availability to plants can increase tissue N concentration, and many herbivores have been shown to prefer prey plants with higher N. Parasitic plants are somewhat analogous to herbivores in that they obtain nutrition from their host plants, but it is not known if parasitic plants have similar preferences for elevated nitrogen. We fertilized plots in the Carpinteria Salt Marsh Reserve that were dominated by *Salicornia virginica* (pickleweed) and/or *Jaumea carnosa*. Both of these plants are commonly infected with the holoparasite *Cuscuta salina* (dodder). We measured percent cover of *Cuscuta* in fertilized and unfertilized plots, and sampled tissue carbon and nitrogen in both *Cuscuta* and host plants. We also analyzed the stable isotope ratios of carbon and nitrogen in both parasite and host plants to see if stable isotopes were fractionated between host and parasite, and if food quality influenced the magnitude of the fractionation. Percent cover of *Cuscuta* increased in fertilized plots. Nitrogen content of hosts and parasite plants increased in fertilized plots, but fractionation of nitrogen isotopes was not observed. Thus holoparasites appear to respond similarly to herbivores in their preference for plants with higher N content, but there are likely biochemical differences in the way they process host nutrition. This parasite appears to feed more aggressively on hosts with higher N content, suggesting that eutrophication may indirectly affect marshes through impacts of *Cuscuta* on their biomass and community composition.
The opposing effects of competition and facilitation on preservation of genetic diversity in an annual plant (*Plantago erecta*)

Erin K. Espeland, Ecology Graduate Group, Department of Plant Sciences
University of California, Davis

Effective population size (Ne) is a critical index of population endangerment and is a fundamental unit of population genetics. Populations with low Ne are more susceptible to genetic drift compared to populations with large Ne. Models of plant competition predict that asymmetrical competition for light (large plants have higher relative growth rates than smaller plants due to shading) will increase size variance among individuals. In a population where few individuals are large and fecund, they disproportionately contribute to the gene pool of the next generation (reducing Ne). In annual plants, reproductive variance (RV) is strongly correlated with size variance. We would expect that increased plant densities and stronger competition for light would increase RV and reduce Ne. This effect would be expected to be less strong on serpentine soils, where the greatest intensity of competition is below ground and is more symmetrical. By manipulating *P. erecta* densities in plots with and without competition on serpentine and nonserpentine sites, I found a difference between intra- and inter-specific competition, where increased intraspecific competition drove RV down (increasing Ne) and also increased fitness. Increasing interspecific competition decreased plant fitness and increased RV (decreasing Ne). The facilitation that occurred among *P. erecta* plants was a stronger driver of RV than the competition *P. erecta* experienced from other species, and soil type did not affect RV. This might indicate that *P. erecta* is less affected by competition for light than plant competition models predict.

Geographic variation in a species interaction network: Interactions between *Greya* and *Lithophragma* in California

Kate Horjus, Department of Ecology and Evolutionary Biology
University of California, Santa Cruz

The nature of an interaction between two species can show considerable variation across space. We know that this variation can be driven by the presence or absence of additional, unrelated species in the community. In addition, pairwise interactions are commonly embedded within a more phylogenetically and ecologically complex system of coevolving networks. For example, interacting species may diverge over time and across space, assembling into interaction networks of related species replicated within different communities. A current challenge of evolutionary biology is to understand how networks of interacting species are influenced by the ecological context in which they occur and the phylogenetic constraints that are inherent to related species. This research addresses this challenge using an interaction network between two related moth species (*Greya politella* and *G. obscura*) and two related plant species (*Lithophragma parviflorum* and *L. heterophyllum*) that is widespread in the California Coast Ranges. For the past two years I have collected field data to evaluate how each species of *Greya* is using each *Lithophragma* species throughout the Coast Ranges. These data have revealed that the interaction networks are stable across years, but differ geographically in how moths are using each species of *Lithophragma*. Current work is addressing the geographic variation in *Greya* host plant preference and the evolutionary history of the Coast Range populations of moths and plants.
Abstracts

A latitudinal comparison of thermal tolerance and gene expression patterns in Nucella larvae
Mackenzie Zippay, Department of Ecology, Evolution and Marine Biology
University of California, Santa Cruz

As environmental temperatures increase globally, biologists are exploring the consequences this will have on coastal and near shore species’ distributions. It has been suggested that species with limited gene flow, such as benthic invertebrate communities, should be more likely to exhibit geographic differentiation in response to different climatic regimes than species with greater dispersal potential. If the climate change is sufficiently extreme, it could shift the distribution of an organism and ultimately, decrease population abundance. One critical step in understanding how temperature will affect biodiversity in coastal ecosystems is to gain insight into how the tolerances, and ultimately survival, of early life history stages will influence the distribution and abundance of adults. Not surprisingly, embryos are hypothesized to have a greater sensitivity to high temperatures as compared to adults. In order to further explore this issue, determining the thermal tolerance threshold and gene expression pattern of whelk larvae (genus Nucella) that are found on the west coast will ultimately help to answer a larger question of how climate change affects biodiversity in reserves and supply us with additional information about adult population distribution.