The NRS
Transect
Special GIS Issue

Volume 12, No. 1 University of California Natural Reserve System Fall 1994

In this special issue:

Report of the Director: NRS Goes GIS!

Computer-based geographic information systems (GISs) have become powerful tools for collecting, analyzing, and displaying information about our environment. This technology is being used by land-use planners, facilities managers, and environmental scientists, among others, to store and retrieve data of all kinds, including geo-referenced information, such as maps, rectified air photos, and standard field data. By building GIS models, we can more easily inventory, analyze, and manage a given environment, be it a campus laboratory or a natural landscape.

GIS technology has been used by NRS researchers for several years. Most notably, Faculty Reserve Manager Frank Davis, along with colleagues and students from UC Santa Barbara, are compiling a GIS for Sedgwick Ranch (a UCSB reserve that will join the NRS soon), and Reserve Director Mike Hamilton has created one for the James San Jacinto Mountains Reserve and surrounding ecological region (see page 8). We began to use GIS in the systemwide NRS office during the winter of 1992 as a tool for analyzing issues that pertain to property management, land stewardship, and data management, as well as research and teaching support.

We chose the Bodega Marine Reserve (BMR) for our initial GIS project. This reserve was well suited for GIS: it was already accurately mapped and gridded, and detailed aerial photo information and biological databases were available. Former NRS Cartographer André Zerger, a visiting geography student from Melbourne, Australia, developed the GIS by working with Reserve

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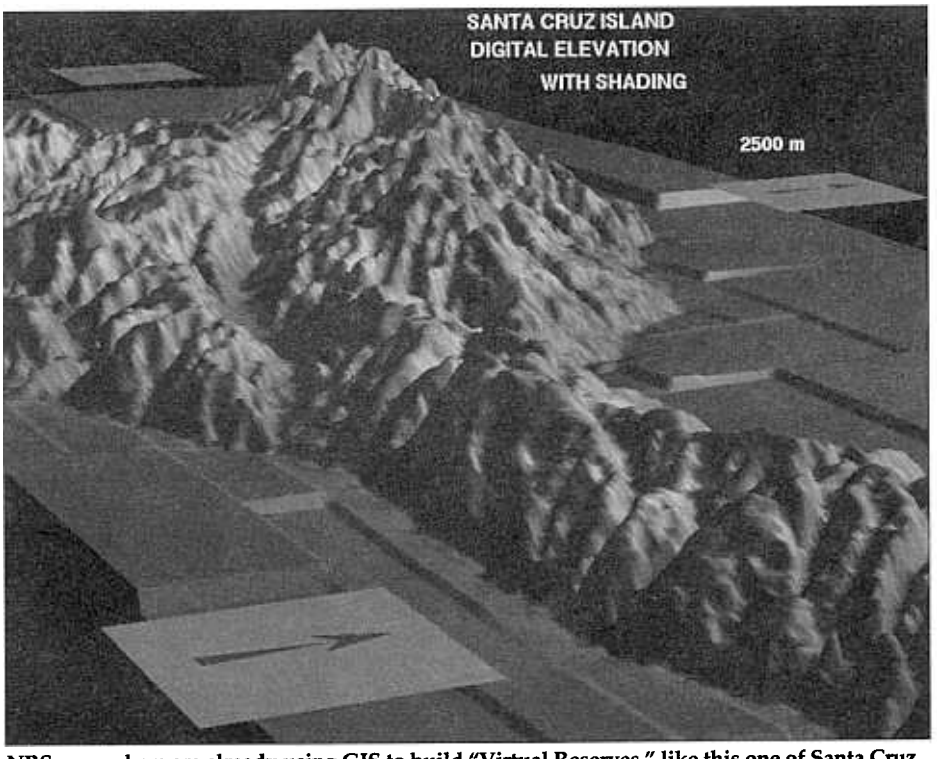

NRS researchers are already using GIS to build "Virtual Reserves," like this one of Santa Cruz Island. See page 4 for a more complete explanation of this graphic.

Our World According to GIS

Imagine having a series of maps on your computer depicting such things as topography, hydrology, soils, vegetation, and fire history for your research site. With a simple command, you could view or print combinations of any or all of these maps; using other commands, you could analyze the relationship between various factors, such as the areas of chaparral burned in recent fires as a function of slope. By clicking on a particular feature — a creek, for instance — you could access a database that describes it — in this case, the area drained by the creek, its discharge, and the species it supports, among other information. What you would have is a geographic information system (GIS — an abbreviation that is pronounced by saying each letter: "GEE-EYE-ES").

Loosely defined as a computer-based system for storing, managing, and analyzing geographic information and associated data, GIS is a powerful analytical tool that helps users examine ecosystems holistically. By integrating a variety of information in a manner based upon spatial relationships, GIS enables scientists, resource managers, policymakers, and others to analyze and interpret geographic and nonspatial data in ways previously impractical — if not impossible — using manual cartography, flat-file databases, or statistical techniques alone.

Raster versus Vector

Traditionally, GISs have been classified as either *raster* or *vector* systems based on the ways they handle maps, photos, and other

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Our NRS World *continued from page 1*

spatial components. In raster-based systems, images are broken down into a grid of equal-sized squares, called *cells*. To each cell you assign a value that corresponds to a particular feature, such as a road, an archaeological site, or a mixed conifer forest (see page 3 diagram). You can also link nonspatial data, such as information about a research plot, to specific cells or to cell-defined features.

Because remote-sensing data are collected in raster format, a grid-based GIS is useful for processing satellite imagery. However, the resolution of the original image limits the geographic specificity of the GIS; each cell can carry only one value per layer, even if the cell contains multiple features, such as several types of vegetation. An example of raster-based GIS software is ERDAS, a program frequently used for processing and analyzing remotely sensed data.

In contrast to the gridlike organization of raster data, vector images are made up of points, lines, and polygons. These geometric elements are used to represent spatial features on the ground, such as faults or patches of grassland. Nonspatial data, such as species lists, can be linked to the spatial features. This link remains intact, even when a map's graphic elements are duplicated or moved about on the computer screen. Arc/INFO and Geo/Navigator are two examples of vector-based GIS programs.

At the heart of both types of systems is the ability to *geo-reference* the GIS to the land it represents. Once you've specified the real-world coordinates of several control points, such as the corner of a building or the top of a mountain, the software can calculate the coordinates of every other point on your map. And because the GIS is geo-referenced, *dimensions* taken from it, such as the area of an animal's home range, correspond to measurements in the real world.

What GIS Does that Others Don't

It can be difficult to distinguish a GIS from other software applications that have similar features, but do not offer a GIS's full spectrum of analytical tools. Here's how to tell a true GIS from basic graphics programs, computer-aided design systems, and database management systems:

Basic graphics programs, such as Aldus Freehand and Adobe Illustrator, may be used to generate vector-based maps in which information is organized by layers, much like a GIS. Other graphics programs, such as Adobe Photoshop, allow you to manipulate raster data. Unlike a GIS, however, these programs produce what are known as "dumb" maps; you cannot geo-reference them, attach data to their features, or perform data analyses and generate reports. Moreover, these programs lack buffering, tiling, and other spatial data-manipulations.

Computer-aided design (CAD) systems utilize layers, have dimensioning capabilities, and can be geo-referenced. Recently developed programs even allow you to attach data to graphic objects. What these systems lack, however, are tools for manipulating and analyzing spatial data, along with the ability to generate reports based upon such analyses. Maps created in CAD programs are frequently used to establish GIS base maps.

Database management systems (DBMS) can perform analytical tasks and generate reports. Yet such systems lack the ability to attach data to objects and display data spatially. Data can be exported from a DBMS into a GIS, where they can then be linked to objects on a map.

Geographic information systems (GIS) allow a user to import, store, manipulate, analyze, revise, and display layers of spatial and database information about an area in the form of digital maps that are accurately referenced to global coordinates. These systems incorporate the functions of a CAD system and a DBMS in a single application. In addition, they allow a user to perform complex analyses and manipulations of spatial data, as well as to generate new maps based on the results.

Where to Take Your GIS for a Run

Widely recognized as the first GIS, the Canadian Geographic Information System was established in the 1960s. Early spatial data-handling systems, such as this one, were custom-built and usually operated on large mainframe computers. Today both raster- and vector-based GISs are available commercially for a variety of smaller hardware platforms, primarily workstations and personal computers.

A **workstation** is a mid-sized computer, generally linked to a server, from which a state-of-the-art GIS application can be run. For example, Arc/INFO, Intergraph, ERDAS, and ER Mapper all run on a workstation network, in either the UNIX or VMS operating environment.

DOS personal computers (PCs) are now one of the most common platforms for running a GIS. Arc/INFO, Atlas GIS, Geo/Navigator, MapInfo, and GRASS can all run on PCs, in either the DOS or DOS-for-Windows operating environments.

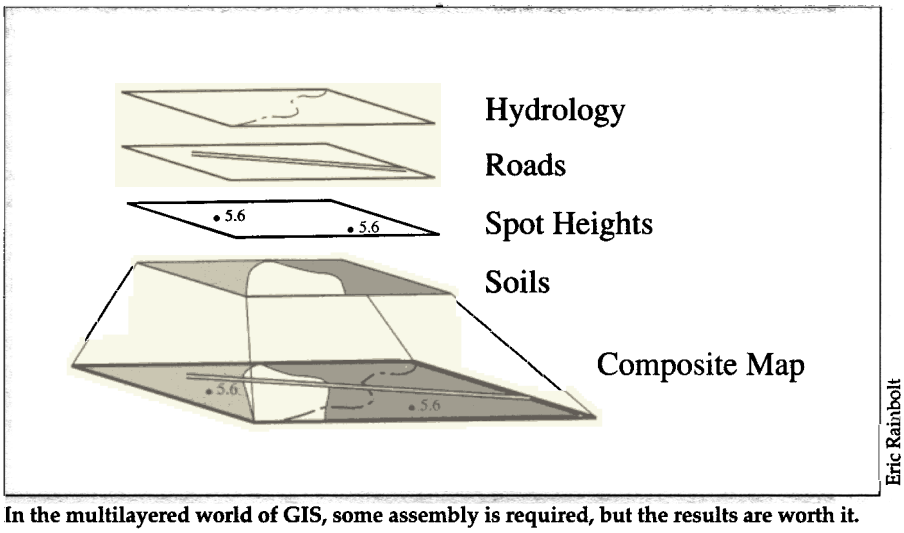
In the past five years, commercial firms have begun developing GISs that will function in the **Macintosh** computing environment. Programs designed for the Macintosh offer the advantage of being completely menu-driven and thus easy to learn. As a trade-off, however, Macintosh systems generally lack the capability for high-level analyses and manipulation of spatial data. Examples of systems that run on a Macintosh include Geo/Navigator, Atlas GIS, and macGIS.

Getting Your GIS Together

The first step in developing a GIS involves generating a base map of the site. This map often includes the site's physical features, such as roads, buildings, topography, and hydrology. Atop this base map, an unlimited number of layers depicting such aspects as geology, plant communities, and occurrences of rare species can be overlayed.

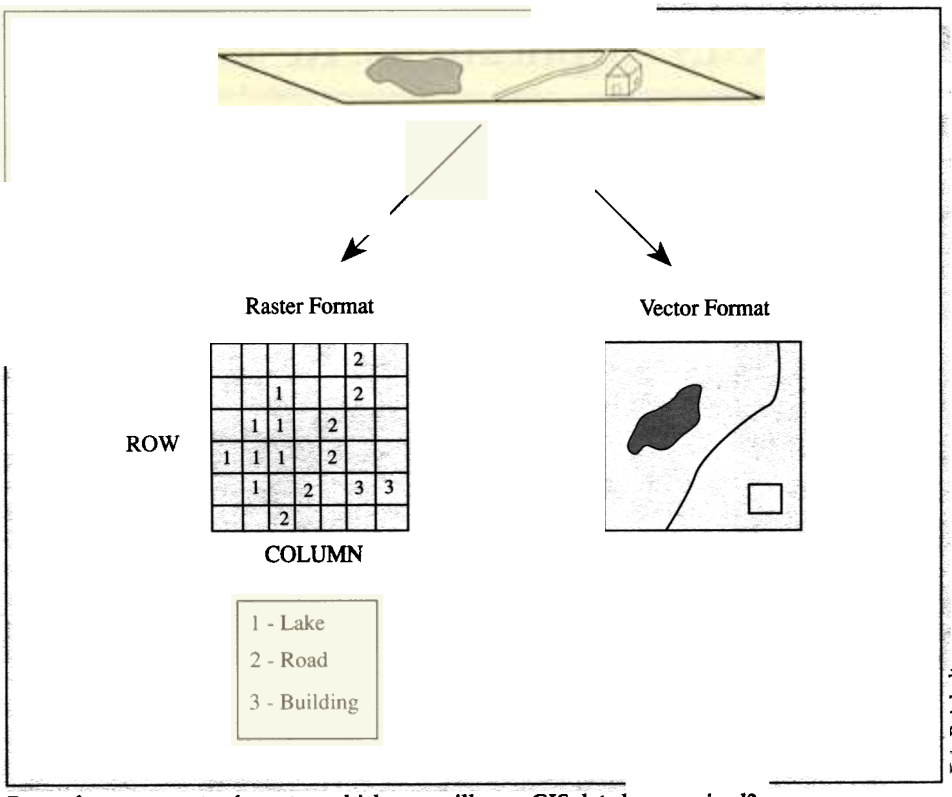
To generate a base map for a raster system, you typically import a scanned or digital image, then encode its cells.

You can create a map for a vector-based GIS in various ways, depending on how much data you have and how much detail you require. The traditional method for obtaining detailed topographic data involves surveying the site, then downloading the coordinates directly into the computer. Some map information, such as USGS topographic data, is readily available in a digital format that can be imported directly into a GIS. If



Eric Rainbolt

In the multilayered world of GIS, some assembly is required, but the results are worth it.



Raster format or vector format which way will your GIS data be organized?

only hard copy is available, you can digitize a base map either by using a digitizing tablet or by scanning an image.

Are You Ready for GIS?

GIS is not a technology to be adopted blindly. It is a complex, expensive, and time-consuming tool. Consequently, prospective users should begin with a clear vision of their end goal and how GIS can help them meet it. Even after their project is developed, regular staff may need to be diverted from their usual duties, or, if the GIS project is very large, additional staff may need to be hired to manage it.

To choose the right program, GIS managers should know what the intended users need from the system and how computer literate they are. It is unrealistic to expect most prospective users to become experts in a computing environment that is new to them. Some developers offer alternatives by marketing their GIS over a variety of platforms. Arc/INFO, for instance, runs on workstations and PCs. A Macintosh-based version is also available in a *read-only* format, meaning that users can view existing data, but cannot alter it in any way. You can even move a GIS project from one type of computer to another as needed.

The systemwide NRS office recently selected software to use for its GIS projects. Since we were already equipped with Macintosh computers and skilled in their use, we focused on programs that operate on the Macintosh platform, and eventually chose Geo/Navigator. Although this program lacks the ability to perform sophisticated spatial analyses, it offers the most developed database capabilities of all the Mac-based GISs available. It is relatively easy to move projects between Geo/Navigator and other GISs (such as Arc/INFO), as well as other types of programs (such as statistical packages) that make temporal modeling possible. Furthermore, Geo/Navigator's gentle learning curve makes it useful as a teaching tool for both high school and college students. Several of the reserve GIS projects covered later in this issue were created in Geo/Navigator. The NRS is also using Arc/INFO in a UNIX workstation environment on the campuses.

What's Yet to Come?

In the years ahead, the GIS field will advance rapidly. The gap between raster- and vector-based systems will close; already companies are working to develop systems that can operate interchangeably between the two formats. Advances in computer technology will also help increase the compatibility between computing environments, giving GIS users a greater range of options. Increasingly, such agencies as the U.S. Geological Survey are converting maps into digital formats and allowing easy access to data over the Internet. As these improvements are made, GIS will become even more useful as a tool for research, management, education, and information dissemination.

— Eric Rainbolt
NRS Environmental Analyst/Cartographer

NRS Goes GIS! *continued from page 1*

Manager Peter Connors and other BMR staff. The GIS project is being further refined by NRS Environmental Analyst/Cartographer Eric Rainbolt and BMR staff so that it can handle geo-referenced information on site; assist staff in monitoring, restoration, and adaptive management planning; and serve as a scientific tool for teachers, students, and researchers (see page 6).

It is our short-term goal to develop at least one reserve GIS project for each of the general UC campuses that currently administer NRS sites. Rainbolt and Environmental Analyst/Cartographer Emily Prud'homme, two systemwide NRS staff members, have been working with faculty, students, and reserve managers to compile data for 11 sites:

- Hastings Natural History Reservation (UC Berkeley)
- Jepson Prairie Reserve, Eagle Lake Field Station, and the Putah Creek campus reserve (UC Davis)
- San Joaquin Freshwater Marsh Reserve (UC Irvine)
- Motte Rimrock Reserve (UC Riverside)
- Kendall-Frost Mission Bay Marsh and Scripps Coastal reserves (UC San Diego)
- Carpinteria Salt Marsh and Santa Cruz Island reserves (UC Santa Barbara)
- Landels-Hill Big Creek Reserve (UC Santa Cruz).

Several of these projects are discussed in this issue of *Transect*.

We are ready to begin establishing GISs for other reserves, including one administered by UCLA. Upcoming GIS projects high on our list include: UCSB's Sierra Nevada Aquatic Research Laboratory and Valentine Camp, where we hope to facilitate ongoing ecological monitoring and management; Boyd Deep Canyon Desert Research Center, a UCR site with abundant, long-term biological data; and Granite Mountains Reserve, a UCR site located in the heart of the planned 1.5-million-acre Mojave National Park.

Eventually, by creating a GIS for each of our 32 sites (beginning with the high-use ones), the NRS will be better able to fulfill its threefold mission of research, teaching, and public service.

Deborah L. Elliott-Fisk
Director of the NRS

16 Great NRS Things To Do with a GIS

Students can:

1. "explore" a reserve by computer, even if they cannot visit the site in person.
2. learn to think both spatially and interactively by generating maps, examining data sets, and addressing scientific problems.
3. pose scientific questions using the GIS and integrate the results into their field studies.
4. support future studies by adding to reserve databases.

Scientists can:

5. examine, via computer, the characteristics of a physical environment; track changes in populations, communities, ecosystems, and landscapes over time; and infer how soils, topography, and other environmental variables influence the biota of a site.
6. calculate the areas and perimeters of specific distributions, as well as undertake numerous other mathematical or statistical analyses of data.
7. obtain real-world coordinates for locations of research plots and species occurrences.
8. create a library of aerial photography and maps to explore historical changes in land use, vegetation, or hydrology.

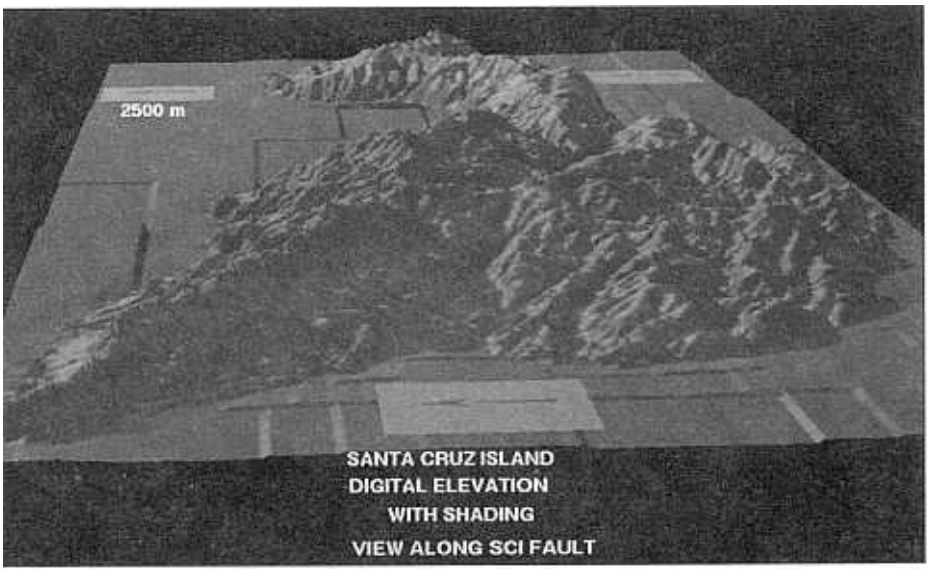
Natural resource managers can:

9. delineate and maintain accurate reserve boundaries, easements, and inholdings.
10. locate species of concern and other sensitive resources, potential environmental hazards, and adjacent land-use conflicts.
11. monitor areas in need of restoration.
12. plan for future acquisitions, site or facility improvements, and educational projects, such as kiosks and nature trails.

In addition, GIS can support *public service* efforts:

13. by making high-quality and versatile data, reports, and graphics readily available.
14. by offering a platform for interactive video presentations.
15. by demonstrating site importance visually (for example, with maps of listed species and critical habitats).
16. by providing state and federal agencies with geo-referenced files, which they can import for a variety of research, management, and public outreach purposes.

Reserve GIS Applications: Research



This computer-generated graphic, like the one that appears on page 1, is a digital terrane map of Santa Cruz Island Reserve. The original digital data was provided by Kate Faulkner and Linda Dye of the Channel Islands National Park. The image was created by L. Mertes in GRASS-GIS, with assistance from Helena Mitasova, Michelle Cobb, and Chuck Ehlschlaeger.

A "Living, Breathing GIS" for Santa Cruz Island

"What we need is a living, breathing GIS, not just something that sits on a computer no one uses," explains Leal Mertes, a geography professor at UC Santa Barbara. Building on work performed during the late 1980s, she has been instrumental in developing a GIS for the Santa Cruz Island (SCI) Reserve. Largest and most topographically diverse of the Channel Islands, SCI hosts a multitude of research and educational projects. Mertes aims to establish a multidisciplinary GIS of the island made accessible to researchers, teachers, and land managers.

Mertes plans to use GIS as a tool for her own geographical research as well. "The main reason I'm interested in this is not because I *want* to build a GIS," she says. "I'm not a GIS technician. It's the terrain of the island that I ultimately plan to study." Her desire to examine SCI's geomorphology stems, in part, from a fascination with its unusual drainage patterns. Understanding these intriguing streams involves analyzing other physical characteristics of the island, including tectonics, erosion, sedimentation, and vegetation.

In 1992, Mertes linked up with a GIS expert, UCSB geography graduate student Michelle Cobb, who wanted to embark on a vegetation project on SCI. Since then, Cobb has begun to build the GIS, and she is currently creating islandwide floral maps and databases by integrating GIS, remote sensing, and field techniques. She field-checks the locations of plant communities against aerial photographs and satellite images by analyzing 150 field plots, each consisting of 360 square meters. This is no easy task; SCI's tremendous floral diversity is represented by more than 500 native species. Cobb's new series of high-resolution map layers will provide future researchers with base maps for their specific areas of study.

By sharing her GIS expertise, Cobb has already aided another researcher, graduate student Kevin Crooks. Currently at UC Santa Cruz, Crooks studied the endemic island fox and spotted skunk, the two largest of only four flightless native mammal species on SCI. Beginning in the winter of 1991, he monitored two field sites occupied by both species. Toward the end of his 12-month study, Crooks received help from Cobb in superimposing and analyzing various combinations of map layers using GIS. This enabled Crooks to observe the ways in which his two target species share resources within the same habitat. "If he had known the capabilities of GIS earlier in his study, he probably could have reached the same conclusions in a less labor-intensive manner," says Reserve Manager Lyndal Laughrin. Moreover, Crooks adds that the GIS allowed him to perform examinations he previously would not have attempted, including analyses of the spatial distributions between and within the two species.

In much the same way that Cobb helped Crooks with his studies, other UCSB students are expected to aid a variety of SCI

researchers. Laughrin and Mertes are planning to supervise a GIS internship program through which upper-division geography undergraduates would provide GIS support to field researchers. "The students are available and know the tools," explains Mertes. "It will be an educational experience for them and they'll be providing a service." To establish a centralized GIS workstation on the island for use by researchers and interns, Laughrin and Mertes are preparing a grant proposal to be submitted to the National Science Foundation next year.

In the meantime, Mertes is enthusiastic about the ways in which the whole GIS project has come alive, as well as the response from researchers and managers alike. Eventually, Mertes hopes to help develop a GIS for the entire Santa Barbara region, including all of the Channel Islands. Already, she reports, collaborative GIS use has helped promote cooperation between several major organizations associated with SCI, including the NRS, The Nature Conservancy, UCSB, the Channel Islands National Park, and the Channel Islands National Marine Sanctuary. GIS could help these organizations examine complex resource-management issues, such as feral pigs and exotic fennel on Santa Cruz Island, as well as the threat of oil spills. "Because of GIS and mutual needs," Mertes says, "we're all taking agreed-upon steps to make things work in the long term."

— Elaine P. Miller
NRS Senior Science Writer

What's "up" at Big Creek: Topography Used in GIS Vegetation Model

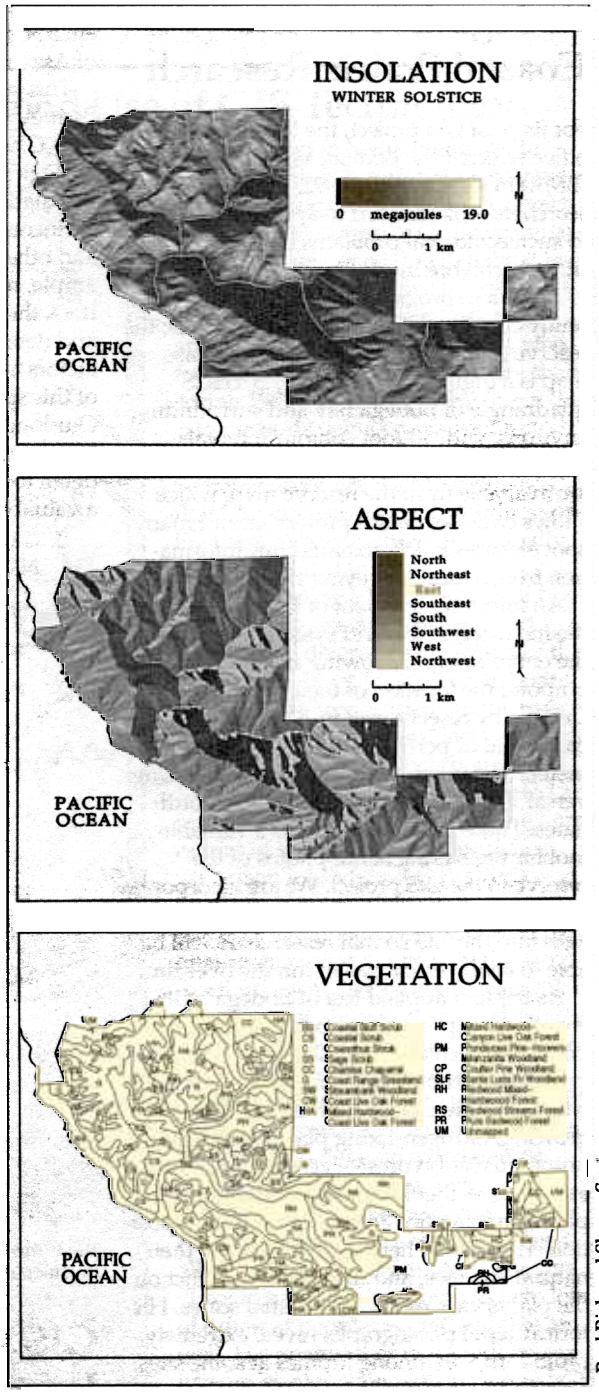
California's steepest coastal range, the Santa Lucia Mountains rise abruptly from the ocean, forming the rich and wild Big Sur region. In the heart of these rugged coastal slopes lies the Landels-Hill Big Creek Reserve, where University of Kansas Professor Paul Rich and graduate student Shawn Saving are creating a GIS-based model for analyzing vegetation in mountainous areas.

The project had its roots in 1979, when, as an undergraduate at UC Santa Cruz, Rich helped create a detailed map of the plant communities at the Big Creek Reserve. He was part of a team of natural history honor students who worked under the direction of NRS founder and Professor Emeritus Kenneth Norris to describe the flora and fauna of the reserve when it was first acquired by the NRS. Rich says that returning to the site to conduct his current project was like coming home.

Today Rich works with Reserve Manager John Smiley and Saving to create GIS maps detailing the physical attributes of the reserve. They analyze these maps to "predict" the kinds of plant communities that occupy different areas within the reserve, then check their predictions against Rich's original vegetation map. "By making these comparisons," Saving explains, "we will better understand the physical determinants influencing the growth of different plant species, aside from biological or human factors."

This study focuses on physical features, and its simplicity is its strength. "We can take a very easy determinant to get — elevation — and go straight from there," says Saving. By analyzing a topographic map, Rich and Saving extrapolate basic factors that determine vegetation distribution, such as aspect (the orientation of a surface toward the north, south, east, or west) and slope. They can then calculate potential insolation (the solar radiation received under clear skies) at different parts of the reserve using these factors, coupled with knowledge of the sun's path and the shadows cast by the terrain.

So far, Rich and Saving have created a multilayered GIS, with each map layer depicting an individual determinant: elevation, slope, aspect, or insolation. They can overlay different combinations of these map layers to ascertain the relative importance of each physiographic factor on various plant species. As long-term weather data become available, the researchers will incorporate them as well. Saving describes their initial approach, based largely on elevation, as a "quick and dirty way of getting an idea about the requirements of vegetation without an abundance of source data." To refine the model, Rich looks to Smiley's years of experience and knowledge of the region for additional determinants to examine, such as extent of the fog layer and other coastal influences.



Paul Rich and Shawn Saving

Examples of map layers in Rich and Saving's Big Creek GIS.

By utilizing GIS, Rich and Saving create maps that researchers from other disciplines can use. "What was needed was a high-quality GIS with core coverages for use by both researchers and land managers," explains Rich. "We are paving the way so that we can do our scientific work and help others do theirs." In addition, their GIS vegetation model could have practical applications worldwide. "We believe our model will serve as a tool for conservation management of habitats and species, since it will provide a method of locating habitats that are likely to support the species in question," says Saving. "Understanding the relationship between the landscape and vegetation will also make it easier to measure the human influences on the natural environment."

— Elaine P. Miller
NRS Senior Science Writer

Bodega GIS Boosts Coastal Prairie Research

For its pilot GIS project, the NRS systemwide office selected the Bodega Marine Reserve (BMR) in the winter of 1992. Reserve researchers look forward to applying the GIS to such ecological problems as the study of plant-herbivore interactions.

A work in progress, the Bodega GIS currently contains information at two scales: the reserve and the region. The regional base map is a digital replica of the 7.5' USGS quadrangle of Bodega Bay and surrounding environs, with 40-foot contour intervals. More detailed topographic and other data are available from the reserve map, which shows two-foot contour intervals and many spot elevations. We acquired this information from a local surveying firm.

An important element of Bodega's GIS is the inclusion of the grid system that covers the entire reserve, allowing researchers to pinpoint the location of their field sites. Created by reserve staff in 1988, the grid is composed of permanent markers every 100 meters and is based on the U.S. Army's Universal Transverse Mercator (UTM) coordinates. These grid ticks serve as a valuable tool for registering aerial photos of the reserve to the GIS project. We are incorporating historical and contemporary aerial images into the GIS so that researchers will be able to analyze changes in the site over time.

As the first applied test of Bodega's GIS, we are attempting to support research on the population ecology of bush lupine, a native perennial shrub that dominates the reserve's coastal prairie plant community. This fast-growing, nitrogen-fixing plant is attacked by numerous herbivores — vertebrates as well as insects — that have striking effects on plant performance and community composition. The type of herbivore, density of their natural enemies, and damage they inflict on the plants vary over small spatial scales. Historical aerial photographs reveal extremely rapid turnover among lupines at some sites; a single location may be devoid of plants in some years and blanketed with them in others. Preliminary evidence indicates herbivorous insects may be driving these rapid fluctuations in lupine abundance.

These and other features of BMR's lupine system have attracted the attention of several scientists from UC Davis, as well as from institutions as far flung as the State University of New York (SUNY) at Stony Brook and the University of Toronto. In 1992, Barbara Bentley, a professor at SUNY, began organizing a biannual research conference to enhance interaction between ecologists who work in coastal prairie plant communities similar to those at BMR. Her grant support for this effort comes from the National Science Foundation and the U.S. departments of Agriculture and Energy.

This spring, as part of the conference, Bentley organized a workshop that explored how GISs might be applied to small-scale ecological problems, such as examining the population dynamics of bush lupine at BMR. By incorporating aerial photos, soil maps, and other information into a GIS, for example, researchers may one day be able to track the history of individual lupine bushes and determine how various environmental factors affect the abundance and distribution of this species over limited geographic areas. Our long-term goal for the Bodega GIS is to incorporate information at a similar level of detail for the entire reserve and thus provide a valuable research tool.

— Eric Rainbolt
NRS Environmental Analyst/Cartographer
and
— John Maron
Reserve Steward
Bodega Marine Reserve

M. L. Herring

Bush lupine (*Lupinus arboreus*) with marsh moth caterpillar (*Estigmene acraea*).

GIS Will Support Hastings Eco-research

Since 1937, ecologists at the Hastings Natural History Reservation in Upper Carmel Valley have undertaken more than 300 research projects, with a wide variety of studies on small mammals and birds. Thus, the reserve's resources include many hand-drawn maps of past study areas, along with a large collection of aerial photographs spanning the period from 1930 to the present. With financial support from the Rana Creek Ranch, Carmel Ranch Company, the NRS systemwide office, UC Berkeley's Museum of Vertebrate Zoology (MVZ), and (hopefully) the National Science Foundation (NSF), reserve staff are working with UCB graduate student Heather Carlisle to develop a Macintosh-based GIS that will allow us to compile all this information into one readily accessible database.

The GIS will benefit individual studies, such as the well-known, long-term research program conducted by Hasting's Research Zoologist Walter Koenig and his students. For nearly 20 years, Koenig has tracked the behavior and population ecology of the site's acorn woodpeckers. A GIS of the greater Hastings area will allow us to map the birds' nesting and acorn-storage trees, as well as their movements. It will also aid ongoing studies of yellow-billed magpies, western bluebirds, orioles, and other birds.

When complete, the GIS will allow researchers to pinpoint the positions of organisms in the field, calculate the distances that animals have moved, determine their home ranges and territory sizes, and much more. With a GIS, we can ask new questions — how nest sites are chosen in relation to such environmental variables as vegetation type, slope, and distance from the forest edge, for example — and answer them quickly.

We plan to combine our GIS with the use of global positioning system (GPS) equipment, which uses satellite signals to determine a user's latitude, longitude, and altitude quickly and accurately. If we are successful with NSF, our neighbors at Oak Ridge Ranch and Boekenoogen Ranches, Inc., will match the MVZ contribution towards purchasing a GPS ground station and oné portable radio receiver.

This technology will enhance our long-term monitoring programs, both on site and off. For instance, Koenig and colleagues have nearly 500 oak trees under study from San Luis Obispo to Palo Alto; they have recorded data from each tree annually for 13 years. As field staff change over time, GPS will enable new staff to relocate individual trees each year. In addition, I monitor 80 grassland sites scattered over the reserve and Carmel Valley, and I am involved in experimental native grassland restoration at many sites around Carmel Valley (see *Transect* 11(2):2), which all can be mapped and their corresponding data files made easily available with the GIS.

Finally, with a GIS we can map and easily update information on the "physical plant" at Hastings, which includes 24 buildings, miles of roads, fences, pipelines, junction boxes, valves, fire hydrants, wells, and underground utilities. The extremely rugged western boundary of the reserve has never been surveyed or fenced. GPS equipment will allow us to mark that boundary and assist our neighbors in eventually fencing cattle out of Hastings.

— Mark Stromberg
Reserve Manager
Hastings Natural History Reservation

Reserve GIS Applications: Teaching

From Birds to Bromes: Motte Reserve Makes Good Use of GIS Technology

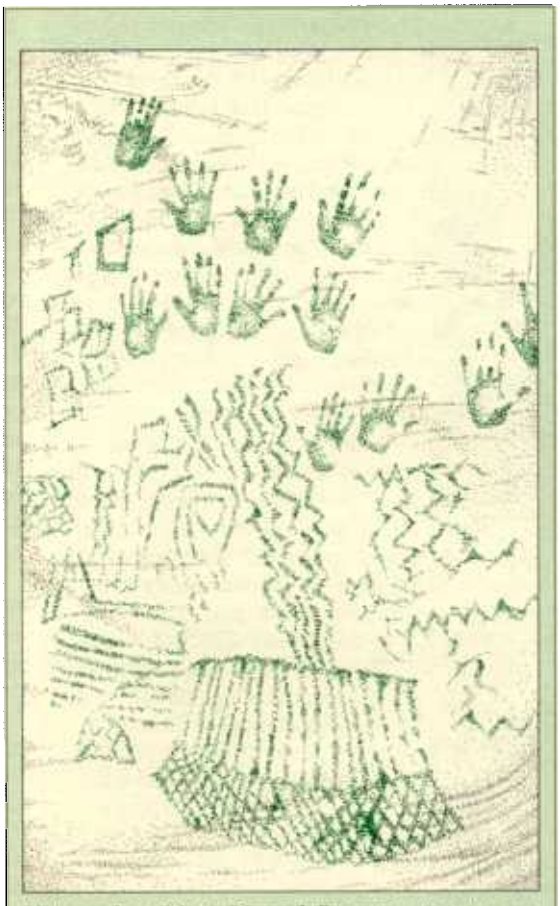
Located on a rocky plateau overlooking Perris Valley and the sprawl of modern development, Motte Rimrock Reserve in Riverside County protects large expanses of coastal sage scrub. NRS reserve staff have designed a GIS that exposes UC Riverside (UCR) undergraduates to modern field techniques, while helping researchers preserve this dwindling habitat.

Incoming freshmen in the UCR Summer Honors Session are contributing to a long-term project to develop detailed GIS maps of the reserve's vegetation. For the past three summers, Matthew Schreiner, a junior at UCR and assistant to Reserve Director Barbara Carlson, has trained teams of honors students to identify plant species in the field and create GIS map layers.

The students map coastal sage scrub and grassland species, including those crucial to the federally endangered Stephens' kangaroo rat (*Dipodomys stephensi*). They also map elderberry trees, a riparian species and food substrate for the federally threatened California gnatcatcher (*Polioptila californica*). Having a detailed GIS vegetation map will enable scientists to locate and monitor habitats, determine fire recovery rates, and manage rare plant species. "The honors students provide a lot of help that might not otherwise be available," says Schreiner.

At the end of each summer, all of the honors students present to each other their multidisciplinary projects. This occasion gives students working at the Motte Reserve an opportunity to share their newly acquired environmental skills and knowledge with those who performed projects at different kinds of sites, such as museums, art galleries, and laboratories.

Since the program began in 1992, however, more and more students of all disciplines have chosen to participate in the GIS project at the Motte Reserve. Schreiner believes they prefer the site because it is something out of the ordinary. "Aside from environmental awareness," he says, "it gives them a chance to learn outside." According to Heather Fredrics, who helps administer the program, "The goal of the honors session is to give students cross-disciplinary experience by exposing them to a variety of disciplines outside their majors."



Pictographs at Motte Rimrock Reserve. (M. L. Herring)

Reflections on Motte

Art Salazar, a UCR sophomore majoring in business administration, helped lead the Motte Reserve honors team last summer after participating in it as an incoming freshman. "It gave me a good jump into college," says Salazar. "I'm the first one in my family to graduate high school and go to college. No one in my family had a clue about a direction for me to take. Participating in the program at the beginning was like taking a blind leap of faith, but I learned a lot." To Salazar, the program represents more than an opportunity to learn field techniques. His experience at the Motte Reserve has left a profound impression on him: "When we were out doing our work, seeing the Indian markings [pictographs] made me aware of that aspect of my heritage, and just being there gave me more respect for nature and the land."

— *E. P. M.*

In addition to helping honors students, Schreiner assists field researchers by developing GIS maps layers depicting the home ranges of California gnatcatchers. Threatened due to habitat loss, these pocket-sized, grayish birds measure only 4.5 inches from beak to tail and are difficult to spot. Carlson, who has been monitoring gnatcatchers since spring 1993, has trained Schreiner to locate the birds using specialized techniques, including patience. What helps, Schreiner says, are the colored bands that Carlson uses to tag the birds, allowing them to be identified individually even from a distance.

After sighting a breeding pair at least 60 times in a season, Schreiner and Carlson can determine the extent of the couple's territory. In addition to gnatcatchers that "commuted" to the reserve or used it as a "rest stop" last year, eight breeding pairs made their homes at Motte. Last spring, Schreiner created an initial GIS map layer depicting the home ranges of these resident gnatcatchers.

Carlson looks forward to overlaying map layers from consecutive seasons. She and Schreiner have discovered that gnatcatchers nest in virtually the same locations each year, though a particular pair does not always return to the same nesting site. By analyzing GIS map layers from several breeding seasons, researchers will be able to pinpoint critical nesting areas, locate gnatcatchers in the field, and develop management strategies for protecting them.

Schreiner finds his fieldwork "different and exciting, a new world not usually open to undergraduates." He says, "I believe our work is going to help lots of different people" — and wildlife as well. His gnatcatcher maps will be analyzed in conjunction with additional GIS maps layers, including those of other sensitive species and of vegetation, to identify critical habitats at the Motte Reserve. Currently, researchers are developing GIS maps of several species that are either listed or are candidates for listing, including the Stephens' kangaroo rat, sage sparrow, rufous-crowned sparrow, orange-throated whiptail, and San Diego coast horned lizard. "In mapping several sensitive species and vegetation types," says Carlson, "we can overlay habitats and home ranges to determine the areas which need super protection."

— Elaine P. Miller
NRS Senior Science Writer

Reserve GIS Applications: Management

Fire Away! James GIS Supports New Program For Fire Management

"It's revolutionary!" exclaims Reserve Director Michael Hamilton from the James San Jacinto Mountains Reserve in Riverside County. Leader of a major multimedia GIS project, Hamilton is using cutting-edge technology to record, analyze, and depict the vegetation and other physical characteristics of the San Jacinto Mountains above 4,000 feet. It is all part of a new Forest Stewardship Program, which is designed to encourage public involvement in land-management issues, beginning with fire prevention and safety.

Located on the western slope of the San Jacinto Mountains, the James Reserve and neighboring town of Idyllwild lie in the heart of fire country. Historically, frequent but small, low-intensity wildfires have helped rejuvenate the rich mixed-conifer forest by clearing away the chaparral and woody undergrowth. In recent decades, however, fire suppression has contributed to a profusion of underbrush and dead wood, making the area vulnerable to catastrophic conflagration.

Through a federal grant administered by the California Department of Forestry and Fire Protection, Hamilton is working with the U.S. Forest Service and several Idyllwild homeowners' associations to develop fire safety and prevention strategies. To document the current health of the forest, high-resolution digital aerial videographs were taken of the mountain range. Hamilton says videotape footage, also shot from the air, allows him to zoom in and view mere centimeters on the ground. "We're talking about identifying individual leaves from the sky," he explains. "It's a way of visualizing patterns of biodiversity from the perspectives of whole ecosystems all the way down to individual species on the ground."

With help from computer programmer Michael Flaxman, a graduate student from the University of Oregon, Hamilton is developing a new multimedia GIS or "macroscope" (see *Transect* 5(2):1). The two of them are discovering ways to integrate aerial and ground-based photographs and videos with vegetation and fire history data and maps. Also incorporated into the macroscope will be property lines and street-level photographs depicting each of the 4,000 homes in Idyllwild, with short video clips of forestry experts describing ecological hazards and stewardship practices.

The multimedia GIS will enable Hamilton to determine the fire risk associated with each land holding and see how individual properties fit into the larger landscape picture. "The Idyllwild residents believe the benefits of the project outweigh any 'big-brother-in-your-backyard' issues," he says. By revealing the optimal sites for tree thinning and controlled burns, the macroscope will enable researchers and land managers to mimic the natural rejuvenation processes of the forest. It will also help them combat pest infestations and other environmental threats. "It's not just about fire," says Hamilton. "That's why the project is called 'Forest Stewardship.'"

Ultimately, Hamilton embraces the project as an opportunity to educate the public in support of the environment. He plans to display the macroscope in town meetings and possibly establish one in the Idyllwild Public Library. Homeowners would then be able to view their properties from a variety of perspectives or scales and as part of an ecosystem. "It's 'eco-democracy' in action," says Hamilton. "The public will make decisions for fire prevention and safety and can find out about the ecological risk at their own site. It shows that precisely where you live greatly influences the ecosystem around you."

— Elaine P. Miller
NRS Senior Science Writer

Pines rooted among boulders at James Reserve.
(Norden H. (Dan) Cheatham)

GIS for Jepson Prairie Helps Managers Monitor Sensitive Plant Species

The Jepson Prairie Reserve, a remnant of the prairie grasslands that covered much of California until a century ago, supports about 250 native plant species, including large stands of perennial bunchgrasses. Owned by The Nature Conservancy (TNC) and jointly managed by TNC and the NRS, this Solano County site is home also to one of California's last remaining vernal-pool ecosystems. To understand this unique landscape, it is important to examine the interaction between physical and biological processes. Over 20 months, I put together a GIS for the reserve to aid in the study of these processes and to serve as an educational and management tool.

The Jepson Prairie GIS currently consists of four maps: a site map, regional map, soils map, and rare plant species map. The site map contains base-layer information, such as topography, hydrography, roads, railroads, buildings, and reserve boundaries. The regional map is a smaller-scale location map that shows the reserve as a part of the greater Sacramento-San Joaquin Delta ecosystem. The locations of the seven different soil types found in the area of the reserve appear on the soils map.

The rare plant species map is the highlight of this GIS. This map consists of a large-scale (1: 9,600), color aerial photo and three overlays that show the locations of 11 rare, threatened, or endangered native plant species. In addition, the project's database includes the more than 320 plant species found in and around the reserve, 26 of which are listed. This data was compiled over the years by Carol Witham and other dedicated volunteers associated with the TNC/UC Jepson Prairie docents program. The database also includes a key by which the California Native Plant Society monitors the population status of sensitive species.

In addition to storing maps and data tables for research use, the Jepson Prairie Reserve GIS will serve as a tool for monitoring grazing, controlled burns, and eradication of eucalyptus and other exotic plant species. The GIS also enables reserve personnel to keep complete records of the reserve as it changes through time, facilitating wise management decisions.

— Emily Prud'homme
NRS Cartographer/Environmental Analyst

GIS Benefits Restoration Of San Joaquin Marsh

At the San Joaquin Freshwater Marsh Reserve on the UC Irvine campus, my students and I are reintroducing coastal sage scrub in an experimental manner at a series of sites. We are also creating a GIS that allows us to monitor the vegetation and track our restoration research. The GIS project was constructed by NRS staff André Zerger and Eric Rainbolt.

Coastal sage scrub once grew on the upland bluffs surrounding the marsh, but was almost completely eliminated by historic agriculture and grazing. Beginning in the fall of 1992, students in my restoration ecology course designed and planted two sites on the reserve in an attempt to recreate a coastal sage scrub canopy. We transplanted nearly a thousand seedlings of nine species from a natural stand of coastal sage on campus slated for development. As the next phase of our restoration project, we will begin establishing understory herb species.

Using the GIS, we are now monitoring the growth, cover, and mortality of the transplants. Survival has been quite high (95 and 96 percent among the California sagebrush and encelia, respectively), and most of the plants flowered and set seed. This summer we will begin examining the seed rain from the young plants and how it affects recruitment in the new stands.

Currently, our Geo/Navigator GIS contains base maps for the marsh and the restoration sites. We have also begun digitizing and entering data on each plant in the project. Individual plants are linked to an Excel database, with growth measurements recorded every three months. Thus, the plants will be able to "grow" in this GIS as the projects mature.

As a fantasizing restoration ecologist, one can envision slipping on the glove and weeding one's restoration site through Virtual Reality. Not to encourage armchair ecology, but it is possible to run transects and sample quadrats electronically on a GIS (although doing that requires some programming beyond Geo/Navigator). Thus, future ecologists may be able to use a GIS not only to predict vegetation infilling, but also to do Shannon-Wiener, Fisher's, and Kempton-Taylor diversity indices. It's only a double-click away!

Peter A. Bowler
Adjunct sociate Professor
UC Irvine

Peter Bowler's Undergrads Get Involved In Learning How to Nurture Nature

For 16 years, Peter Bowler, now an adjunct associate professor at UCI, has contributed to the goals of the San Joaquin Freshwater Marsh Reserve while helping students develop environmental field skills. In addition to coordinating academic use of the marsh, he engages hundreds of undergraduates each year in restoration projects. Many of these students might not otherwise be exposed to environmental field science.

Students in Bowler's restoration ecology class have been working intensively to replace an exotic artichoke at the reserve with native coastal sage scrub species (see main article). Bowler says the students "rescue" native seedlings from areas of the Irvine campus "doomed" for development and transplant the sprouts at the marsh. "Some of these students have never really stopped to touch a plant before," explains Bowler, who has also studied the psychological aspects of restoration. "But when they actually see a bulldozer plow through a natural area, it changes their way of thinking. They try somehow to reverse the effects of the bulldozer."

Courtesy of UC Irvine

Peter Bowler (right) and UC student working to restore native habitats of the San Joaquin Freshwater Marsh.

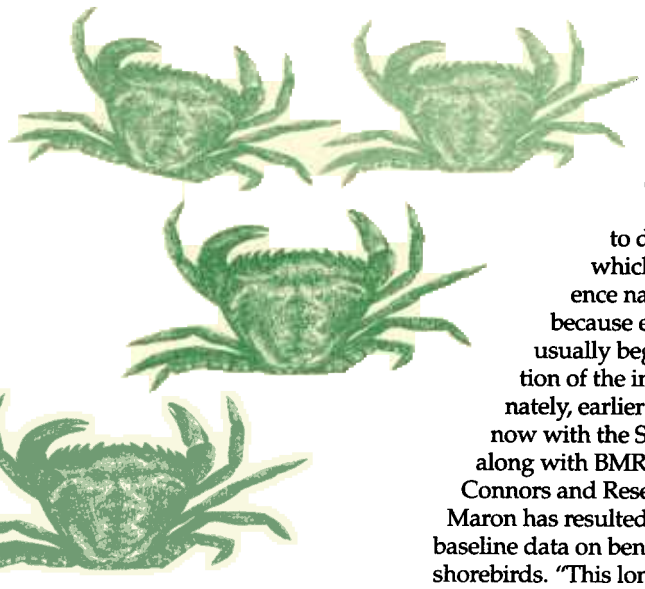
In addition to receiving hands-on experience in restoration, several of Bowler's independent study students got a taste of public speaking when they presented six papers describing their fieldwork at the 1994 annual meeting of the Southern California Academy of Sciences. Held in May on the Irvine campus, this year's meeting was co-hosted by the NRS and UCI's Cooperative Outdoor Program, which Bowler has overseen for many years. Junior Shelly Feeney received the academy's 1994 ARCO Best Environmental Science Paper Award for undergraduates for her presentation on the effects of watering and weeding on young coastal sage scrub plants. Another one of Bowler's students, senior Michael Milane, recently received a UCI Excellence in Research Award for his work on the marsh GIS.

"Few people instruct and affect as many students as Peter — literally hundreds each year," says Reserve Manager Bill Bretz. "He really understands the potential of the NRS to motivate students." In addition to taking his own classes to the marsh, Bowler leads and/or organizes a number of educational student field trips to other NRS sites, including the Burns Piñon Ridge, Motte Rimrock, and Granite Mountains reserves. After graduating, many of Bowler's students return to NRS sites as volunteers. Bowler believes exposure to natural areas in general, and to restoration in particular, enhances their respect for environmental processes and makes them want to stay involved.

E. P. M.

Instruction & Research Highlights

Another British Invasion!



Elaine P. Miller

The green coats are coming! Armored with five spines jutting out from each side of their protective carapaces, European green crabs (*Carcinus maenus*) are invading the Bodega Harbor in Sonoma County.

Named for the color of their undersides during molting, the exotic crustaceans were first detected in San Francisco Bay between 1989 and 1990. By January 1993, they had ventured as far north as Bodega Harbor, infiltrating other embayments along their way. The challenge to researchers is to monitor the crab's exponential population growth and determine its possible effects on the coastal ecosystem.

Scientists at the Bodega Marine Reserve (BMR) anticipate that the abounding crabs will cause decreases in the populations of some native species of benthic invertebrates. Current experiments reveal that the exotic crabs are quick to devour numerous invertebrates that live in the Bodega Harbor sand flats, including small clams, crustaceans, and tube-building phoronids (wormlike, filter-feeding organisms). Ted Grosholz, a researcher from the UC Davis Center for Population Biology, is leading the green crab studies at BMR. "The reduction of benthic invertebrates," he says "may result in the subsequent reduction of wintering shorebird populations in Bodega Harbor that also depend on these invertebrates for food."

Grosholz expects predation by the prolific crabs will hurt the region economically by reducing the oyster populations harvested by fisheries in nearby Tomales Bay. The innocuous Dungeness crab, an [illegible] source to Bodega Bay, is similarly expected to suffer from the presence of the voracious exotics.

Generally, it is difficult to determine the extent to which foreign species influence native populations, because ecological monitoring usually begins *after* the introduction of the invasive species. Fortunately, earlier work by Greg Ruiz, now with the Smithsonian Institution, along with BMR Reserve Manager Peter Connors and Reserve Steward John Maron has resulted in ten years' worth of baseline data on benthic invertebrates and shorebirds. "This long-term data is critical in determining whether reductions seen in invertebrate or shorebird populations are due to natural fluctuations or to the presence of the crab," says Grosholz, underscoring the importance of baseline information to all NRS sites.

Widespread along the shores of Europe, especially Great Britain, the crabs somehow made their way to the east coast of the United States during the nineteenth century. Researchers speculate that the European crabs were introduced to the California coast as stowaway larvae in ballast water. Once in San Francisco Bay, they may have spread northward via a newly discovered longshore current that occurs when upwelling winds shut down. During these "relaxation periods," nearshore waters can actually flow *northward*, counter to the southward movement of the large-scale California Current, says Stephen Wing, a UCD postdoctoral researcher. Wing works with a team of UCD scientists studying the relationship between this northward-flowing current and the periodic arrivals of sea urchin and crab larvae to Bodega Bay. "So far," says Wing, "studies show that the longshore current is the most important oceanographic feature for settlement."

As with most exotic invasions, scientists can do little to stop the green crab. Some suggest introducing a parasite of the crustacean, but the effectiveness and long-term implications of this method are unknown at best. Grosholz asserts that the one approach to controlling these fist-sized exotics would be to find an economic use for them, perhaps as a bait species. Nevertheless, he pushes prevention as the only real way to limit such introductions. He hopes the green crab studies will make an impact "both scientifically and from a public policy perspective." This research should encourage scientists to work with shipping interests to find ways "to stop moving millions of gallons of water, with all the associated organisms, across the planet."

— Elaine P. Miller
NRS Senior Science Writer

Editor's Note: Ted Grosholz was recently awarded a $185,000 grant from the National Science Foundation's Conservation Biology Panel. This new funding will enable Grosholz to expand his work on green crabs at BMR.

Local High School Students Get Crustacean Education

Among those benefiting from green crab research at Bodega are students at Piner High School discovering an interest in field research. As reported in the fall 1993 issue of *Transect*, BMR scientist Vic Chow heads a mentorship program that provides high school students with an opportunity to develop scientific techniques at the reserve. Ted Grosholz and BMR technician Cheryl Dean work with Piner students who are studying green crab behavior. Junior Matt Dillon, for example, observes how the exotic crustaceans and native shorecrabs compete for food and shelter. Grosholz says the efforts of Dillon and other students help reserve scientists, who use student findings to supplement their own research. Dillon says his experiences at BMR have helped demystify scientific processes and have made him feel that, through learning, he can make a difference. "It's more than just reading about science in books," he says. "I can really *feel* what I'm doing, and I can *see* the impacts it's going to have."

— E. P. M.

Bodega Marine Reserve Managers Save a Species

Not many people have the satisfaction of knowing their work makes a profound difference to another species. Among the fortunate few are Bodega Marine Reserve (BMR) Manager Peter Connors and Steward John Maron, who are in the process of rescuing a clover from extinction.

Their quest began on Memorial Day 1993, when they discovered a single showy Indian clover (*Trifolium amoenum*) on a grassy ridge in Sonoma County. Last seen in 1969, *T. amoenum* (whose species name means "lovely") had been presumed extinct since the early 1980s. The plant Connors and Maron recently found was growing on private land that was for sale, along a lane that had been bulldozed the previous summer to provide access for prospective buyers. Subsequent searches of the hillside established that the population consisted of but one individual.

Unfortunately, since *T. amoenum* was thought to be extinct, it receives less protection than an officially listed endangered plant. Fortunately, the potentially dangerous gap in the law allowed Connors and Maron to initiate research immediately, without having to go through the permitting process typically required when studying a listed species.

After close calls with a bulldozer and a tractor, the clover — which seems to be self-fertile — produced 92 seeds. Connors collected them all, sent half to the U.S. Department of Agriculture National Seed Storage Laboratory, and kept the other half for research and recovery efforts.

"No one has studied *Trifolium amoenum* before, so we had to begin by working out its germination and cultivation," says Connors. Using seeds of the common but closely related *T. macraei*, Connors experimented with propagation techniques in the new BMR greenhouse. By November 1993, he was batting 1,000 with *T. macraei*. Over the next several weeks, he used the same procedures to germinate 18 *T. amoenum* seeds.

Meanwhile, the parent plant, being an annual, had died; once again the clover was extinct in the wild. But there was still much to gain from it. As do other members of the Fabaceae family, *Trifolium* fixes atmospheric nitrogen through symbiosis with a bacterium living in nodules on the plant's roots. Connors found three such nodules on the spent plant. These he sent to a commercial laboratory that isolated the *Rhizobium* and returned an inoculant culture, which Connors introduced into the seedling soil.

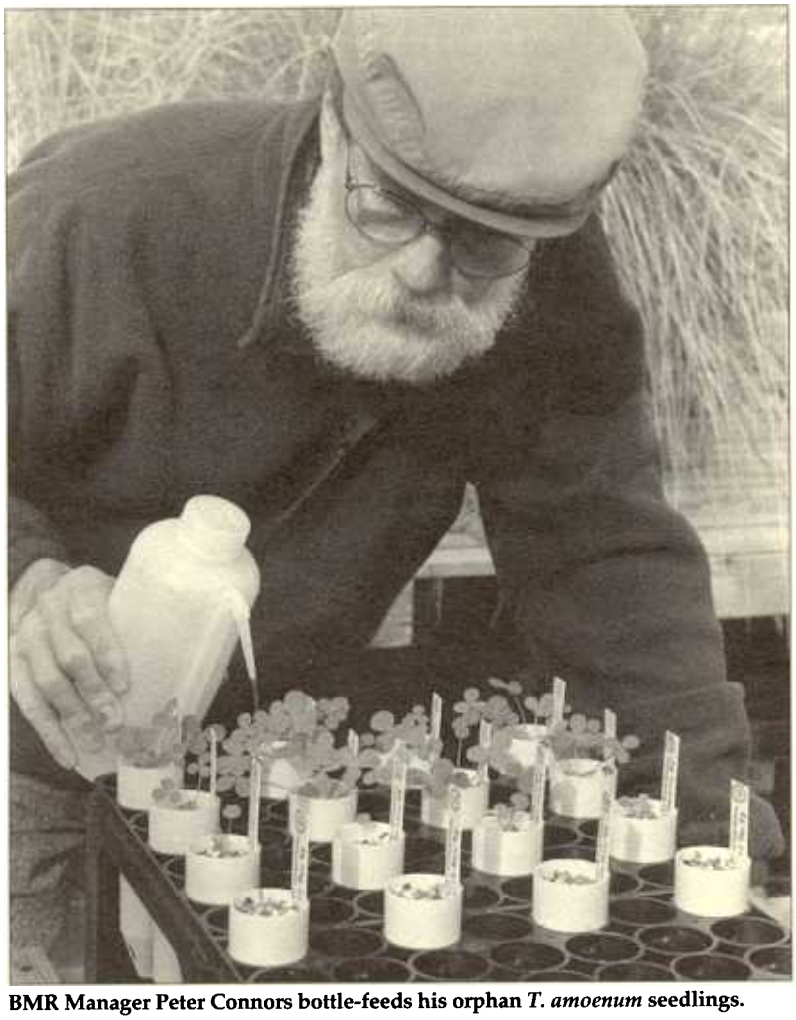
So far, Connors's efforts have been a huge success. Seventeen of his 18 seeds produced healthy plants that bloomed in May. Partway through the summer harvest, he had already collected more than twenty thousand seeds. "With this many seeds, I can begin to do some experiments," says Connors. "It's also a viable number to think about reestablishing a population in the wild."

According to Connors, the surprising reappearance of *T. amoenum* raises several questions: What caused its near-extinction? What is the source of this single individual, and can such a small population survive over time? Will one plant be enough to parent an entire population? "Further experimental research will increase our understanding of the plant's breeding system as well as the factors contributing to its extinction process," says Connors. "This will be crucial to reestablishing and managing a new population."

To make their single-founder population more viable, Connors would like to increase its genetic diversity. The Center for Plant Conservation has already targeted *T. amoenum* as a prime candidate for Project Phoenix, which attempts to rescue plants from extinction by germinating seeds found on herbarium specimens. And Connors hopes his work will step up efforts to locate other individuals growing in the wild. "Perhaps the most significant aspect of the 1993 discovery is simply that showy Indian clover still exists, and that its long-lived seeds may produce seedlings at any of its former sites in any year."

For Connors, the initial thrill of that discovery has carried over into his research and recovery efforts. "It's exciting to be studying a plant that's so rare, and extremely satisfying to be growing something where every plant matters," he says. "The work has so much promise. Even though the clover was not found on a reserve, it shows how the NRS, through its facilities and personnel, can contribute to saving our natural resources."

—Sarah Steinberg Gustafson
NRS Transect *Editor*



John Maron

BMR Manager Peter Connors bottle-feeds his orphan *T. amoenum* seedlings.

NRS People

New Co-directors Care for Remote Site

After several years as biological consultants, Claudia Luke and Jim André wanted an opportunity to focus on desert biology and contribute to the research and management of arid lands. They've had that chance since January, when they became co-directors of the NRS's Granite Mountains Reserve (GMR), a UC Riverside site in the East Mojave Desert.

Life in the remote Granite Mountains is nothing new to Luke. She spent eight months living and doing lab work at the reserve while conducting doctoral research on color change in side-blotched lizards at Pisgah Lava Flow, located about 60 miles to the west (see *Transect* 7(1):4). In 1989, she received her Ph.D. in herpetology from UC Berkeley. André, whose graduate work focused on the population biology of alpine plants in the southern Sierra Nevada, received his master's degree in botany that same year from Humboldt State University. They began working together in the fall of 1989 at BioSystems Analysis, Inc., in Tiburon, California. Today they live in the Pink House in Granite Cove, just down the hill from the site's new research and residential facility.

Among the many goals André and Luke set for GMR, one of the first was to provide improved housing for classes by renovating Dorner's educational facility, a project they completed in March. They are now in the process of upgrading the Staple's residence, which will soon house the new reserve steward (see *Editor's Note*).

Soon after their arrival at GMR, Luke and André began to develop communication with future managers of the East Mojave National Park. The creation of the park, which would completely surround GMR, is one provision in the California Desert Bill, expected to be enacted by the end of the year. "Our ability to support research and education in the new park will be crucial to the long-term success of the Granite Mountains Reserve," says André. "Over 80 percent of the researchers and classes on the reserve use areas outside of the reserve boundaries."

André and Luke have also begun updating the reserve's species lists with an eye towards answering questions about the area's biogeography. "The biotic communities of the eastern Mojave Desert are poorly understood," says André. "We're interested in collecting field data to study the distribution ecology of species and community associations." These data, adds Luke, would also be of primary interest to researchers and managers in the region.

To further support educational uses, Luke and André plan to develop another facility to accommodate large classes and to organize a summer undergraduate course in scientific methodology. "Reserves are an ideal place to learn the scientific method," says Luke. "Unlike cities, where people shut themselves off from their surroundings, natural environments like the Granite Mountains inspire students to observe, ask questions, and search for answers."

—Sarah Steinberg Gustafson
NRS Transect *Editor*

Editor's Note: David Lee joined André and Luke at the Granite Mountains as full-time reserve steward in September. Lee, who worked at UCLA's White Mountains Research Station for nine years, brings to GMR a great deal of experience in construction and plumbing, a talent for illustration, and a passion for archaeology. He is responsible for maintaining the reserve's facilities, freeing more of the co-directors' time to support and conduct research and teaching.

Happy Trails

We will miss UC Davis NRS Administrative Coordinator Jonellen Goddard who, after 18 years with the NRS, is leaving — for real this time. Officially she retired in December of 1992, but she has continued to spend many hundreds of hours working part-time.

"I've been interested in conservation all of my life," says Goddard. Trained as a paleobotanist and accustomed to life on a ranch, she has profound ties to the land. Driven by unwavering dedication to environmental education, research, and preservation, she convinced various administrators that reserves are important and deserve funding. She has been instrumental in obtaining campus financial support for reserve operation costs, student research grants, and reserve steward salaries. Her other contributions to the reserve system include work on the Steering Committee on Long-Range Planning and the University-wide NRS Advisory Committee.

Goddard's trail of achievements leaves her with a sense of accomplishment; this motivates her to keep working, even in "retirement." She will remain active in the NRS by continuing to volunteer for the Quail Ridge Campaign, a $500,000 fundraising effort for this NRS site on Lake Berryessa. She also plans to travel, manage the family ranch in Oregon, and spend time with her two burros, Pommie (the mother) and Surprise (the unexpected addition to the family), whom she adopted from the Bureau of Land Management.

"Jonellen's been the link between the land and the administration," says UCD Reserve Manager Kevin Williams. "Her work on campus keeps me fed." To reap these kinds of benefits for the NRS, Goddard had to be, as Williams puts it, "tough as nails." Yet, he also sees her gentler side. "When my two-year-old son visits the office," says Williams, "he always goes dashing into her arms without hesitation."

Good luck, Jonellen!

—Elaine P. Miller
NRS Senior Science Writer

Jonellen Goddard and her burros, Pommie and Surprise, adopted from the Bureau of Land Management in a "Surprise-ing," two-fur-one package. (Courtesy of UC Davis)

Jeff Kennedy

Long-time NRS Planner Leaves for Grad School

After devoting nearly twenty years to designing and managing NRS reserves, Jeff Kennedy will now enjoy the fruits of his labor as a reserve user. He resigned from his position as NRS Principal Environmental Planner on July 1 to pursue a Ph.D. in Ecology at UC Davis. Kennedy will conduct some of his doctoral research at the Landels-Hill Big Creek Reserve, one of the first sites for which he played a key planning role from its earliest days.

Kennedy became involved with the NRS in 1975 while pursuing a master's degree in Landscape Architecture at UC Berkeley. In the course of conducting some contractual planning projects for the NRS, he realized the program needed a full-time environmental planner. He wrote a proposal to create such a position, which he filled from 1977 until mid-1994.

In all his years with the NRS, Kennedy views his most important accomplishment as catalyzing the annual Reserve Management Workshop, which he characterizes as "the most tangible expression of the systemness of the NRS." Before the first workshop in 1984, few individual reserve personnel had met one another; most operated in isolation. "The workshops pulled us together as a team," says Kennedy, who often served as an informal liaison between reserve staff and the systemwide NRS office. "At the meetings, we began sharing information and experience, as well as identifying common problems and possible solutions. We've accomplished some remarkable things as a group."

Kennedy also found great satisfaction in two other areas: (1) starting and, initially, overseeing the NRS Publications Program; and (2) assisting major facilities development on reserves by networking with the Organization of Biological Field Stations (OBFS) and the National Science Foundation (NSF). Through involvement with the OBFS, Kennedy and several reserve managers advised the NSF on its special competition for equipment and facilities at biological field stations. Due in part to NRS input, the NSF allowed undeveloped sites with high potential for research productivity (such as many NRS reserves) to compete with developed stations, as long as their parent institution provided a funding match. To help the NRS take advantage of this new funding program, Kennedy worked with the University-wide NRS Advisory Committee to design an internal NRS competition to award reserves potential matching funds. As a result, NRS sites received four major NSF facilities grants in as many years during the late 1980s and early 1990s. "I'm tremendously proud of that," he says.

Kennedy also enjoyed seeing the direct impact his work had on reserve users. "Aside from my involvement with the reserve managers, some of my fondest NRS memories are of working with Ken Norris [then a professor of natural history at UC Santa Cruz] and his Environmental Field Program [a former UCSC undergraduate research program] to implement resource inventories at reserves like Big Creek," he says. "It was such a joy to go into the field as a planner and experience what I had a part in facilitating. Here were these students using the reserves to learn skills and launch their careers while filling a real-world need."

One of the careers launched through reserve work was that of Paul Rich, now a professor at the University of Kansas. As part of his dissertation research, Kennedy will be collaborating with Rich to develop a Geographic Information System for the Santa Lucia Mountains (see page 5). "This is a delicious closing of the circle for me," says Kennedy. "Paul and I will be working together at Big Creek again, but this time he's the teacher and I'm the student."

Kennedy began his doctoral coursework in the fall of 1993. A student in the Graduate Group in Ecology at UCD, he chose systems and landscape ecology as his area of emphasis. He's particularly interested in how abiotic factors, such as climate and disturbance regimes, affect spatial and temporal patterns of biodiversity at the landscape scale. "I see this as a natural segue from years of gaining very practical planning experience to immersing myself in science-driven reserve design and management."

He hopes to complete his degree in 1997, the year he turns 50. After that, his plans are wide open. "I want to lead an interesting and productive life," says Kennedy. "Whatever keeps me gainfully employed while satisfying those criteria would be fine."

— Sarah Steinberg Gustafson
NRS Transect *Editor*

Henry Offen

Early Retirement Claims NRS Campus Director

The NRS bids a fond farewell to Henry Offen, who oversaw UC Santa Barbara's reserves for 22 years. Offen, a newly emeritized professor of chemistry, stepped down as the NRS campus director in March.

During Offen's tenure, UCSB's NRS office took on several new reserves and developed an administrative structure that has served as a model of efficiency for other campuses. For part of the time, Offen also served as dean of research development in the graduate division, then as director of the Marine Science Institute, the administrative home of the campus NRS office. "The fact that I had connections within the administration helped when push came to shove with respect to protecting the NRS budget," he says.

At the systemwide level, Offen was instrumental in developing the 1992 NRS Long-Range Plan, served on the University-wide NRS Advisory Committee for several years, and chaired the 1988 search committee for a new NRS director.

Under the conditions of UC's VERIP retirement plan, Offen will continue to teach freshman chemistry at UCSB for three years and may work part-time in UC administration. He also plans to pursue other interests, including environmental issues, organic gardening, and what he refers to as "experimental chemistry" in the kitchen.

"Henry was the strongest driving force on the Santa Barbara campus for developing the reserve system since its earliest days," says Dan Dawson, manager of two UCSB reserves. "He has an appreciation for reserves uncommon to people who don't do field science. He devoted a tremendous amount of energy to the NRS at the expense of his own career advancement, because he knew it would benefit so many faculty and students for such a long time."

— Sarah Steinberg Gustafson
NRS Transect *Editor*

News and Notes

Crocker Endowment to Benefit Carpinteria Salt Marsh Reserve

Reserve Manager Wayne Ferren sees exciting times ahead for the Carpinteria Salt Marsh Reserve in Santa Barbara County. Earlier this year, Donald W. Crocker generously donated $100,000 to the reserve in memory of his parents, Roy P. and Josephine Scott Crocker, reserve neighbors who loved the area. The marsh represents one of the few remaining Southern California estuaries and supports a variety of wildlife, including two endangered birds, the light-footed clapper rail and Belding's savannah sparrow.

Most of the Crocker gift will be used to establish the reserve's first endowment fund, which Ferren hopes will attract other donations. Remaining Crocker funds will be used to establish a GIS, publish a volume on the marsh's zoological resources, and continue current studies on nutrient pollution and marsh fishes. "All of these projects have great management implications," says Ferren. "The gift brings us forward enormously."

Elizabeth Riddle

Trudi Emerson and Harvey Emerson hoist the dedication plaque at a summertime on-site celebration of the creation of the Emerson Oaks Reserve in Temecula, California.

Waters offshore at Big Creek Become a State Reserve

The habitats and organisms offshore the Landels-Hill Big Creek Reserve have enjoyed an unprecedented level of protection since January 1, when the California Fish and Game Commission designated the area as one of four new ecological reserves mandated by the Marine Resources Protection Act of 1990. The designation prohibits anyone from entering the two-mile-square marine reserve except to conduct research or participate in research-oriented classes. Commercial and sport harvesting, as well as recreational uses, are excluded.

"This designation is very important," says John Smiley, manager of the Big Creek Reserve. This NRS site lies at the core of the Big Sur wilderness that extends from coastal ridge to ocean floor. "It will help prevent the kelp forest communities off Big Creek from being exploited and will expand protection for the entire watershed." Originating in the adjacent Ventana Wilderness, the Big Creek-Devil's Creek watershed supports a native steelhead trout population in water clean enough to drink at sea level. With the new marine reserve designation, the watershed is now fully protected from its headwaters at 5,155 feet above sea level to a depth of 300 feet below.

According to Smiley, the commission will provide one-time grant money for research start-up. Among the projects Smiley hopes will be funded is the development of a detailed underwater map that can be incorporated into the reserve's GIS (see page 5).

The new Big Creek Marine Reserve also receives national protection by the recently designated Monterey Bay National Marine Sanctuary, which extends from the Gulf of the Farallones to near San Simeon, reaching more than 50 miles offshore in places. Managed by the National Oceanic and Atmospheric Administration, the sanctuary bans offshore oil development and new waste discharge or dumping of dredging spoils. The NRS's Año Nuevo Island Reserve also lies within sanctuary boundaries.

Out with the New, In with the Old at Younger Lagoon Reserve

An undergraduate team of Mathias grant winners from UC Santa Cruz is restoring native vegetation at the NRS's Younger Lagoon Reserve, one of the few remaining protected wetlands along California's central coast. During the 1880s, local land owners introduced poison hemlock to the region as an ornamental plant. Today, solid stands of this exotic species outcompete native grassland and coastal scrub communities.

"Experience has shown that poison hemlock stands can be reduced and native vegetation can be restored to these types of communities," says Reserve Steward Grey. He is leading the undergraduate team in replacing the exotic stands with native flora. Just before the hemlock seeds ripened in the spring of 1992, the students cleared entire stands of the exotic plant. To suppress germination of the hemlock seeds that remain in the soil of the cleared areas, they have been comparing the effectiveness of two kinds of mulch: straw and plastic sheeting.

The students next will apply native grass seed hay. "Application of this type of hay not only produces the desired mulch," Grey says, "but also creates a stand of native grass to occupy the empty habitat that is left, further reducing the chance of invasion by exotic pest plants." Reintroduction is also decreased thanks to neighboring farmer Julio Renaldi, who has voluntarily set aside some of his farmland adjacent to the reserve to serve as a buffer zone.

To restore the native Santa Cruz County flora, the undergraduate team has been planting coastal scrub and grass seedlings, including lizard tail, coyote bush, and beach sagewort. Establishing themselves in the winter rains, all of the plantings are expected to thrive without irrigation.

Grey believes the students' work will set a precedent for the restoration of other areas of the central coast of California and hopes to contribute to similar projects in the region. "In this day and age, there are not many activities that are more constructive," says Grey. "Coastal scrub and coastal prairie grasslands have disappeared for the most part, and the preservation and management of this island of native vegetation are of great importance."

You Still Have Time to Turn In Your Proposal for An NRS Student Grant

Again this year, the NRS systemwide office will issue calls for proposals for three student funding programs: (1) the Mildred E. Mathias Graduate Research Grants, (2) the Elizabeth Hall Blakey Travel Grants, and (3) the Robert M. Norris Undergraduate Research Grants. What follows are a description of the conditions of each grant and a list of NRS campus coordinators to whom proposals must be submitted. Good luck!

Mathias Graduate Research Grants

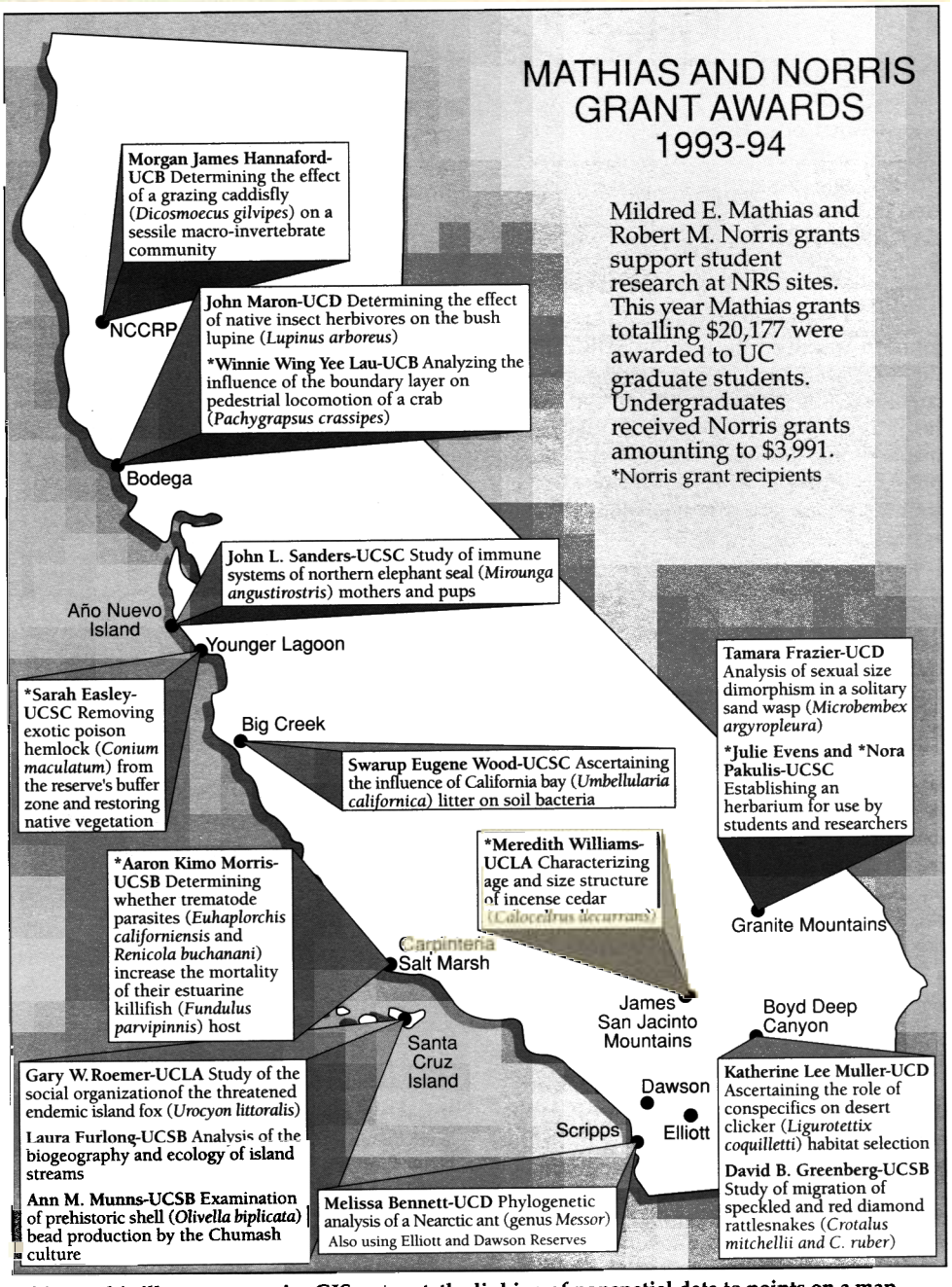
Support graduate student research at reserves. Maximum award: $2,000. *Research must be done on UC NRS reserves.* Funding pool of $20,000 available. **Student applications due to campus coordinators by November 5, 1994.** Awards announced by December 15.

Blakey Travel Grants

Support undergraduate use of NRS reserves by covering reserve-related travel expenses of undergraduate classes and undergraduate independent (and small group) studies. Maximum grant for undergraduate course travel expenses: $1,000; for undergraduate student's independent study travel expenses: $250. *A fiscal match must be provided by the department, college, or other sources* (grantees are encouraged to seek a 1:1 match). Funding pool of $12,000 available. **Applications for winter 1994-95 and spring 1995 terms accepted until December 9, 1994.** Awards for these terms made December 23.

Norris Undergraduate Research Grants

Support undergraduate student research at reserves. Maximum award: $1,000, issued directly to students. *Research must be done on UC NRS reserves.* Funding pool of $5,000 available. Official call issued by November 1, 1994. **Student applications should be given to the NRS campus coordinator by January 15, 1995.** Awards announced by February 15.



Emily Prud'homme and Elaine P. Miller

This graphic illustrates a major GIS concept: the linking of nonspatial data to points on a map. And thanks to a generous gift this year from Jane McKenzie, applied to the Robert M. Norris Research Grants fund, select UC undergraduates will continue to receive support for their investigation of the natural world on NRS reserves.

1994-95 Campus Contacts for Grants

Berkeley: **Mary Power**, Integrative Biology, 360 Valley Life Sciences Bldg., UC, Berkeley, CA 94720; (510) 643-7776. **Margaret Race**, Dean's Office, College of Natural Resources, 101 Giannini Hall, UC, Berkeley, CA 94720; (510) 642-7571. **Frank Pitelka**, Museum of Vertebrate Zoology, 3101 Valley Life Sciences Bldg., UC, Berkeley CA 94720; (510) 642-1373.

Davis: **Jeanne MacKenzie**, Office of Research, 410 Mrak Hall, UC, Davis, CA 95616; (916) 752-7073. **John D. Kemper** (retired), 1742 Midway Dr., Woodland, CA 95695.

Irvine: **Peter Bowler**, NRS Academic Coordinator, Ecology and Evolutionary Biology, UC, Irvine CA 92717; (714) 856-5183 (changes to **824**-5183 on November 4, 1994). **Bryan Vila** (on sabbatical until June 1995), School of Social Ecology, UC, Irvine, CA 92717; (714) 856-6148 (changes to **824**-6148 on November 4, 1994).

Los Angeles: **Robert Gibson**, Biology, 2203 Life Sciences Bldg., UC, Los Angeles CA 90024; (310) 825-6459.

Riverside: **John Rotenberry**, Biology, UC, Riverside CA 92521; (909) 787-3953.

San Diego: **Isabelle Kay**, Scripps Institution of Oceanography, UC-San Diego (A-0201), UC, La Jolla CA 92093; (619) 534-2077.

Santa Barbara: **Scott Cooper**, Biology, UC, Santa Barbara CA 93106; (805) 893-4508. **Frank Davis**, Geography, 5710 Ellison Hall, UC, Santa Barbara CA 93106; (805) 893-3438. **Donna Moore**, Natural Reserve System, c/o Marine Science Institute, UC, Santa Barbara CA 93106; (805) 893-4127.

Santa Cruz: **Margaret H. Fusari**, Campus NRS Office, 272 Applied Sciences, UC, Santa Cruz CA 95064; (408) 459-4971.

Old Growth Gets New Name, New Owner

The Nature Conservancy (TNC) has given UC title to the remote Northern California Coast Range Preserve (NCCRP) in Mendocino County. Since 1989, the NRS has managed this site along the Eel River, which was the first TNC preserve in the western United States.

TNC's Director of Stewardship Steve Johnson described the transfer of this site to the UC reserve system as "an excellent outcome" and says he is "delighted with the arrangement." TNC cannot administer and maintain indefinitely all the properties it is protecting; for this reason, the conservancy sometimes seeks new owners who will manage the land with regard for its ecological values. Transfer of this reserve to the University is considered a success for all parties involved — TNC, UC, and the Angelos, descendents of the land's original owners — since it will protect the property "in perpetuity by a dedicated and skilled long-term owner."

As part of the title change, this 4,055-acre site was renamed the "Heath and Marjorie Angelo Coast Range Reserve." Alarmed by intense logging in the region, the Angelos began purchasing the land in 1931 to protect its centuries-old forests from harvest. To preserve this pristine site for future generations, they sold their land to TNC in 1959. Through a five-year use agreement with UC, NRS Resident Reserve Manager Peter Steel, the Angelos' grandson, has continued the family tradition of land stewardship. He oversees research, educational, and public service use of this site, which contains the largest virgin Douglas-fir community remaining in California and received international recognition by the United Nations Environmental, Scientific, and Cultural Organization.

"I think the transfer of title is a great thing," says Steel. "And the transitional period we've been in has shown that it's possible for both organizations — the NRS and TNC — to work together." In the future, Steel hopes to enhance ties with the U.S. Bureau of Land Management, which owns 3,580 acres of wilderness adjacent to the reserve. He also plans to expand reserve-based education, integrating it more fully into local public schools. "This land is part of my family heritage, and I feel extremely close to it," Steel explains. "It's important to me to work here and actively fulfill my desire to be part of the natural environment and help other people to experience it."

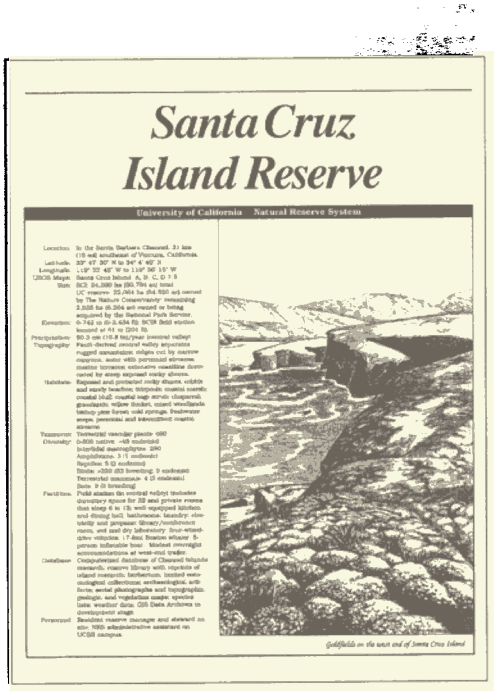
Publications

New Brochure off the NRS Press

The NRS recently produced a brochure on the Santa Cruz Island Reserve. Designed for prospective reserve users, the publication describes the site's natural resources and contains information on access, facilities, management, and use.

Santa Cruz Island is the largest and most topographically and biologically diverse of the eight Channel Islands. It is one of only two Channel Islands to offer academic facilities (Catalina is the other). The reserve's field station draws considerable use. At the Fourth California Islands Symposium, held this past March on the mainland at the Santa Barbara Museum of Natural History, almost 30 percent of the papers and posters presented covered work based at the Santa Cruz Island Reserve field station. Many of these works were the result of cutting-edge research being performed by graduate students investigating such areas as the effects of feral pigs on native species, the use of GIS and remote sensing to map vegetation recovery, and the history of faulting and uplift of the northern Channel Islands.

The NRS has published brochures for many other sites. All are sent upon request, free of charge. Contact the systemwide NRS office for a publication list.



100% Recycled paper printed with soy-based inks
Sarah Steinberg Gustafson, *Transect* Editor
Elaine P. Miller, Sr. Science Writer
Susan Gee Rumsey, Pr. Publications Coordinator
Margaret Herring, Science Editor/Illustrator
Pam Fabry, Design Consultant

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