The University of California
Natural Reserve System
2004 MATHIAS SYMPOSIUM

Bodega Marine Laboratory/Reserve
February 27-29, 2004

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THE CALIFORNIA ENVIRONMENT PROVIDED TO THE NATURAL RESERVE SYSTEM BY
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LECTURERS

Frank Davis (PhD Johns Hopkins, 1982) is a professor in both Geography and in Environmental Science and Management at UCSB. Between 1995 and 1998 he served as Deputy Director of the National Center for Ecological Analysis and Synthesis, a National Science Foundation Center at UCSB that sponsors synthetic, interdisciplinary ecological research. His expertise is in terrestrial biogeography, plant ecology, and conservation biology. His research has focused on the ecology of California chaparral and oak woodlands, and on the use of digital satellite data and geographic information systems for mapping vegetation, modeling species distributions, Gap Analysis, and conservation planning.

Davis has been involved in a variety of large-scale conservation and ecosystem management project, serving as principal investigator of the California Gap Analysis Project, a Science Team member on the USDA Forest Service Sierra Nevada Ecosystem Project, and related research projects for NASA, EPA, the USDA Forest Service, the Nature Conservancy, and the Resources Agency of California.

Susan Harrison (Ph.D. Stanford University, 1989) is a professor in the Department of Environmental Science and Policy at UCD. She is also the UC Davis faculty director for the UC Natural Reserve System. Her fields of research are plant population and community ecology, invasion biology, and conservation. She is especially interested in the role of landscape structure, such as habitat patchiness and heterogeneity, in shaping patterns of natural diversity. Much of her current research concerns plants on serpentine soils in California.

Susan Harrison teaches ecology and conservation biology, and is active in regional conservation organizations.

2004 MATHIAS SYMPOSIUM

Bodega Marine Laboratory / Reserve February 27-29, 2004

FRIDAY, Feb. 27, 2004

12:00 – 1:20 p.m.	Lunch (Food service 12:00-12:45)
1:30 – 2:00 p.m.	Peter Connors - Introduction to Bodega Marine Laboratory and Reserve
2:00 – 2:20 p.m.	***Locating marine reserves based on coastal features: coupling ocean circulation and larval settlement around a headland*** Amber J. Mace (UCD)
2:20 – 2:40 p.m.	***Effects of water speed and meiofauna flux on the distribution of benthic suspension-feeding Hydropsychid caddisfly larvae* (*Trichoptera*: Hydropsychidae)** Sarah E. May (UCLA)
2:40 – 3:00 p.m.	***Characterizing the nearshore fish assemblage of the Scripps Coastal Reserve*** Matthew T. Craig (UCSD)
3:00 – 3:20 p.m.	***Neurobiological mechanisms of host behavior modification in the California killifish*** Jenny C. Shaw (UCSB)
3:20 – 3:40 p.m.	Break
3:40 – 4:00 p.m.	***Parasites of parasites: selfish genes and genetic conflict in* Trichogramma** James E. Russell (UCR)
4:00 – 4:20 p.m.	***Spatial and phylogenetic mosaics of antagonistic coevolution: a study of resistance structure variation in wild flax (genus* Hesperolinon*)*** Yuri Springer (UCSC)
5:00 – 6:00 p.m.	Tour of Laboratory
6:15 – 7:45 p.m.	Dinner (Food service 6:15-7:00)
8:00 – 9:00 p.m.	***Plant diversity on serpentine soils*** Susan Harrison
9:00 –10:00 p.m.	Social

SATURDAY, Feb. 28, 2004

7:15 – 8:30 a.m.	Breakfast (Food service 7:15-8:00)
9:00 – 9:20 a.m.	***Effects of climate change and grazing on the invasive annual grass***, Bromus tectorum Alden Griffith (UCSC)
9:20 – 9:40 a.m.	***Plant invasion impacts soil aggregation and soil carbon in serpentine soils*** K.M. Batten (UCD)
9:40 –10:00 a.m.	***Nitrogen transformations in native perennial and exotic annual grasslands in California*** Sophie S. Parker (UCSB)
10:00 – 10:20 a.m.	***Resource-modification interactions in a grassland detrital foodweb*** Justin Bastow (UCD)
10:20 – 10:40 a.m.	Break
10:40 – 11:00 a.m.	***Evaluating prehistoric land and resource use along the Cambria coastline, San Luis Obispo County*** Terry L. Joslin (UCSB)
11:00 – 11:20 a.m.	***Taxonomic diversity and composition of communities of benthic algae and photosynthetic bacteria in a southern California wetland system: landscape-level patterns and influences on productivity*** Christopher N. Janousek (UCSD)
11:20 – 11:40 a.m.	***Ecological consequences of gene flow in an intertidal alga*** Cynthia Hays (UCSC)
11:40 – 12:00 noon	***Significance of particle-associated bacterial communities in denitrification along a nitrate gradient in Carpinteria Salt Marsh*** Yiping Cao (UCSB)
12:15 – 1:30 p.m.	Lunch (Food service 12:15-1:00)
1:30 – 3:30 p.m.	Tour of the Reserve
4:00 – 4:20 p.m.	***The effects of nectar reward quality on hummingbird foraging behavior: implications for the evolution of dilute sucrose concentration in*** **Ipomopsis aggregata** Aaron Gabbe (UCSC)

4:20 – 4:40 p.m. ***Getting fat in thin air: the cost of hover-feeding as a function of altitude and temperature in migratory rufous hummingbirds* Selasphorus rufus**
Kenneth Welch (UCSB)

4:40 – 5:00 p.m. ***Adult responses to fear screams of young California towhees* (Pipilo crissalis) – *the role of vocal recognition***
Lauryn Benedict (UCB)

5:00 – 5:20 p.m. ***Thinning populations of Valley Oak: female flower production, pollen neighborhoods, acorn production***
Bill Kuhn (UCSB)

6:15 – 7:45 p.m. Dinner (Food service 6:15-7:00)

8:00 – 9:00 p.m. ***Planning to conserve California's biodiversity***
Frank Davis

9:00 – 10:00 p.m. Social

SUNDAY, Feb. 29, 2004

7:15 – 8:30 a.m. Breakfast (Food service 7:15-8:00)

9:00 – 9:20 a.m. ***Biomechanics and life-history strategy of an intertidal seaweed***
Bryce D. Wolcott (UCB)

9:20 – 9:40 a.m. ***Does natal habitat type affect habitat selection by dispersing brush mice,* Peromyscus boylii***?*
Karen Mabry (UCD)

9:40 – 10:00 a.m. ***Induced effects of herbivory on reproductive tissues in* Nicotiana attenuata *(Solanaceae)***
Andrew C. McCall (UCD)

10:00 – 10:40 a.m. Break

10:40 – 11:00 a.m. ***Predator induced phenotypic plasticity and local adaptation in Pacific treefrogs***
Michael Benard (UCD)

11:00 – 12:00 noon Forum: ***Future issues and career choices in environmental science***

12:10 – 1:30 p.m. Lunch **[End of symposium]**

ABSTRACTS

Locating marine reserves based on coastal features: coupling ocean circulation and larval settlement around a headland

Amber J. Mace, Ecology Graduate Group, University of California, Davis

Oceanographic processes affect transport of marine invertebrate larvae and strongly influence larval distribution along the coast of California. I examined how a small-scale topographic feature, Bodega Head (~6 km), affects larval transport, retention, and settlement of marine invertebrates including crabs, mussels, barnacles, and urchins. The marine portion of the Bodega Marine Reserve (BMR) is located around Bodega Head, which is the focus of the ocean circulation and larval settlement aspect of this project. The BMR is also important to this study because it is the subject of a proposed boundary expansion and it provides a basis for the evaluation of the placement of no-take marine reserves. I deployed three replicate moorings with artificial substrate settlement collectors at multiple sites around Bodega Head in 2000, 2001, 2002, and 2003. Each mooring had collectors at two depths (surface and bottom) and consisted of a mesh bag containing 3 Tuffy scrub pads, and a barnacle plate. I sampled these collectors every 1-15d during the peak settlement and upwelling season of April through September. I collected continuous salinity, temperature, and wind stress data and weekly site-based CTD data. I found that larval settlement was higher in the lee of the headland than along the windward side, indicating the presence of a retention zone. These results also indicated that species richness and abundance of settlers differed significantly between the surface and the bottom, suggesting multiple mechanisms for larval transport. This research will inform our understanding of how ocean circulation and topography affect larval distribution and abundance. This information is critical to making an informed decision concerning the Marine Life Protection Act's proposed boundary expansion of the BMR. It is also necessary to evaluate the effective placement of marine reserves in general.

Effects of water speed and meiofauna flux on the distribution of benthic suspension-feeding Hydropsychid caddisfly larvae (Trichoptera: Hydropsychidae)

Sarah E. May, Department of Organismic Biology, Ecology and Evolution, University of California, Los Angeles

Spatial distributions of passive suspension feeding caddisfly larvae were examined in relation to changing water flow parameters in artificial stream channels in Sierra Nevada, California. Instar V net densities of Hydropsychid caddisflies were not significantly related to water speed ($p = 0.9949$, Spearman's Rho) in riffles, but the change in net densities in riffles was significantly related to water speed ($p = 0.0016$, $r = 0.23$ polynomial regression). Water speeds in riffles below about 40cm/s experienced losses in net densities and the loss rate increased with decreasing water speeds. Above 40 cm/s there was no correlation of density change with water speed. Settling of hydropsychid instars on artificial hemispheres was significantly related to water speed in riffles ($p < 0.0001$, Spearman's Rho) and highest settling densities occurred between 40 and 60 cm/s. Significantly higher numbers of meiofauna were caught in the drift just after dusk. Channel one, which had the highest caddisfly larval densities at the beginning of the experiment, had the highest ratio of drifting animals to organic matter

suggesting that the quality of food delivered to this channel might account for the high densities of caddisfly larvae present throughout the experiment.

Characterizing the nearshore fish assemblage of the Scripps Coastal Reserve

Matthew T. Craig, Scripps Institution of Oceanography, University of California, San Diego

Marine reserves are quickly becoming a primary tool in the management of coastal resources worldwide. With a growing demand for appropriate management strategies and enforcement of existing regulations, an urgent need has developed to obtain baseline data for regional faunal assemblages. In an attempt to develop a comprehensive list of fishes for one of California's southernmost marine reserves, nearshore marine species were qualitatively sampled within the Scripps Coastal Reserve (SCR). A variety of techniques were used over the calendar year 2002 including visual surveys, otter trawls, gill nets, beach seines, and ichthyocide collections. The fish assemblage of the SCR was typical of other soft bottom habitats in Southern California and was numerically dominated by the specklefin sanddab, *Citharichthyes stigmaeus*. Many were represented by juvenile or young-of-the-year age classes suggesting that the Scripps Coastal Reserve may serve as critical habitat and nursery ground for several species of nearshore fishes.

Neurobiological mechanisms of host behavior modification in the California killifish

Jenny C. Shaw, Department of Ecology, Evolution, and Marine Biology, University of California, Santa Barbara

The California killifish (*Fundulus parvipinnis*) is an abundant estuarine fish throughout Southern California and Baja California. At Carpinteria Salt Marsh Reserve, the trematode parasite *Euhaplorchis californiensis* infects all killifish over a given size. Typical infections number in the hundreds to thousands, with cysts packed tightly in the fish's braincase. When infected with *E. californiensis*, killifish exhibit conspicuous behaviors, e.g., contorting and flashing near the surface, four times more than uninfected conspecifics. By making the fish more visible, the parasite renders it thirty times more likely to be eaten by a bird, the parasite's final host. Trophic transmission occurs when a parasite is transmitted from one host to the next via predation; here the predator is a piscivorous bird, and the prey is a killifish. Parasite-induced susceptibility to predation (PISP) has been postulated as a parasite strategy to increase transmission success for systems involving trophic transmission. Although behavior modification is a well-documented phenomenon, the underlying mechanisms remain relatively unknown. Furthermore, no one has worked out the physiological mechanisms for a system with a clear demonstration of PISP. My research examines the neurobiological basis by which *E. californiensis* manipulates killifish behavior. I will use immunohistochemical methods to detect anatomical and chemical differences between infected and uninfected killifish. Understanding the mechanisms behind behavior modification will increase understanding of the neural basis of behavior and, ultimately, how parasites drive food-web dynamics in coastal wetlands.

Parasites of parasites: selfish genes and genetic conflict in *Trichogramma*

James E. Russell, Department of Entomology, University of California, Riverside

Selfish genetic elements are inherited entities that increase their transmission at the expense of the organism. Two such genetic elements are *Wolbachia*, an intracellular bacterium, and *PSR*, an extra chromosome carried by some species of parasitic wasps in the hymenopteran genus *Trichogramma*. Several Mojave Desert *Trichogramma* species have been found to carry infections of both elements and their frequency and distribution has been the topic of ongoing research for several years. For the past year we have been collecting infection frequency data across the Mojave with the intent of investigating the transmission dynamics of *Wolbachia* and *PSR* within and between species. Our preliminary laboratory results indicate infections of both genetic elements in species previously uninfected; suggesting infections can spread between species. Laboratory experiments with wasps collected in 2003 show variation in the transmission efficiency of *Wolbachia* within species. We are currently investigating the possible role of nuclear suppressers in *Wolbachia* transmission efficiency variation in *Trichogramma* wasps. The biology of these important parasitoids is of interest to ecologists, evolutionary biologists, and those concerned with biological control of agricultural pest species. The University of California Natural Reserve System plays an important role in helping to understand the population dynamics of *Trichogramma*, *Wolbachia*, and *PSR* in a natural setting. The Sweeney Granite Mountain Reserve intersects an area in which three *Trichogramma* species co-occur allowing researchers to investigate the interaction of *Wolbachia* and *PSR* both within and between species.

Spatial and phylogenetic mosaics of antagonistic coevolution: a study of resistance structure variation in wild flax (genus *Hesperolinon*)

Yuri Springer, Department of Ecology and Evolutionary Biology, University of California, Santa Cruz

Despite the numerous and profound impacts of parasites in human, agricultural, and natural systems empirical research on the evolution of antagonistic species interactions in the wild is lacking. A notable consequence of this deficiency is an incomplete understanding of the maintenance and distribution of genetic resistance to parasites. Theory predicts that the context-dependent nature of coevolution should result in heterogeneity in host resistance structure. While these assertions are supported by small-scale research on host-parasite interactions the limited phylogeographic scope of most studies precludes comprehensive documentation of heterogeneity in resistance structure. Such detailed characterization is necessary to 1) quantify the full range of variation in outcomes for a given antagonistic interaction 2) investigate mechanistic explanations for population, species, and clade level coevolutionary patterns, and 3) develop a general framework with which to predict coevolutionary outcomes. My research seeks to advance current understanding of the maintenance and distribution of parasite resistance through an investigation of spatial and phylogenetic variation in host resistance structure. The study focuses on interactions between 13 species of serpentine-associated wild flax (genus Hesperolinon) and a parasitic fungal rust and is premised on the working hypothesis that variation in serpentine-associated edaphic conditions experienced by host plants may affect the frequency and/or consequences of parasite infection and contribute to patterns of spatial and phylogenetic variability in host resistance structure.

Effects of climate change and grazing on the invasive annual grass, *Bromus tectorum*

Alden Griffith, Environmental Studies, University of California, Santa Cruz

The invasion of the annual grass *Bromus tectorum* (Poaceae; Cheatgrass) into sagebrush communities of the North American intermountain West has produced profound ecosystem-level effects. This drastic ecological change – at its extreme, from native sagebrush communities to cheatgrass monocultures – has dramatically altered fire regimes, creating a positive feedback loop between increased fire frequency and cheatgrass dominance. It is likely that poor grazing management was instrumental in the successful invasion of *B. tectorum,* and that future research-informed management practices will be important for its widespread control in the face of climate change. An ongoing factorial experiment investigating the effects of grazing and reduced snowfall on *B. tectorum* was initiated during the winter of 2002-2003 at the Valentine Eastern Sierra UC Reserve (SNARL unit). Demographic and physiological measurements aim to uncover population-level effects and controlling mechanisms on *B. tectorum* abundance and production. Results from the first field season reveal a strong positive effect of grazing on *B. tectorum* total biomass and abundance. Grazing also negatively affected soil water potential and percent water content through June, well after snowmelt. However, the snow removal treatment did not significantly affect soil moisture or leaf-level photosynthetic gas exchange of *B. tectorum* and the native grass *Elymus elemoides.* Continued work will build upon this first season to investigate responses to long term climate trends.

Plant invasion impacts soil aggregation and soil carbon in serpentine soils

K. M. Batten, Department of Land, Air, and Water Resources, University of California, Davis

Increased soil aggregation is often considered desirable, especially in agriculture or when restoring degraded soils. However if invasive plants increase soil aggregation in invaded serpentine soils, they may be "improving" the quality of these soils, potentially facilitating future invasions and affecting the success of restoration projects. Our previous research has shown that the soil rhizosphere microbial communities of two invasive plants, *Aegilops triuncialis* (barb goatgrass) and *Centaurea solstitialis* (yellow starthistle), have higher concentrations of a fatty acid biomarker for fungi (18:3_6c 6,9,12) compared to the rhizospheres of the native plants examined (*Plantago erecta*, *Lasthenia californica*, *Hemezonia congesta*, *Holocarpha virgata*, and *Lotus wrangelianus*). Additionally, goatgrass rhizospheres are enriched in an arbuscular mycorrhizal fungi (AMF) biomarker fatty acid (16:1_5c). Fungi produce carbon compounds which aid in soil aggregation, such as ergosterol and glomalin. AMF also increase soil aggregation through production of hyphae which hold soil particles together. Soil samples from goatgrass, starthistle, and native plant patches were analyzed for water stable aggregate (WSA) distribution and ergosterol and are currently being analyzed for glomalin. Goatgrass appears to be increasing soil aggregation in the areas it invades; however, no differences in ergosterol concentrations were observed between goatgrass and native soil. In contrast, starthistle soil had significantly less ergosterol than native soil, but no differences in WSA distribution were observed between starthistle and native soil. Results from the glomalin analysis are pending. Goatgrass and starthistle appear to have different effects on soil structure in invaded areas, and these effects may be linked to changes in the soil fungal community.

Nitrogen transformations in native perennial and exotic annual grasslands in California

Sophie S. Parker, Department of Ecology, Evolution, and Marine Biology, University of California, Santa Barbara

Given that nitrogen is the most common limiting nutrient in California grassland soils, and that the introduction of even a single plant species can have large effects on nitrogen cycling in an ecosystem, the invasion of native perennial bunchgrass communities by exotic species of annual grasses from Europe raises many questions regarding the processing and retention of nitrogen in these systems. We have employed a mechanistic approach to understanding these changes by using experimental grassland plots with homogeneous initial soils at Sedgwick Reserve. Plots were seeded with a mix of either native perennial grasses (*Nassella pulchra*, *Bromus carinatus*, and *Elymus glaucus*) or nonnative annuals (*Bromus hordeaceus*, *Bromus madritensis*, and *Hordeum murinum*). We quantified leaching losses of nitrate, ammonium, and dissolved organic nitrogen, and measured rates of microbial nitrogen transformations (mineralization, nitrification, and denitrification) to examine the relative importance of these different processes in contributing to nitrogen loss from each grassland type. Nitrogen fertilization was used as a tool better understand process interactions. We made measurements over two growing seasons in order to characterize changes in process rates over the course of the year. Exotic annual grass stands may be somewhat more "leaky" with regard to nitrogen than stands of native perennial grasses. Seasonal trends in microbial process rates that correspond with soil moisture indicate that rates of nitrification and denitrification, as well as leaching losses, are controlled by rainfall, or the lack thereof.

Resource-modification interactions in a grassland detrital foodweb

Justin Bastow, Population Biology Graduate Group, University of California, Davis

Species may interact when they modify resources used by other members of the community. In the coastal prairie of the Bodega Marine Reserve, the dominant woody shrub is the yellow bush lupine, *Lupinus arboreus*. *L. arboreus* forms dense stands of 3 /m^2, which experience periodic mass die-offs. I was interested in the fate of the woody debris (approximately 1400g / m^2) produced by such die-offs. The most abundant macrodetritivore in this system is the sowbug *Porcellio scaber*. *P. scaber* reaches densities of over 300 /m^2 and increases decomposition rates by as much as 40%. When feeding on lupine wood, *P. scaber* inhabits caverns formed by the root and stem-boring caterpillar *Hepialus californicus.* This suggests that *H. californicus* facilitates *P. scaber*'s utilization of lupine wood by modifying its structure. Because *P. scaber* is an important detritivore and *L. arboreus* a prodigious nitrogen fixer, the facilitation of *P. scaber* by *H. californicus* may have important consequences for the rate of decomposition and nutrient cycling in the coastal prairie. In order to test this interaction, I used a litterbag experiment with bagged lupine wood. Simulated *H. californicus* boring (vs. no simulated boring) was crossed with sowbug access (vs. sowbug exclusion) in order to measure the impacts of both these species on the decomposition of lupine wood, as well as their interaction. This experiment will run for two years, with litterbags collected every six months.

Evaluating prehistoric land and resource use along the Cambria coastline, San Luis Obispo County

Terry L. Joslin, Department of Anthropology, University of California, Santa Barbara

The Kenneth Norris Rancho Marino Reserve provides a diverse ecological setting for the study of prehistoric settlement and subsistence pursuits along the northern coastline of San Luis Obispo County. The current research is designed to investigate the choices and timing of human resource use within various ecosystems (rocky shoreline, coastal grasslands, Monterey Pine forest, and Coast Live Oak woodland) and how these decisions effect settlement patterns. Initial results from a recent survey and excavation program have provided new perspectives on prehistoric populations along this stretch of coastline. Excavation data and spatial information suggest the preferred settlement locations were along ocean terraces in the open grassland, with dietary preferences that shifted over time during the middle and late Holocene. These changes are apparent in transitions in terrestrial and marine subsistence remains, artifact assemblages, and subsurface features. Subsistence pursuits appear oriented towards a diversity of rocky intertidal species dominated by black turban snail (*Tegula funebralis*), red abalone (*Haliotis rufuescens*), and limpet species, with the importance of the black turban snail and near shore fisheries increasing over time.

Taxonomic diversity and composition of communities of benthic algae and photosynthetic bacteria in a southern California wetland system: landscape-level patterns and influences on productivity

Christopher N. Janousek, Scripps Institution of Oceanography, University of California, San Diego

In coastal marine wetlands, resident communities of benthic algae and photosynthetic bacteria (microphytobenthos) support important community functions such as primary production. Microphytobenthic communities in wetlands may show variable composition in time and space. In this research summary, I will describe the results of a mensurative (non-controlled) study of microphytobenthic diversity and composition in wetlands in Mission Bay, San Diego, California, a system characterized by both restored and natural habitat and a variety of wetland landscapes: vegetated salt marsh, creeks and intertidal mudflat. Photopigment data collected from creek-bank sediment communities suggests that variation in taxonomic diversity, largely the result of differences in the evenness of major taxonomic groups, was not positively associated with chlorophyll a-normalized production rates. Productivity was, however, positively related to the degree of diatom dominance but was unrelated to the dominance levels of other taxonomic groups. In addition, there was no significant correlation between taxonomic diversity and microalgal standing biomass (chlorophyll a). Overall, these results tentatively suggest an important role for diatoms as major producers but little effect of diversity on productivity. Using additional sediment samples, I will also explore the hypotheses that there are (a) landscape-level differences in the biomass, diversity and composition of microphytobenthic communities and (b) differences in those features between natural habitat and restoration site communities. I argue that an understanding of the patterns of variability in microphytobenthic communities and how changes in composition and diversity influence their functional roles will help us better understand overall functional dynamics within wetland ecosystems.

Ecological consequences of gene flow in an intertidal alga

Cynthia Hays, Department of Ecology and Evolutionary Biology, University of California, Santa Cruz

Gene flow across a changing environment can counter natural selection and prevent adaptation; this may have profound consequences for the way that different species are distributed in space. My research examines the effects of gene flow on adaptation to, and distribution across, a strong environmental gradient, using the alga *Silvetia compressa* and its distribution in the intertidal zone as a model system. This work includes (1) mapping the gradient in emersion time spanned by *S. compressa* populations at selected sites from Bodega Marine Reserve to San Diego and examining how genetic structure varies across the intertidal gradient and among populations; (2) measuring dispersal distance directly by mimicking colonization events; (3) assessing local adaptation to position in the intertidal zone with reciprocal transplant and common garden experiments; and (4) directly testing the consequences of gene flow across the gradient by conducting controlled crosses and outplanting zygotes into the field. My results thus far suggest that both positive and negative effects of gene flow on fitness (i.e. reduction of inbreeding depression and disruption of local adaptation) may be important in this system at different spatial scales. Recent theoretical advances have shown that gene flow and local adaptation may jointly determine species distributions, yet for no organism do we currently understand how these processes interact at the edges of a range. The results of this study will provide a key empirical test of current thinking on the antagonistic effects of gene flow among different selective environments.

Significance of particle-associated bacterial communities in denitrification along a nitrate gradient in Carpinteria Salt Marsh

Yiping Cao, Donald Bren School of Environmental Science & Management, University of California, Santa Barbara

Particle-associated bacteria that are encapsulated in an exopolymeric substance (EPS) are often called bacterial biofilms, as opposed to planktonic bacteria. Research has shown that the biofilm growth mode provides both survival and metabolic advantages to bacteria, in that the EPS protects against environmental stresses and creates physical microenvironments that favor metabolic cooperation between different bacteria. For example, the complete denitrification process that reduces nitrate to nitrogen gas usually requires multiple bacterial species. Also, EPS can inhibit oxygen diffusion, which is another advantage for denitrification. However, the differences in denitrification by biofilm communities versus planktonic communities haven't been specifically evaluated before. In this research, denitrification capacity, abundance and diversity of denitrifiers are compared between biofilm and planktonic communities. The hypothesis is that biofilm denitrification communities are more abundant and possess higher denitrification capacity compared to their planktonic counterparts. Four sites in the Carpinteria Salt Marsh with different nutrient levels (NO_3^- and total carbon) were selected. Preliminary data show that total carbon and denitrifier population size are important determinants of denitrification potential. Furthermore, denitrification does occur in particle-associated communities and particle size appears to influence the population size of denitrifiers and denitrification potential. A linear regression model is proposed to test the overall hypothesis.

The effects of nectar reward quality on hummingbird foraging behavior: implications for the evolution of dilute sucrose concentration in *Ipomopsis aggregata*

Aaron Gabbe, Department of Environmental Studies, University of California, Santa Cruz

A discrepancy exists between the dilute sugar concentrations of nectar in hummingbird pollinated flowers (~25-30%) and the sweeter nectar invariably preferred by hummingbirds in experimental trials (40-65%). Plants that secrete sweeter nectar should be more attractive to pollinators. It is therefore expected that competition between plants for pollinators would lead to the evolution of nectar with sucrose concentrations preferred by hummingbirds. Why then, do hummingbird-pollinated plants produce dilute nectar? I manipulated artificial nectar in *Ipomopsis aggregata* to test the hypothesis that the sucrose concentration that maximizes pollination rate, and hence plant reproductive success, should be subject to stabilizing selection. An optimal, dilute concentration (similar to natural levels) will balance the tradeoffs between being sweet enough to attract hummingbirds but not so sweet that hummingbirds become quickly sated and reduce inter-plant pollination and/or increase intra-plant pollen movement. Using florescent dye as a surrogate for pollen, I compared pollen transfer, pollen donation, and seed set between plants receiving three different levels of artificial nectar: 18%, 30%, and 45%. Pollen donation, receipt, and seed set did not differ between plants receiving different sucrose concentrations although plants with medium and high concentrations tended to export more pollen than low concentration plants. The lack differential fitness response is likely because dye treatments were only conducted for a two week period in which pollinator abundance was extremely high and plants had extraordinarily high visitation rates. In ensuing field seasons I will conduct dye treatments throughout the field season to evaluate seasonal differences in selective regime.

Getting fat in thin air: 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 effects of increasing altitude and decreasing ambient temperature on hover-feeding metabolic rate, I measured oxygen consumption rate and wing-beat frequency on captive *S. rufus* at several locations along an altitudinal gradient and at a variety of ambient temperatures. Among adult female *S. rufus*, increased altitude significantly increases hover-feeding metabolic rate. After taking the effect of altitude into account, hovering metabolic rate is increased at both extremes of temperature (high and low). The relative intraspecific competitive dominance of *S. rufus* is dependent upon its age-sex class. A greater understanding of intraspecific variability in locomotory and foraging costs,

and the effects of altitude and temperature shall lead to better understanding of optimal foraging strategies, and will help to predict if dominance relationships are consistent across the range of these environmental variables.

Adult responses to fear screams of young California towhees (*Pipilo crissalis*) – the role of vocal recognition

Lauryn Benedict, Department of Integrative Biology, University of California, Berkeley

This project assessed the ability of adult California Towhees to recognize their offspring on the basis of vocal cues alone. Breeding pairs of adult towhees were given a preference test in which they could choose between playback of screams produced by their own chick and playback of screams produced by an unfamiliar chick. Fear screams were employed as a test vocalization because adult California Towhees show a strong approach response to chick fear screams, providing a convenient behavioral measure of interest. If adult California Towhees can recognize their young by voice, they should show a preference for the scream playback of their own offspring. Experimental trials were constructed in such a way that chick location, chick age and chick appearance were not informative to the responding adults. Preliminary analyses suggest a positive approach response to fear scream playbacks, but no preference for familiar over unfamiliar chicks. Further experiments will test the hypothesis that the location and/or age of a screaming chick affect adult responses to the fear signal. Results will be used to inform future studies of the function of fear screams among California Towhees.

Thinning populations of Valley Oak: female flower production, pollen neighborhoods, and acorn production

Bill Kuhn, Department of Geography, University of California, Santa Barbara

Populations of oaks in California have been subject to both large-scale removal as well as stand thinning. Among extant stands, inter-tree distance declines, and may have negative consequences for gene flow, and maintenance of population genetic diversity (refs). Oaks are wind pollinated and obligate crossers. Recent study has found that acorn production declined as density of blue oaks decreased and an ongoing study of valley oaks has found the large majority of pollen flow to be restricted within a narrow distance from the source tree (father).

Among many factors that may contribute to individual tree acorn production is the effort allocated to production of female flowers that may vary among trees in a population. Valley oak female flower production and acorn production were measured within populations of valley oak (*Quercus lobata*) on UC managed Sedgwick Reserve, Santa Barbara County. In the fall of 2001, visits were made to the reserve to select potential sampling trees. Trees were selected that were mature (at least ~150 years old) and in good physical condition, and with an adequate number of branches that reached to within viewing distance from the ground. A total of 78 trees were sampled in Spring 2002 for female flower production. In the fall, the trees were sampled for acorn production.

Linear regression analysis found that female flower production was not a predictor of tree acorn production. The same analysis also found that distance to nearest neighbor (potential pollen donor) was also not a predictor of tree acorn production. It is likely that acorn production is determined by a number of factors, female flower production and potential

donors just two of many. Past research has suggested that these factors include an anisotropic pollen flow regime, tree interference, topography, weather conditions during pollination period, cycles of acorn production (masting), and the previous winter's rainfall. The results suggest that flower production is not a critical or important factor in determining tree acorn production. Results also suggest that, at least at the tree spatial geometry encountered, distance to nearest pollen neighbor (assuming isotropic effects) is not a factor affecting tree acorn production.

Biomechanics and life-history strategy of an intertidal seaweed

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Plants and animals living in the rocky intertidal zone are subject to violent water motion beneath broken waves. Damage and dislodgement in this habitat may contribute to the observation that wave-swept organisms are generally small relative to those in adjacent subtidal and terrestrial communities. To examine the consequences of wave-induced dislodgement on an intertidal seaweed, *Pelvetiopsis limitata* was collected monthly from a wave-exposed site within the Bodega Marine Reserve. I measured plant size, reproductive effort, and attachment strength of 25 individuals each month. Hydrodynamic forces imposed on algae in the field were estimated using a mechanical model of a flexible seaweed in flow. Maximum flow velocities and their accompanying wave periods each month were calculated using buoy recordings of offshore wave height, and lab measurements provided parameter values for the model. The model predicts that imposed forces increase faster with algal size than attachment strength, leaving larger individuals more susceptible to being ripped from the rocks by large waves. Model results incorporating seasonal variation in wave height were consistent with field observations that algae were small during the winter, when waves were large. *P. limitata* was reproductive only during summer and fall, when algae were large and waves were small. This species illustrates a life-history strategy that appears common in the face of temporally-predictable disturbance events; reproduction occurs when large individuals are most likely to survive.

Does natal habitat type affect habitat selection by dispersing brush mice, *Peromyscus boylii*?

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The response of a natal disperser to a heterogeneous landscape, including the location in which the animal eventually settles, may be affected by the animal's familiarity with the different habitat types it encounters as it moves through the landscape. Since dispersal is a key parameter affecting population dynamics, knowledge of how animals respond to different habitat types while dispersing and selecting a new home range is crucial to understanding the population consequences of individual behavior. Both dispersal and habitat selection behavior are likely affected by habitat variation; however, whether animals with experience in a particular habitat type are more likely to move through and/or settle in that habitat type (habitat preference induction, or HPI) remains unknown. I am studying the influence of natal habitat type on dispersal and habitat selection behavior of brush mice born in oak woodland and chaparral habitat types at the Quail Ridge Reserve in Napa County, CA. Brush mice in chaparral and oak woodland habitats have similar densities, survival, and movement rates. In addition, there are abrupt transitions between the two habitat types along canyons and

ridgetops. Thus, both habitat types are available for settlement by dispersers born near the boundary between them. I am radio-tracking juvenile dispersers born in both habitat types, and preliminary results suggest that HPI may influence dispersal and habitat selection behavior of brush mice. The results of this study will have implications for ecological and conservation issues associated with animal movement and settlement patterns in heterogeneous landscapes.

Induced effects of herbivory on reproductive tissues in *Nicotiana attenuata* (Solanaceae)

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Plant herbivory is extremely variable in extent and timing. One response to damage is to alter internal chemistry to ensure protection against future herbivory. This phenomenon, termed induced resistance, has been studied in plant leaf tissue but has rarely been reported in reproductive parts. We conducted research into the possible effects of leaf damage on induced resistance in tobacco (*Nicotiana attenuata*) flowers at the Sierra Nevada Research Laboratory (SNARL). In 2002, we found that mechanical damage significantly reduced floral herbivory (P=0.052), prompting us to repeat the experiment using different methods in 2003. In 2003 we mechanically damaged plants at two sites and looked for responses in floral size and floral herbivory. There were no significant effects of damage on rates of floral herbivory or flower size, although floral herbivory differed significantly among sites (P<0.001). We also attempted to induce resistance in flowers using methyl jasmonate, which is known to induce the production of nicotine in tobacco. Floral damage was not independent of treatment, with a significantly lower percentage of experimental plants receiving floral damage than control plants (P=0.022). Using a broad survey of three populations of tobacco, we also found that plants with severely damaged apices produced significantly smaller flowers than plants with intact apices (P<0.001), suggesting that major herbivory can reduce floral size. Altogether, these results suggest that induced responses in tobacco flowers are possible, and that the response strength varies from year to year and with the type of herbivore damage involved.

Predator induced phenotypic plasticity and local adaptation in Pacific treefrogs

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Predator induced phenotypic plasticity is widespread in nature. Despite many studies examining the benefits and costs of predator-induced phenotypes, there are few studies that test for geographic variation in predator-induced plasticity. I tested for differences in predator-induced phenotypic plasticity between two ponds at the UC Quail Ridge Reserve. Most phenotypic responses did not exhibit genetic differences between the ponds. However, there was a significant genetic difference between the two ponds in overall tail length and the increase in tail length in the presence of non-lethal predator cues. The pond with a higher predator density had the greater degree of the predator-induced tail phenotype. Additionally, there was a significant sire pond X dam pond interaction in size at metamorphosis. As these two ponds are only 3.5 km apart, this indicates that local adaptation can occur on relatively small spatial scales.