Elkhorn Slough Research Project Ideas

The following are some of the many possible questions student researchers are encouraged to attempt to answer at Elkhorn Slough. Some are well-suited to short-term projects, others would require longer efforts, such as thesis research.

We at the Elkhorn Slough National Estuarine Research Reserve particularly encourage projects that examine threats to Slough ecosystems and how best to minimize them. The questions below are organized first by habitat type, then mostly by threats to each. While these questions represent priorities for informing conservation, we're curious and interested in all aspects of the Slough. Feel free to contact Kerstin Wasson (kerstin.wasson@gmail.com) for advice about a project at the Slough. If you would like to conduct research on the Elkhorn Slough Reserve (northeast portion of Slough), you will also need to contact her to apply for a research permit.

1) ESTUARINE HABITATS

- **SALT MARSH LOSS**

What are the major causes of salt marsh degradation in undiked areas?
Some regions of the Slough have had extensive marsh dieback over the past decades, while other have had relatively stable marshes, and still others have even seen gain in marsh cover. Correlative studies linking marsh health to factors such as ground table depth, pore water salinity, sediment types, and sulfide concentrations might shed light on causes of marsh dieback. Manipulative experiments could also test the role of potential factors.

What is the sediment load of Carneros Creek and how much of this is entering Elkhorn Slough?
Elkhorn marshes appear to be subsiding. A greater amount of suspended sediments in the water would help reverse this problem. Historically, a lot of sediment probably came from the Salinas River, which now has been largely diverted from the Slough. One of the biggest sources of sediment at least for the upper estuary may be the water that enters through the tidegates under Elkhorn Road at Hudsons Landing, fed by Carneros Creek and Corncob Canyon. A student could measure the sediment load and estimate its relative importance to the Slough sediment budget.

Do grapsid crabs eat pickleweed or macroalgae?
There are enormous numbers of Pachygrapsus and Hemigrapsus crabs in Elkhorn Slough marshes. Might their abundance be driven by increased macroalgal abundance? Might they be eating pickleweed stems or roots? Conduct mesocosm experiments at a marine lab offering a variety of food options including pickleweed and macroalgae, to determine how favored these are as foods.

What is the distribution and abundance of crabs?
Gather data from transects from channel to uplands and mouth to head of estuary, and quantify abundance of crab borrows (and crabs themselves, from pitfall trapping) relative to these gradients and in relation to channels, tidal creeks and mud pannes. Extrapolate from these estimates to the entire estuary.

What will the future of Elkhorn Slough's salt marshes look like?
Using existing ESNERR data on rates of erosion, subsidence, and marsh dieback, and a variety of published sea level rise projections, conduct a GIS analysis to determine what future distribution of channels, mudflats and marshes will look like.

- **TIDAL EROSION**

What geomorphic or hydrodynamic factors predict erosion rates?
Some channel banks in Elkhorn Slough are undergoing rapid erosion, while others appear to be more stable. Likewise, some mudflats appear to be eroding rapidly, while others have broad expanses of deep mud. Can some of this spatial variation be explained by geomorphic and hydrodynamic factors? For instance, wind strength could be measured at various sites. Plaster could be deployed in channels at various places and disappearance rates quantified as a proxy for current speeds. These factors could be correlated to ESNERRs bank erosion data, to try to explain spatial trends.

How have regulators approached tidal erosion in the past and what regulatory mechanisms could be used in the future to address erosion from dredged channels and harbors?
Some evidence suggests that the dredging of the Moss Landing Harbor may influence tidal erosion in Elkhorn Slough. How have decision makers analyzed this impact elsewhere in the world? What regulatory mechanisms have been used or have potential to be used in our region?

- **TIDAL RESTRICTION**

How do water quality and estuarine assemblages change with distance from tide control structures?
For large sites with water control structures that restrict tidal exchange (e.g., North Marsh or Moro Cojo), do water quality and biotic diversity decline with increasing distance from these structures?

- **HISTORICAL BASELINES**

What range of environmental conditions were typical at the Slough for the past 5000 years?
Use modern isotope techniques to examine fish otoliths and mollusc shells from Native American shell middens to determine relative marine vs. terrestrial inputs to Slough systems.

Which Slough wetlands today most resemble conditions before major human alterations?
Compare indicator assemblages (e.g. forams) at sites with varying amounts of tidal and freshwater influence today, and take cores at these same sites to assess past assemblages. Is today's main channel foram assemblage most similar to that of the main channel 1000 years ago, or most similar to that of a brackish system like Moro Cojo?

How have eelgrass invertebrate assemblages changed since the 1920s?
Repeat MacGinitie's sampling of eelgrass fauna and look for broad changes (missing species? new invaders?).

How important are historical baselines to successful restoration?
The use of historical baselines is an oft-cited restoration practice. But, does referencing historical conditions in any way aid in restoration of communities or organisms? A review of

existing literature and trends could help many restoration professionals better approach their work in many ecosystems.

- **REGIONAL PATTERNS**

How do Elkhorn Slough area brackish marshes compare to others in region?
Most of the Slough's brackish marshes occur in areas with artificial tidal restriction. How do the plant and animal communities of these marshes, and their physical properties such as soils, salinity, and hydroperiod compare to more natural brackish marshes in central California?

What are patterns of estuarine habitat loss and conversion in California's estuaries?
In order to set regional conservation goals, we are missing a synthesis of overall acres of salt marsh, brackish marsh, intertidal mudflat, and subtidal channels today vs. 100-200 years ago (before major human influences). A broadscale GIS analysis would help inform restoration planning.

How do shorebird numbers at Elkhorn compare to those at other wetlands in the region?
Convert shorebird abundance data at Elkhorn into Slough-wide total estimates, and then compare these to numbers from monitoring programs at Morro Bay, San Francisco Bay, Bolinas Lagoon, etc. Is Elkhorn Slough particularly important for certain bird species?

Are there patterns to the cultures of estuarine management and regulation?
How does tidal wetland management and regulation differ in northern California differ from southern California? Are there trends in management and restoration that suggest information sharing or barriers to knowledge? Where do managers and regulators get their information and what are their information needs?

- **RESTORATION**

Can small-scale measures decrease bank erosion?
Small scale experiments with structures to reduce velocities (e.g., anchored Christmas trees, living shorelines of oyster reefs, etc.) could reveal whether bank erosion could be slowed by such mechanisms.

Might native *Spartina foliosa* be a viable alternative or addition to hydrological management strategies to combat tidal erosion?
The Slough has no native (or non-native) *Spartina* marshes. Introducing the native species into intertidal mudlfats (degraded former pickleweed marshes and bank edges) might increase sediment deposition and decrease bank loss. Carry out literature review and simple modeling to determine where *Spartina* beds could potentially survive at Slough (maximum and minimum estimates of extent), given what is known about elevation and salinity tolerances of the species from elsewhere. Make predictions about effects on tidal erosion / depositional process at the Slough, under maximum and minimum estimates of distribution, based on sediment trapping studies elsewhere.

What role do microbial biofilms play in stabilizing sediments?
Biofilms may help stabilize sediments, but have never been examined at Elkhorn Slough. What role are they playing in existing banks and marshes? What factors increase or decrease them?

Can biofilm colonization at newly restored sites be hastened? This project could involve descriptive components (examining existing biofilms: composition, and where they are more vs. less well developed). It could also involve experiments attempting to stimulate biofilm growth. This could be important for informing a new restoration project, where sediment will be placed on a mudflat to create a salt marsh. Could some sort of inoculation with water and microbes help stabilize these new sediments so they don't wash away?

How have Parsons Slough assemblages changed since restoration?
This area was opened to tidal exchange in 1980, with initial monitoring of plant and animal communities. Repeat sampling to assess how assemblages have changed. Constructed islands have shrunk due to bank erosion and channels have deepened, so there are likely to be significant effects of tidal erosion that could be documented here.

What is restoration success and how do we monitor for it?
Amongst the many restoration projects, how has success been defined? Are there success parameters that are better than others in terms of practicality of monitoring and management?

How much does restoration cost?
There have been many tidal wetland restoration projects. What drives the costs of these projects? How much is spent in planning, permitting, construction, maintenance, and monitoring? Are restoration planning, construction, and maintenance costs related to restoration success? Are costs increasing through time or decreasing?

- **ECOSYSTEM SERVICES AND HABITAT VALUE**

What is the habitat value of vegetated vs. unvegetated estuarine habitats?
Compare larval settlement, fish abundance, etc. in paired areas with and without dense pickleweed (intertidal) or eelgrass (subtidal). Or, using isotopes, compare marsh plant vs. algal sources of N and C in key indicator species (such as commercially harvested fish).

What sort of mudflats are most valuable to migratory shorebirds?
Compare eroded, high energy mudflats of lower estuary to depositional (but more eutrophic) mudflats of upper estuary. Compare historical mudflats to mudflats that were recently created due to salt marsh loss (from diking, or from dieback in upper estuary). How does abundance of shorebirds differ in these mudflats? How does their feeding rate?

What do leopard sharks eat while using Reserve as nursery?
Conduct caging experiment to determine which invertebrate species are most affected by shark foraging on the Reserve, and correlate shark abundance to abundance of these species.

Are raccoons playing an important role linking terrestrial and estuarine habitats?
ESNERR camera trapping has revealed high frequency of raccoon visits to estuarine shorelines. Collaborate with ESNERR staff to conduct further camera trapping to examine raccoon distribution, abundance, and foraging in estuarine habitats and adjacent uplands. Conduct isotope analyses on scat to determine importance of estuarine food sources. Conduct caging experiment to quantify raccoon effects on estuarine crabs. Examine whether raccoon abundance

or foraging impacts (e.g. on nesting birds) is higher near estuarine margins due to estuarine subsidies.

➢ POLLUTION AND WATER QUALITY

What are major sources of nutrient-loading to the estuary?
Collaborate with and expand Reserve monitoring to determine flow and concentrations of nutrients entering estuary.

What is the role of coastal fog in affecting water quality?
Use ESNERR water quality and weather databases to examine effect of foggy weather on water temperature, salinity, and dissolved oxygen.

Has the estuary become more acidic or basic over time?
Use ESNERR water quality data to track trends in pH over time.

How is estuarine water quality affected by oceanographic conditions?
Correlate ESNERR water quality data parameters (such as temperature, salinity, oxygen) to oceanographic indices for Monterey Bay, such as upwelling or ENSO index. How does strength of effect differ at a station near vs. far from the mouth of the estuary?

Does water quality correlate with adjacent land uses?
Use our 15 year database of water quality around the Slough, and pick specific case history sites to carry out GIS analysis of links between changed land practices and adjacent water quality.

How does turbidity correlate with suspended sediment?
ESNERR has 20 years of data on turbidity from multiple stations around the estuary. Preliminary attempts to correlate turbidity to total suspended solids have failed. A student could examine this relationship more closely, accounting for variation among sites and seasons.

How does water quality in a tidally restricted site differ from a fully tidal one?
We have summer water quality data from continuous (every 15 min) sampling at an adjacent restricted and fully tidal site. Restoration of full tidal action to the former site is planned. A student could examine water quality before and after restoration at the control and restoration sites, in a statistical analysis.

Has the abundance of *Ulva* mats increased over time?
Macroalgal mats are very common today, and are likely the result of agricultural nutrient-loading. However, we lack baseline information. Examine aerial photographs to determine how peak abundance of Ulva has changed from 1930s to present in different parts of the Slough.

How do dense algal mats influence the distribution and abundance of infaunal invertebrates?
Compare invertebrate diversity and abundance in areas with and without dense algal mats (naturally occuring, or manipulate). Map distributions of dense algal mats to identify areas where invertebrates might be influenced most.

How do dense algal mats influence bird distributions?
Map bird distribution and abundance as a function of algal cover; experimentally change or look at natural variation. Presumably birds cannot access invertebrates through dense blanket of algae.

Are pesticides accumulating in Slough organisms?
Are pesticide concentrations causing chronic toxicity to organisms low in the food web at Elkhorn Slough, and is this resulting in bioaccumulation in birds and mammals?

Are ghost shrimp sensitive to polluted run-off?
Collect ghost shrimp from beds on the Reserve and grow them in Reserve water vs. water from Tembladero Slough and other polluted areas to test hypothesis that decline of ghost shrimp near mouth may be due to polluted run-off.

What is the role of groundwater and atmospheric sources of nitrogen relative to freshwater run-off?
Use isotopes or other tools to determine relative importance of different sources of nutrient loading.

What are the main sources of fecal coliform bacteria in the Slough?
Concentrations are highest in areas receiving the most freshwater input, but it is not clear whether sources are residential septic tanks or agricultural.

How does polluted runoff affect individual organisms, especially economically important fish and shorebirds?
Mixed pollutants may have additive or emergent toxic properties and individual pollutants may not presently be recognized as harmful; decision makers need information about which pollutants have which specific effects on tidal organisms.

How has sediment loss changed over past decades?
Work with Monterey Public Works to determine how frequency of road scraping (to remove eroded sediment) has changed.

- **INVASIONS BY NON-NATIVE SPECIES**

What are the effects of the introduced Japanese mudsnail *Batillaria* on diatom communities and macroalgal mats?
Assess diatom diversity & abundance and/or *Ulva* mats in areas with differing (naturally varying or experimentally manipulated) *Batillaria* densities. Interesting because enormous densities must be changing food webs in Slough, but effect hasn't been documented.

What factors influence *Batillaria* distribution and abundance?
The mudsnails appear to be densest in low elevation intertidal mudflats, particularly in subsided (formerly diked) areas; they are rare along the Slough's main channel. Is this due to patterns of spread from initial introduction sites? Or increased population growth in the subsided mudflats? Or lower predation (by crabs, shorebirds?) there than along the main channel?

Which invertebrate invaders are transported to the Slough on boat bottoms?
Examination of boats in Moss Landing Harbor, esp. those which have recently arrived from San Francisco Bay or other places with established populations of invaders; demonstration of local boat traffic as an important mechanism of transport might lead to boat-cleaning regulations.

Do non-native species fare better under human-altered conditions than natives?
Test a particular guild with natives and non-natives, such as fouling community, for survival and reproductive success in different pollution conditions, artificial vs. natural substrates, etc.

- **RARE ESTUARINE ENDEMICS**

What are the microhabitat correlates of the threatened brackish snail *Tryonia imitator* and/or tidewater goby?
Fieldwork to map small-scale and large-scale distribution of these rare species at Slough; correlate to environmental factors (nutrients, pickleweed cover, predators). For the snail (which is not listed), manipulative mesocosm or laboratory experiments could confirm the role of putative environmental factors.

Why have green phoronids become so rare?
In terms of native estuarine biodiversity, the dramatic declines of the green phoronid (formerly a mudflat dominant near the mouth, now virtually absent) is concerning, especially since there are only about a dozen species in this animal phylum. Carry out multi-estuary study to determine microhabitat requirements and environmental tolerances of green phoronids, assess the distribution of such microhabitats at Elkhorn Slough. Could carry out manipulative experiments at sites where they still are abundant (Bodega) to test role of possible limiting factors at Elkhorn (burial with *Ulva*, etc.).

How does species diversity of salt pannes differ from adjacent habitats?
Salt pannes elsewhere have been shown to host various threatened species (e.g., tiger beetles) adapted to the extreme hypersaline conditions; the fauna of Elkhorn Slough salt pannes (e.g., in the North Marsh area) has never been examined; these habitats may be of high value to these rare communities.

- **MARINEMAMMALS**

What correlates with otter behaviors as seen on otter cam?
Review footage from the camera on otters in Yampah Creek and attempt to address questions about correlates of behaviors. Why do all otters appear to flee at once sometimes? How does weather correlate with behaviors or numbers? Etc.

- **RECREATIONAL USES**

How do kayakers and duck hunters influence marine mammal and bird behavior?
Observations to determine whether recreational visitors influence behavior of resident animals; results could lead to management recommendations.

How do mudflat smells affect visitors?
How do visitors respond to the smells of some of the Slough's stinkier mudflats (e.g. North Marsh)? Does the smell affect their experience? Do perceptions of the estuary differ for visitors

who encounter the stinky areas vs. less stinky ones? What physical factors (such as depth, tidal range, etc.) correlate with mudflat stinkiness?

What is the intensity of mudflat harvesting, and what are the effects?
Intensity could easily be assessed by visiting common clamming sites in lower Slough; effects would require controlled experiments with fenced take and no-take zones.

What explains visitor use patterns in the Elkhorn Slough region?
Visitors in natural areas seek particular features and activities. What are the expectations of visitors to the Elkhorn Slough Reserve and are these expectations met? Do visitors to our region lack certain experiences that they desire? The answers to these questions can help shape development of future recreational improvements such as trails, parking lots, roads, and boat landings.

2) FRESHWATER AND RIPARIAN HABITATS

- **THREATENED AMPHIBIANS AND REPTILES**

How do various mosquito control practices compare in terms of efficacy and ecological impacts?
Mosquito and other disease vectors are becoming increasingly of concern, spurring control measures with unknown consequences to the Slough's salt and freshwater ecology. Research into the efficacy of these measures weighed against the ecological impacts could help inform better practices. Compare Bt, mosquitofish and native predators such as three-spine stickleback or dragonfly larvae as control mechanisms in 18 Reserve water tanks (guzzlers) or in regional ponds.

What are the patterns of habitat use by southwestern pond turtles in the Elkhorn watershed?
Explore aquatic habitats and adjacent areas on the Reserve to locate nesting/breeding sites, count numbers of adults, and track their movements.

What lizard and salamander species are found on the Reserve and what are their relative abundances?
A combination of visual encounter surveys of lizards on the trails and capturing for identification would allow the Reserve to establish a baseline inventory of what species are present and in what abundances. This would be important for future comparisons to establish how populations are faring. A similar survey for salamander species including the placement of coverboards and checking for presence under natural debris would also have importance for future comparisons.

What is the distribution and abundance of amphibian roadkill along Elkhorn Rd. during the rainy season?
Even low levels of traffic are known to have large impacts on amphibian populations near roads. Nighttime or early morning surveys along Elkhorn Rd. during rain events for the duration of the rainy season would allow for quantification of these impacts to local populations, as well as highlight areas where an underpass or culvert could boost rates of connectivity between reserve populations and those off the reserve.

How are amphibians responding to rainwater-fed guzzlers?
Wildlife guzzlers have recently been re-configured to capture rainwater. How is this affecting amphibian use? In the past, some have appeared to be important habitat for frogs.

- **VEGETATION, HYDROLOGY AND RESTORATION**

What are the current conditions of aquatic vegetation in the watershed's freshwater wetlands?
Map distribution and types of freshwater habitats in the watershed currently, including aquatic plants and communities as well as hydrological characterization.

What strategies can improve water quality in Reserve freshwater wetlands?
Bioretention pits or heavy mulch to improve quality of freshwater inputs coming from adjacent agricultural fields? Annual dry down and removal of sediments? Bubbling stations to increase dissolved oxygen?

- **GROUNDWATER DYNAMICS**

What are the links between groundwater and surface water?
Have past changes to the Slough's tidal prism (e.g., return of tidal exchange to Parsons complex) affected local groundwater (saltwater intrusion)? How would future changes to the tidal prism of different wetlands (moderate decreases at Parsons, slight increases at South Azevedo, etc.) affect adjacent groundwater? Does surface impoundment of freshwater (e.g. in Moro Cojo area wetlands) help to restore groundwater and decrease saltwater intrusion?

- **POLLUTION**

How does polluted runoff affect individual organisms, especially endangered species?
Mixed pollutants may have additive or emergent toxic properties and individual pollutants may not presently be recognized as harmful; decision makers need information about which pollutants have which specific effects on freshwater organisms.

3) COASTAL PRAIRIE

- **GRAZING AND OTHER RESTORATION TECHNIQUES**

What tools are effective for increasing native biodiversity in a very degraded grassland?
Compare various techniques (variants of grazing, mowing, planting, etc.) on the highly invaded Reserve grasslands, and determine effects on key targets (native grasses, annual forbs, perennial forbs). Pair such treatments with large-scale monitoring of similar grasslands in the region where such practices have taken place.

Which native grasses should be planted on what parts of the Reserve?
Fieldwork to permit GIS mapping of soil types and microclimates; match to different plant optima; native grass should be better at resisting invasion if planted in ideal physical conditions.

How does grazing pressure differ in grasslands with more vs. less native species?
Use camera traps to quantify grazing in varying types of grasslands, including ones dominated by native grasses vs. by weedy forb patches.

What is the effect of species diversity on invasibility?
Do grassland restoration with multiple species, singly and in combinations, to look at whether species mixes are more effective than single species at preventing invasion by non-native species.

What is the effect of patch size on restoration success?
Plant natives in degraded grasslands in patches of varying sizes to determine whether bigger areas resist invasion better than do smaller ones.

- **SPATIAL PATTERNS OF PRAIRIE DISTRIBUTION**

Where are remaining stands of intact coastal prairie, and what do they correlate with?
Fieldwork to find remaining native grasses stands, and GIS work to determine whether land use history, current management, slope, surrounding vegetation type, proximity to wetlands, etc. explain distribution of species in the watershed.

How to soils correlate with native cover?
Compare soil properties in areas with high vs. low native grass cover, to determine conditions that appear to favor natives. These might be the most promising sites for restoration work.

- **RARE PRAIRIE ENDEMICS**

What is the foraging efficiency of the many sensitive raptor populations in various types of grasslands in the watershed?
Anecdotal information suggests that thatch accumulation increases vole abundance, and yet raptors forage more frequently in grazed areas with little thatch accumulation. Are these observations born out by more scientific methods? What characteristics do grasslands exhibit that support raptor foraging?

What is the distribution and habitat use of the listed Salinas Harvest Mouse and Salt Marsh Ornate Shrew?
These species are endemic to a small area around Elkhorn Slough, and haven't been studied since the 1950s; their taxonomy and ecology should be revisited so that their small populations can be wisely managed.

Does seed number limit introduction of Santa Cruz tarplant and other species?
This species is endemic to coastal prairie and one of the few remaining populations is in the Elkhorn Slough watershed at the Porter Ranch. Research to date has suggested that the number of seeds in any particular population's soil seedbank may be key to long term survival of the species. This may be because of the species' ability to withstand year-to-year stochasticity or it may have more to do with low-level chemical compounds deterring herbivory. Experiments with this and related species may help determine the influence of seed number to the survivorship of experimental coastal prairie wildflower introductions.

- **HABITAT USE OF PRAIRIES**

How important are prairie, salt marsh and freshwater wetlands for foraging by raptors at Elkhorn Slough?

Various raptors such as Red-tailed hawks and White-tailed kites nest on the Elkhorn Slough Reserve, but little is known about where they spend their time foraging, and what they feed their young. The mosaic of adjacent habitat types allows observation of relative importance for foraging and prey sources, and how this changes with seasons or between years (wet vs. dry, etc.). Cameras could be placed at raptor nests (such as the one of a reliable Red-tailed hawk pair that breeds on the Reserve) to observe prey items delivered to young. Observations of foraging linked to spatial data on habitats could address broad questions of foraging. Isotope analyses could reveal importance of marsh vs. terrestrial food webs.

How does habitat use differ on lands of different ownership?
Do field surveys or camera trapping to compare abundance of birds or mammals in lands under conservation ownership, farm ownership, residential ownership in the watershed (must obtain permission of private landowners).

How does poison hemlock influence community composition?
Examine diversity and abundance of some native plants or animals (e.g., songbirds; grasshoppers in areas with hemlock and areas where hemlock has been removed.

What effect does herbivory have on prairie plants?
Conduct caging experiments to exclude herbivores of different sizes (snails, rodents, deer, etc.) and compare plant community vs. control sites.

How are large predators using Elkhorn grasslands and surrounding landscape?
Which large predators are present? Are their populations viable? What movement pathways are they using, and how large is their range? Do protected lands such as those managed by ESNERR and ESF provide important refuges or connectivity?

4) MARITIME CHAPARRAL

- **HABITAT LOSS AND CONSERVATION**

How can manzanita best be propagated?
Various species of manzanita (Arctostaphylos spp.) comprise a key component of maritime chaparral habitat. Some species are highly endemic and even the more widespread ones may have important local genetic adaptation. We thus would like to use locally collected material in restoration projects, but are unsure about the best methods for doing so, especially since manzanita has evolved with fire and appears to grow best after fires. Students could compare different methods such as Fall/Winter cuttings collection and propagation; fall berry collecting and stratification; liquid smoke; and fire germination trials.

Explore the value of conservation easements and model effectiveness of conservation banking strategies.
Map current conservation easements, document their past and present condition, and evaluate their ecological value. Help design baseline characterization and monitoring programs for chaparral easements. Or, evaluate the benefits of a maritime chaparral conservation banking program in the watershed.

5) COAST LIVE OAK

- **HABITAT VALUE RELATIVE TO EUCALYPTUS**

How do ecosystem processes differ in oak woodlands vs. eucalyptus groves?
For instance, how does water usage differ between the two tree species? How does nutrient cycling differ?

What is the value of oak vs. eucalyptus groves for native bird species?
Preliminary work has shown similar bird species composition in oak vs. eucalyptus groves. It would be interesting to track fitness parameters (nesting success, survival, etc.) to see whether the two woodland types are different or equivalent for particular bird species.

- **OAK RESTORATION**

How can native oak understory be enhanced?
Experiments with various methods to initially remove and then to discourage re-establishment of non-natives. Include comparison of areas with varying canopy cover and proximity to edge to determine where long-term success is most likely.

What is the best method to remove periwinkle?
Periwinkle (*Vinca major*), is a non-native invasive oak understory herb species that is very widespread. What is the best way of removing it without harming the oaks? Methods may include black tarping, herbicide, scraping, and others. How might the removal methods affect the soil surrounding oak trees (under the oak canopy) and might this have an effect on the health of the oaks?

- **WOODLAND CAVITY NESTERS**

What are the effects of providing nestboxes to cavity nesters?
We have 150 nestboxes used mostly by chestnut-backed chickadees (CBCH). Does providing nestboxes increase CBCH densities? (can compare woodlots with and without nestboxes). Does providing nestboxes increase CBCH reproductive success (have to find natural nests in cavities to make this comparison). Does neotropical migrant density correlate with CBCH density (it has been suggested that neotropical migrants are attracted to CBCH and preferentially flock with them)?