

Project Ideas for the Bernard Field Station

Carry out/simplify/expand one of these, or use them as inspiration in designing a different project.

Physics/math

How do the tendrils of *Marah macrocarpus* curl? Is the direction always the same? What are the physical principles and constraints? How does the structure of a tendril change as it curls around an object? How much resistance is provided by the tendril coils when the wind blows? What is the tensile strength? How many would be required per unit mass of plant?

What are evaporation rates in different locations? How and why do they change over time? Do they correlate with changes in morphology of nearby plants? How might these reduce water loss? Can you model this? If you calculate the precipitation/evaporation ratios using monthly rainfall figures for Claremont, how do the values compare with published values for coastal sage scrub and other biomes?

Is there a correlation between leaf specific mass, thickness and density in coastal sage scrub plants under different conditions? What are the possible physical benefits/constraints?

Do plant allometric relationships (e.g. total leaf area versus height; number of branches/branchings versus height) change during development or in response to competition? Are they related to sexual dimorphism if that exists in a particular plant species?

Can you model growth characteristics of a chosen plant at different planting densities or under different environmental conditions?

How do loading conditions experienced by stems and leaves of elderberry (or other) change during growth?

Are there changes in material properties of Yerba Santa (or other) leaves/stems during maturation?

Does flexural stiffness change during development of a plant organ so that the ability of the organ to bend and deform also changes? Are any changes scaled to changes in self-loading?

How does the heterogeneous character of a plant stem affect its mechanical properties? Can this be modeled for different species? Does it vary with species?

What is the design factor (ratio of allowable stress to the working stress for normal, everyday load duration) for different plants? How great a margin of safety is there?

What are the forces that affect emergence of a seedling from the seed/soil? How does the structure of the seedling change in response to them?

How does the shape of a plant/pollen/wind-dispersed seed or fruit affect air flow around it? What are the characteristics of the flow?

What are the heating/cooling advantages of different shapes, surfaces, etc. What relation do they have to coping with environmental changes? Do leaf movements in plants function to exploit radiative heating or cooling at different times of day?

Chemistry

What is the composition of the volatiles given off by *Artemisia californica* or *Salvia apiana*, as determined by HPLC fitted with columns suitable for terpenoids, or GC-MS?

What secondary metabolites are produced by *Brassica* (or other species) and does the concentration of these change if the plants face competition/water stress/changes in light availability?

Is there allelopathy in any coastal sage scrub plant? What compounds are produced and in what quantities? Does production change in response to age/time of year/damage?

Why doesn't coastal sage scrub grow to the west of the BFS entrance road? Is there something in the soil?

What are the bacterial communities in soil, rhizosphere, and inside roots at the BFS as determined by fatty acid methyl ester analysis?

What is the chemical constitution of plant cuticles? Do they differ by species, age, or environmental conditions? How easily do they break down in nature? Does their structure vary?

What is the chemical structure of a harvester ant pheromone?

Is there a change in the composition of the air/soil as you get farther from the edges of the BFS?

Is there a change in protein composition of a chosen plant under stress?

Does the composition of nectar vary at different times of day, on different plants, in different locations?

Molecular: genetics/evolution/other

Is there evidence for inbreeding in populations of some chosen species found at BFS, using restriction fragment length polymorphisms and gel electrophoresis to determine Wright's inbreeding coefficient?

Are there genetic differences among populations of a chosen species found at BFS and on the 5C campuses or in other nearby areas? (allozyme assays have been worked out for many local species)

Can you identify vesicular arbuscular mycorrhizal fungi ("VAMs") from different plants using PCR?

What shifts are there in the bacterioplankton community composition in pHake Lake over time, measured by denaturing gradient gel electrophoresis (DGGE) of 16S rRNA genes.

How stable is the mating system for a chosen plant as determined using electrophoresis?

Is the endangered *Berberis nevadensis* at the BFS genetically identical to the specimens grown at the botanic garden?

Animal behavior:

What evidence for habituation to human activity is there in lizards or birds?

How does Harvester ant (or other ectotherm) activity vary with temperature? A comparison between native and Argentine ants would be particularly interesting. What patterns are related to body size and so on.

How does mosquito fish distribution and feeding rate vary with the presence of barriers to dispersal among feeding stations, barriers to visibility among stations, different levels and kinds of predation risks and so on.

How is predator switching affected by presence of non-prey species (a lab experiment)?

Is there territoriality in carpenter bees (or some other insect)?

What are the parental provisioning patterns in one of the bird species? How often do birds come back to feed chicks, how much food do they bring (body mass) and what are the relative contributions of each parent?

What interactions are there between Argentine and Harvester Ants?

Are there honeypot ants? If so, is there a shift to animal/plant parts as a food source in autumn?

What are the vertical migration patterns of zooplankton (eg, copepods) in pHake Lake? Do they correlate with changes in specific physico-chemical variables in the water?

What territoriality and aggression behavior do you see in different species of dragonflies at pHake Lake? Do these species have a fixed perch? What home range is defended? Will they defend a larger range against a different species than against their own?

How do grasshoppers avoid predators? Do they select variegated over uniform substrate patterns? Do they land so as to cast no shadow? Do they always fly an erratic course? Etc.

What characterizes thermoregulation behavior in grasshoppers? When undisturbed, do they switch between sun and shade? Is this related to air or ground temperature, age/size of animal, local relative humidity, etc?

What characterizes thermoregulation behavior in dragonflies? Is local perch temperature correlated with cooling/heating behaviors, etc?

Does perch height of lizards vary with local prey abundance, temperature, perceived risk, visibility, and so on?

Physiology/development:

Are water/light availability correlated with size/growth pattern/carbon or nitrogen assimilation, etc. for a plant species?

What mycorrhizal fungi are present and associated with development/health in different plants?

What is the effect of competition on plant allometric relationships?

What factors affect development in fairy shrimp or Western toads (or some other species)?

How are malaria infection rates of lizard related to squirrel burrow proximity, lizard density, etc? Lizard malaria is reported have a ~10% infection rate (Noah Levine HMC 02) with the vector being a fly that lives in ground squirrel burrows.

Do any of the BFS plants have seedlings which undergo developmental changes in response to the presence of nearby plants (modeled by a change in the characteristics of available light)?

How does limb morphology of lizards differ between individuals found on different perches or between populations (subpopulations) found in different habitats?

Is energy intake rate limited by capture rate or processing rate in lizards, spiders, etc. Examine energy intake rate vs. satiation or metabolic rates.

Are there any effects of increased soil nitrogen on germination and early growth of coastal sage scrub plants?

How does energy metabolism of an insect vary during rest and motion? Is this correlated with gender or with being parasitized?

How do the large *Epiphragmophora* snails native to the area around pHake Lake cope with the dryness of their native habitat? Can you characterize temperature conditions necessary to trigger summer hibernation? Will they form a plug (epiphragm) in the shell entrance in response to temperature?

What is the effect of mechanical perturbation (wind, handling) on growth and development characteristics in the field?

Ecology

What is the difference between two habitats (of your choice) in terms of species composition and environmental gradients? Can these be manipulated?

Are particular animal species in an area associated with all the plants in that area or only with some?

If you change the available microhabitats in an area, for instance by setting out logs or rocks, do you see a change in the distribution or abundance of organisms?

If you remove one species from an area, does another increase, or a new one replace it?

How do annual precipitation/evaporation ratios change for different regions of the BFS at different times of year and how do these relate to vegetational structure?

How does the insect fauna, species richness, etc. vary around different plants, or at different times of day, or caught by sweep netting as opposed to pitfall traps?

Can differences in insect activity over a 24 hour period be related to insect size, heat tolerance, or coloration/reflectance?

Is there a correlation between butterfly (or some other species) diversity and abundance and the degree to which a patch of coastal sage scrub is isolated by development?

Is plant structure or plant diversity more highly correlated with insect diversity (eg, Homoptera)?

Are better plant competitors simply large or only large in relation to their particular neighbors? A field and lab study, which could include the effects of ant predation.

What effect does herbivory have on the establishment and growth of seedlings of a chosen plant?

Does early germination lead to increased survival and reproduction? Is it related to seed size, parent plant, or competition?

Is there a relation between plant species number and culturable soil bacteria, and does this act as an indicator of biodiversity?

What organisms exploit the cattails on pHake Lake? How do they interact? Are any restricted to particular portions of the plant?

Are there any insects whose eggs or larvae use the specialized air-conducting tissues (aerenchyma) of *Typha* (or other emergent vegetation) as an oxygen source (by plugging spiracles into the stems)? Are these restricted to particular zones?

The willows around the lake are parasitized by a gall-forming sawfly and can be studied for insect development, leaf-selection criteria, larval survival in single versus multiple-galled leaves, etc.

Oaks: Why are there few or no oak seedlings along the road into the BFS?

Galls– What types of galls are present on the oaks and in what numbers? What are the associated insects? Are any of the galls parasitized themselves? By what?

Do the numbers of galls vary from tree to tree? Is this correlated with tree density or health? Are twig-borne galls located only on new growth? Is there a correlation between size of gall and number of exit holes? Between these and size of holes?

Acorns--How does infection/predation affect the acorn crop? Do the oaks shed the damaged acorns early? Can the numbers of acorn borer weevils per acorn be predicted from a simple probability function if you know the incidence of infection, or are multiple infections more common or more scarce than expected?

Can a standardized way be developed to quantify the acorn crop and compare it between trees, between years, between locations, and see if it correlates with climate variables or acorn borer infection?

Vernal Pools: Do different light, water and temperature regimes trigger emergence of organisms in mud samples from vernal pools?

What is the order of emergence of organisms from the vernal pool substrate? Are there any carnivorous species or are all essentially algal or bacterial grazers/filter feeders?

What cryptobiotic organisms can you germinate by hydrating vernal pool mud? Are adults of these species desiccation tolerant, or only the eggs? What maximum rates of drying are tolerated?

Pollination biology: If you water fall-blooming plants, does this correlate with differences in pollination or seed set?

How does light pollution affect plants normally pollinated at night? Is the distribution of night-pollinated species correlated with local light intensity at night?

Pollination/seed studies: for the chosen plant—to what extent does nectar build up, what is the composition of the nectar, what visits and when, timing of nectar and pollen production, effect of location on visitor types, pollen/seed set ratios, effectiveness of different pollinators, pollen germination rates, etc.

Does deposition of pollen from another species affect seed set in the plant of your choice?

What effect does heat/rainfall have on synchrony of flowering by conspecifics? Does this affect cross-pollination?

What are the characteristics and consequences of pollen deposition/pollen tube competition or seed size/ packaging variation in the plant of your choice?

More descriptive:

Census and develop a key to ants (or other species) of the BFS.

Is there a difference in bird species and abundance between the BFS, wilderness park, golf course, residential neighborhoods, office park and business district? Do they seem to be correlated with any differences in environmental conditions? If so, which?

What species of (choose plant or animal group, e.g. cacti, grasses, dragonflies, spiders, earthworms) are present at the BFS and where are they located? What environmental conditions are common to these areas?

What are the life history characteristics of the native *Epiphragmophora* land snail found under logs near the lake (or of another plant or animal species)?

What is the habitat use description for a particular species or group of species? This could be complemented with habitat selection experiments similar to Andi Renden's thesis, HMC 2002.