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From the Director
SAREP organic farming support on two fronts: grants, workgroup

Preliminary data from the California Department of Food and Agriculture's *California Organic Program* indicate that registered organic acreage in the state has more than doubled since 1998 to over 170,000 acres, declared sales value of organic agricultural products was over $250 million in 2000, and over 2,200 organic growers are registered with their county agricultural commissioners in 2001. Top value crops include carrots, lettuce, rice, wine and table grapes, strawberries, broccoli, fresh market and processing tomatoes, and several tree crops (almonds, apples, citrus, stone fruit, dates). Although these preliminary statistics are subject to further analysis, they indicate accelerated growth in organic production and markets in the state [see *California Agriculture* 54(4):26-35].

With the fast approach of an October 2002 implementation date for federal certification of organic growers, many observers have noted the lack of research and extension services for the needs of a growing organic farming community. As the statewide special program responsible for funding research and education on organic methods, it gives me great pleasure to announce two new initiatives to respond to organic farming research and extension needs in California.

In August 2001, SAREP received a three-year grant of $450,000 from the Clarence E. Heller Charitable Foundation, which will enable us to make awards to four county-level programs for organic farming and soil health research and extension. In cooperation with Cooperative Extension offices in Marin, Humboldt, and Stanislaus counties, SAREP has made funds available for development of new program areas. In Marin County, a grant to County Director **Ellie Rilla** will fund an organic and sustainable agriculture coordinator to work with an advisory committee, a local farm advisor, the Marin Organic Board, and other community members to assist farmers and ranchers with business diversification/development focusing on the transition to organic practices. In Humboldt County, a grant to County Director **Deborah Giraud** will fund a new organic farming researcher to conduct research and education projects on organic practices with county farm advisors. In Stanislaus County, a grant to County Director **Phil Osterli** will fund a researcher to develop information for soil health and compost science for transitional and organic farmers. A matching grant to an additional county will be used to organize a research and extension program to support local organic farming production and marketing.

The primary intent of the Heller grant is to increase knowledge and information about organic farming systems. We contemplate several new grants to additional county programs in 2002. The grant also includes support for commodity-specific organic production extension manuals, and a California scientific conference on organic farming research in 2002.

On November 1, the DANR Organic Farming Research Workgroup convened in Davis with 65 attendees. Faculty and researchers from 10 academic departments at four UC campuses, farm advisors from 12 counties, and 40 other interested researchers, federal and state program administrators, private foundations and industry representatives and farmers met for an all-day plenary in which members unanimously favored 2002 ratification as a Workgroup; nominated a 12-member steering committee to meet and plan activities in January 2002 for a scientific conference on California organic farming research results with peer-reviewed proceedings; established an organic farming research section of SAREP's Web site with member research interests and bibliographies, and a database of projects primarily funded by SAREP. That page will be up and running in mid-December 2001.

A few highlights from the Workgroup plenary meeting:

- **Karen Klonsky**, an agricultural economist from the agricultural and resource economics department at UCD gave a presentation about the growth of organic farm production in California from 1992-1998. Her new publication "Statistical Analysis of California Organic Agriculture: 1995-1998" describes some interesting trends (see "Resources"). Demand for organic production is increasing faster than the acreage or number of organic farmers in California.

- Researchers discussed multi-year California organic research. Panelists included **Ford Denison**, UCD agronomy and range science department, who is director of the 100-year Long Term Research on Agricultural Systems (LTRAS) project on the "organic effect" and transition studies; **Howard Ferris**, UCD nematology department, whose research is on nematodes as markers of soil community development; **Kate Scow**, UCD land, air and water resources department, a microbiologist conducting research on the DNA "fingerprinting" of microbial communities; and **William Horwath**, UCD land, air and water resources department, who shared information about organic soil fertility and nitrogen management.
- UC Cooperative Extension advisors **Ramiro Lobo** from UCCE San Diego, and **Mario Moratorio** of UCCE Yolo County, **Benny Fouché**, UCCE San Joaquin County, and **Laura Tourte**, UCCE county director, Santa Cruz, spoke about the challenges of working primarily with small farmers, many of whom farm organically and come from a variety of ethnic backgrounds.
- **Ray Green**, program manager of the CDFA-California Organic Program, discussed state and federal regulations relating to organic rules. He noted that each day at least one California farm is registering as organic.
- There were several breakout sessions at the meeting in which researchers shared their work in fruits, vegetables, tree crops, vines and dairy in California, including **Carolee Bull**, USDA-ARS, (strawberries); **Steve Fennimore**, UCD vegetable crops department (strawberries); **Louise Jackson**, UCD vegetable crops department (vegetables); **Glenn McGourty**, UCCE Mendocino (winegrapes); **Janine Hasey**, UCCE Sutter/Yuba (kiwis); **Janet Caprile**, UCCE Contra Costa (apples/pears); and **L.J. "Bees" Butler**, UCD agricultural and resources economics department (dairy).

Workgroup activities are supported by a grant from the Division of Agriculture and Natural Resources Program Council. I would like to thank both the Heller Foundation and the DANR Program Council for their funding of these activities in support of California's growing needs in the organic farming community. Those interested in being added to the Organic Farming Workgroup listserv should contact SAREP Office Manager **Linda Fugitt** at llfugitt@ucdavis.edu or call (530) 752-7556.— *Sean L. Swezey, director, University of California Sustainable Agriculture Research and Education Program.*

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Grape pest management course online

Increasingly stringent environmental regulations are prompting grape growers and their pest management advisers to seek help in many quarters. Now they can find assistance online in a new course, *Ecological Pest Management in Grapes*, developed by SAREP.

Bell bean cover crop in California vineyard.
(photo by Fred Thomas)

Professional entomologist **Chris Geiger** and SAREP education coordinator **David Chaney** created the course in consultation with an advisory committee of UC experts and grape pest control advisers (PCAs) including **Mary Louise Flint** (UC IPM), **Kent Daane** (UC Kearney Ag Center), **Rhonda Smith** (UC Cooperative Extension Sonoma County), **George Leavitt** (UC Cooperative Extension Madera County), **Jenny Broome** (US SAREP), **Cliff Ohmart** (Lodi-Woodbridge Winegrape Commission), and **Larry Whitted** (Larry Whitted & Associates). “Agricultural pest management is requiring more information-intensive strategies and techniques,” Chaney said. “As environmental regulations become tighter, and older pesticides are removed from the market or heavily restricted, many growers are modifying their production systems to include more ecologically based approaches to controlling pests.”

He noted that pest management professionals can play a key role in this transition process, providing clients with important information on the biology of pests and natural enemies, sampling programs, decision support tools, and knowledge of softer, less disruptive control materials when making their decisions.

By making use of the latest educational technologies, the self-guided course offers a highly interactive educational experience. The course includes inquiry-based, problem-solving simulations, and interactive self-tests (drag-and-drop, picture matching, and other formats).

“Because it’s on the Web, students can progress through the units at their own pace at any time of day,” he said. He said its flexibility will complement educational programs offered by UC Cooperative Extension offices and other agencies.

Through a Web site and companion CD, the course is presented in a series of four units: *Concepts of Ecological Pest Management, Insects* (focus on leafhoppers and mealybugs), *Diseases* (focus on Powdery Mildew), and *Scenarios* (emphasizing pest control adviser problem-solving and decision-making skills). The course also covers the biology of specific organisms in the grape ecosystem, field diagnosis and monitoring techniques, and up-to-date summaries of the best available decision-making tools and management options. The use of the CD for large photo files allows access to numerous high-quality images and video without long download times. Graded multiple-choice exams taken online are also included in the package, and are used to determine the number of continuing education credits students receive.

Ecological Pest Management in Grapes covers some of the new knowledge expectations developed by the California Department of Pesticide Regulation for individuals preparing to take the California Pest Control Adviser licensing exam. The course will help previously licensed PCAs get up to speed in some of the IPM areas required of new PCAs. (Knowledge expectations and required study materials for the California PCA exam are on the DPR Web site at www.cdpr.ca.gov/docs/license/knowlists.htm.)

To register for the grape course go to www.sarep.ucdavis.edu/courses/. Students must complete the registration form and send in the course fee ($40) before they can have access to the course. A preview of the course is available at the same Web site. *Ecological Pest Management in Grapes* is offered continuously. Total credits approved for this course are from 6 to 11 Continuing Education (CE) units, depending on test scores. CE units are currently approved for California PCAs only.

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Project Update

BIFS rice survey: Status of straw and weed management, opportunities for input reduction in rice

By Marco Barzman, SAREP BIFS coordinator; Randall “Cass” Mutters, Butte County farm advisor; James Eckert, project coordinator; and Jenny Broome, SAREP associate director

California has 500,000 acres of rice and the highest yields in the world. The state’s rice farming system is highly mechanized and reliant on agrichemical inputs. Components of this system face several challenges: The insecticide carbofuran is no longer registered for use in rice, straw burning has been severely restricted to protect air quality, and herbicide-resistant weeds have appeared. In addition, lower profit margins and the potential reduction in federal subsidies make the use of high-cost agrichemicals less attractive. The rice Biologically Integrated Farming Systems (BIFS) project addresses some of these problems by refining and promoting alternative farming practices through on-farm demonstration trials. The project uses results from previous University of California research on winter flooding, straw incorporation, cover cropping, summer water depth management, and drill-seeded rice to reduce the need for pesticides and synthetic nitrogen.

The rice BIFS project recently conducted a survey of 213 rice growers to garner information on the extent to which conventional and alternatives techniques are practiced and valued two years into the project. The survey also asked about project recognition and sources of information. This “snapshot” of practices, attitudes, and information flow can be used as a baseline against which progress will be measured when a second survey is conducted after the project is finished. This report focuses on non-chemical weed control strategies based on water management, and the reduced use of chemical fertilizer through the use of alternative nitrogen sources. This report helps to identify areas of opportunities for future extension efforts.

Methods

SAREP staff, a Cooperative Extension farm advisor and a professional survey worker developed a four-page questionnaire that was pre-tested on 10 rice growers. A mailing list of 900 recipients was generated by combining the lists of three different Sacramento Valley UC Cooperative Extension farm advisors. In March 2001 we mailed a cover letter, the questionnaire and a business-reply return envelope to 900 recipients in nine counties. A reminder card was sent two weeks later. We received 213 valid responses but not everyone responded to all questions. Short telephone interviews with 53 non-respondents showed that non-respondents were not statistically different from the 213 respondents in their age or farm size distribution. The names and addresses of respondents are confidential. A comparison of the location of survey respondents to official rice acreage figures shows that our sample is geographically representative of the state’s rice growing population (Table 1).

For the purposes of this report, only those results relevant to weed, straw, and soil fertility management are discussed.

Weed management, herbicides

Weed management is key to maintaining high yields in rice and most of the concerns with pesticide risks focus on herbicide use. The California Department of Pesticide Regulation (DPR, 2001) reported several continuing problems related to herbicides: aerial drift, phytotoxicity to non-target crops, weed resistance to rice herbicides, aquatic toxicity, sediment accumulation, and drinking water concerns.

Nearly all California rice growers depend on herbicides. The extent of this dependence is evident in the results where 98 percent of respondents use herbicides. This group uses herbicides on an average of 95 percent of their acreage. Even though most growers do not find herbicides affordable (68%), most find them reliable (71%) (Figure 1). The 29 percent of growers who do not find herbicides reliable may reflect the increased problems with weed resistance to herbicides. Pesticide inputs account for 15 percent to 20 percent of production costs and most of these costs are from herbicide use. The large percentage of growers who do not find herbicides affordable indicates that there are opportunities to promote cheaper reliable alternatives.

UC trials demonstrated that watergrass was effectively controlled with increased water depth (Williams et al., 1990). The BIFS project demonstrated in several field trials that deeper water controlled weeds often without affecting yields. However, interest in this method is low. The survey results show that most growers consider non-herbicide weed control methods neither affordable (72%) nor reliable (88%) (Figure 1).

We find, however, that attitudes toward non-herbicide methods of weed control may depend on farmers’ experience with these methods and the inherent risks associated with these techniques. For example, high winds during the deepwater period may result in seed drift, stand loss, or breakdown of the levies that retain the water in the fields. A grower must weigh the costs associated with both non-chemical and chemical weed control strategies.

Obviously, growers with organic acreage have some experience with non-herbicide weed control methods. At the time the 2000 trials were set up, only growers with organic rice acreage were willing to try this method. Of course, organic growers do not have the option of chemical use and lower yields in organic rice are offset by higher prices as compared to conventionally grown rice. Nonetheless, additional efforts to demonstrate and to provide opportunities to experience the effectiveness of non-herbicide methods of weed control are warranted.

In addition to deep water/dry down, other non-herbicide weed management methods are available. Even though they may not be appropriate to all farming systems, the survey found a number of growers using these methods on some of their acreage. Respondents reported practicing crop rotation (24%), summer fallow flood then plow down (9%), and drill or dry seed with dry down (4%).

Straw management, reduced nitrogen input

Rice grower Eric Tenhunfeld (third from left) shows Butte County farmadvisor Randall “Cass” Mutters and interested farmers photos of a drill-seeded field. R-L: Greg Massa, Mutters, Tenhunfeld, Eric Lundberg, Nancy Schlieger, and Nic Greco. (photo by Macro Barzman)

Straw management is a long-standing challenge for California rice growers. In 1991, due to air quality concerns, the California Legislature enacted the Rice Straw Burning Reduction Act, which mandated a scheduled phase-down in rice straw burning. The California Air Resources Board (2001) reports that the rice acreage burned in the Sacramento Valley has decreased from 303,000 acres in 1992 to 139,000 acres in 2000. The survey showed that in the 2000 season at least 44 percent of respondents burned straw over an average of 36 percent of their acreage (Table 2). Starting in 2001, all rice growers will have to comply with a straw burning limit of 125,000 acres basinwide or 25 percent of each individual grower’s fields, whichever is less. Burning is permitted only if the disease levels in the field are determined by inspection to reduce yields.

Incorporating straw into the soil is the most common alternative to burning, even though the cost of this practice is estimated at $43 per acre, compared to approximately $3 per acre for burning (California Air Resource Board, 2001). In the survey, a large majority (89%) reported incorporating straw during the 2000 season on an average of 80 percent of their rice acreage, while only 11 percent did not incorporate any straw (Table 2).

Growers gather around drill seeding machine at rice BIFS field day at Wallace Ranch in Dunnigan, Yolo County. (photo by Macro Barzman)

Straw incorporation, particularly when it is combined with winter flooding, can generate a number of benefits. Studies have shown that this practice can reduce rice water weevil populations and stem rot inoculum levels (Godfrey et al., 1998; Webster et al., 1999), while improving straw decay and soil quality. In conventional systems, nitrogen fertilizer is incorporated as aqueous ammonia or as dry fertilizer a few days before pre-plant flooding at rates of 150 pounds per acre, sometimes followed by a nitrogen topdressing later in the season. Altogether, fertilizers account for 10 percent of total operating costs (Williams et al., 2001). Incorporating straw in the soil can replace some of this inorganic fertilizer because it increases soil organic nitrogen, a major form of nitrogen used by rice plants. The rice BIFS project now has three years of data from farmer-managed on-farm trials showing that nitrogen rates can be reduced by 30 pounds per acre with no reductions in yields (Mutters et al., 2000).

A large percentage of respondents (78%) reported following soil incorporation with winter flooding on at least some of their acreage, while 12 percent reported not flooding any of their acreage after soil incorporation, and 11 percent reported not incorporating any straw (Table 2). Among other benefits, flooding rice fields during the winter creates habitat for wildlife. The University of California has encouraged this practice for at least 10 years (Brouder & Hill, 1995). In our survey, 73 percent of growers reported using winter flooding as a way to enhance wildlife habitat.

For the majority of respondents (i.e., for the 78 percent who incorporate straw and flood), the conditions were met for reducing their synthetic nitrogen input. During the 2000 season, 33 percent of respondents reported reducing their nitrogen application on at least some of their acreage in combination with incorporating straw and flooding. A few respondents (11%) reported having used this practice in the past but chose not to repeat it this last season (Table 2). The reasons these growers did not to repeat this practice should be investigated to determine the reliability of the practice and the obstacles to its adoption. The survey did not collect data on how many growers chose to repeat the practice. The rice BIFS project's trial results, along with the high percentage of growers already using the prerequisite practices for nitrogen reduction, are encouraging.

For more information, contact **Marco Barzman** at msbarzman@ucdavis.edu, or **Cass Mutters** at rgmutters@ucdavis.edu.

References

- Brouder, S.M. and J.E. Hill. 1995. Winter flooding of ricelands provides waterfowl habitat. Cal. Ag. 49(6):58-64.
- California Agricultural Statistics Service. 2000. California Agricultural Statistics 1990-1999, A ten-year report.
- California Air Resources Board. June 2001. Report to the Legislature. Progress Report on the Phase Down and the 1998-2000 Pause in the Phase Down of Rice Straw Burning in the Sacramento Valley Air Basin.
- California Rice Research Board. 2001. Sacramento Valley Fall Burn Report - 2000. http://www.syix.com/rrb/00rpt/FallBurn.htm
- Department of Pesticide Regulation. 2001. http://www.cdpr.ca.gov/docs/surfwatr/programs.htm Last updated Apr. 25, 2001.
- Godfrey, L., D. Cuneo, and D. Palrang. 1998. Agronomic effects of winter flooding on rice straw decomposition and rice production: Effects on pest arthropods. In: Winter flooding and straw management: Implications for rice production, 1994-1996
- Mutters, R.G., J.W. Eckert and D.T. Parks. 2000. Biologically Integrated Systems in Rice Progress Report, November 2000.
- Webster, R.K., C. Greer. 1999. Cause and control of rice diseases. Annual Report to the California Rice Research Board.
- Williams, J.F., S.R. Roberts, J.E. Hill, S.C. Scardaci, G. Tibbits. 1990. Managing water for weed control in rice. California Agriculture 44 (5):7-10.
- Williams, J.F., R.G. Mutters, K.M. Klonsky, R.L. DeMoura. 2001 Sample costs to produce rice - Sacramento Valley. UCCE.

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Biologically Integrated Farming Systems workgroup meets

by Marco Barzman and Jeri Ohmart, SAREP

The Biologically Integrated Farming Systems (BIFS) Workgroup convened at UC Davis Aug. 16, 2001 for its second meeting. The 45 workgroup attendees included Cooperative Extension farm advisors, farmers, UC researchers, and representatives from commodity boards, grower groups, the U.S. Environmental Protection Agency, and nonprofit organizations.

Cliff Ohmart (Lodi-Woodbridge Winegrape Commission), **Gary Obenauf** (California Prune Board), and **Mark Cady** (Community Alliance with Family Farmers) led a discussion on factors that ensure that BIFS and other partnership projects have a lasting impact. It was recognized that project life span needs to be longer than three years, and that on-farm demonstration trials should cover large areas and be distributed statewide. Recipes for success included: high levels of grower participation, adequate funding, well-established collaborative approaches combined with leadership, and good field days. It was proposed that future projects broaden their participant base, encompass wildlife restoration and biodiversity and use a whole-farm approach not restricted to any one commodity.

Other presentations focused on research tools used to assess grower practices and project impact commodity-wide. **Marco Barzman** (SAREP) and **Randall "Cass" Mutters** (UC Cooperative Extension, Butte County) shared their experience with the implementation of a survey of Sacramento Valley rice growers (see Project Update: BIFS rice survey). **Minghua Zhang** (UC Davis land, air and water resources department) explained the latest advances in using the California Department of Pesticide Regulation's Pesticide Use Report data.

Plans for the year include facilitating several workshops on database development for project management using Microsoft Access, statistics for non-traditional experimental designs, and project impact assessment activities. Workgroup members expressed interest in bringing in more expertise from the social sciences and using the BIFS email listserv and the BIFS Web page as a common resource.

Those interested in being added to the BIFS listserv should contact BIFS program assistant **Jeri Ohmart** by email (jlohmart@ucdavis.edu) or phone (530) 752-5987.

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Jeri Ohmart joins SAREP

SAREP is pleased to announce the addition of **Jeri Ohmart** to the staff as the Biologically Integrated Farming Systems (BIFS) program assistant. She is working with BIFS coordinator **Marco Barzman** and with SAREP grants manager/associate BIFS coordinator Bev Ransom. She will also work on case studies of growers who attend farmers markets with **Gail Feenstra**, coordinator of SAREP's community food systems section. Ohmart began working in sustainable agriculture in 1999, when she assumed responsibilities as a grant writer for the Davis-based Community Alliance with Family Farmers. Previously, she taught writing and literature at the university and community college level in the U.S. and Australia. She has a master's degree in English literature, and earned postgraduate certificates in writing and teaching English as a second language. In 1992 she established an adult literacy program in reading and English language skills for Hmong farmers and Spanish-speaking farmworkers in Chico, Calif.

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New food systems analyst in Alameda Cooperative Extension

SAREP welcomes **Sheila Duffy**, the new food systems analyst in the Alameda County Cooperative Extension office. SAREP has partnered with UC Cooperative Extension and the Expanded Food and Nutrition Education Program (EFNEP) to bring additional expertise in community food systems and community food security issues to the county. Duffy brings with her an extensive background in community development, small business development, teaching and training, and sustainable development research. She will be working with extension professionals and community leaders to strengthen community food systems in Alameda County. She will be working on potential strategies to address food insecurity, the transition of electronic benefit transfers (food stamps) at farmers markets, assisting a new food policy council in West Oakland, and training public school teachers in nutrition and gardening skills. Duffy has a doctorate in agricultural education from Texas A&M University. She may be contacted at (510) 383-1708; email: sbduffy@ucdavis.edu.

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Ag direct marketing workshop March 1

A daylong workshop aimed at developing agricultural direct marketing strategies for successful businesses and communities is scheduled March 1, 2002 at the Buehler Alumni Center at UC Davis.

“The workshop will bring together professionals who work with farmers, ranchers and local communities to increase direct marketing channels,” said **David Chaney**, SAREP education coordinator.

The workshop is sponsored by SAREP, the UC Small Farm Program, Community Food Security Coalition, California Federation of Certified Farmers Markets and Davis Farmers Market Association, with funding from the Western Region USDA Sustainable Agriculture Research and Education program. Participants will include Cooperative Extension advisors, USDA personnel, farmers and ranchers, and representatives from state agricultural agencies and other agricultural and community development organizations. Chaney said information at the workshop is designed to help professionals promote and increase consumer demand for direct marketed products in their local regions, and to build community support for long-term success in direct marketing.

Keynote speakers include **Gus Schumacher**, former Under Secretary for Agriculture for Farm and Foreign Agricultural Services at USDA, and **Sibella Kraus**, a leader in supporting regional food systems now working with the Sustainable Agriculture Education (SAGE).

The conference fee is $60. A full program brochure will be mailed in January 2002. For more information contact Chaney at dechaney@ucdavis.edu or **Gail Feenstra** at gwfeenstra@ucdavis.edu, or call the SAREP office at (530) 752-7556 to receive a brochure.

Technical Reviews

Restoration ecology and conservation biology in agriculture (PART I)

Robert L. Bugg

*[Note: Part 2, focusing on birds, will appear in **Sustainable Agriculture**, Vol. 14, No. 1, Winter/Spring 2002.]*

The expansion of agriculture has often been at the expense of wildlands, native plants, and wildlife (Gall and Orians 1992, Gall and Staton 1992, Merenlender 2000), yet farms and ranches can be managed such that the impact is lessened. This review covers the basics of restoration ecology and conservation ecology.

For many years, the Natural Resource Conservation Service (formerly known as the Soil Conservation Service) has promoted windbreaks, grassed waterways, tailwater ponds, and other on-farm features that support wildlife (consult *Journal of Soil and Water Conservation*). Conover (1998) polled 2000 U.S. farmers nationwide on their experience and opinions concerning on-farm wildlife. Twenty-four percent of the 1,347 respondents were reluctant to establish wildlife habitat because of potential damage to crops, while 38 percent of respondents said that they would oppose creation of wildlife refuges near their farms. Farmers noted that damage was especially severe from mammals such as deer, raccoons, and coyotes. Despite these perceived problems, 51 percent of respondents reported that they modified their management to accommodate wildlife, including providing cover for wildlife near fields (39%), providing a water source (38%), leaving crop residue in the field (36%), leaving some crop unharvested (17%), and providing salt licks (12%). Given the willingness of many farmers to alter their practices, there appears to be continuing opportunity to implement on-farm restoration ecology and conservation biology.

The experience of The Nature Conservancy in its Sacramento River Project points up the major role that farmers can play in restoring native vegetation to riparian corridors that adjoin farms, and the importance of in-field management changes to conserve and enhance native bird species (**Dawit Zeleke**, personal communication). A challenge lies in providing economic incentives and infrastructural support to allow landowners to accommodate, maintain, and enhance or restore ecological parameters on the landscape.

Overview of biodiversity, related sub-disciplines of ecology

Biodiversity refers to the variety of life, but has often mistakenly been equated with species diversity. Franklin (1988) and Noss (1990) depicted a more comprehensive view of biodiversity that encompasses dimensions of composition, structure, and function, and their interaction. Noss (1990) outlined the hierarchies involved in the three main categories of composition, structure, and function:

I. Composition
    A. Landscape Types
        1. Communities, Ecosystems
            a. Species, Populations
                i. Genes
II. Structure
    A. Landscape Patterns
        1. Physiognomy, Habitat Structure
            a. Population Structure
                i. Genetic Structure
III. Function
    A. Landscape Processes, Disturbances; Land-Use Trends
        1. Interspecific Interactions, Ecosystem Processes
            a. Demographic Processes, Life Histories
                i. Genetic Processes

Composition can be assessed through simple species lists from farmland and adjoining wildlands. Structure could be evaluated, for example, through an age-class assessment of wildlands vegetation or a map showing spatial distribution of species of birds. Function would be addressed by a table or figure depicting diets of various birds found on a farm and their use of various habitats on and off the farm. Function would also be addressed by research that determined the roles of various organisms in soil-building and nutrient dynamics on farms. The biodiversity concepts above are interrelated with several subdisciplines and themes, including restoration ecology, conservation biology, landscape ecology, bioindication, target taxa in biological inventories, and ecosystem services, all discussed in brief below.

Restoration ecology may be defined as repair and management of native biodiversity, including composition, structure and function, in a given area. Single or multiple species may be targeted, but typically the emphasis is on complexes of species, based on historical knowledge or speculation about past native communities. Restoration ecology draws on a broad array of experience, knowledge sets and cultural perspectives. Where farmers and managers of forest and rangeland are involved in practical restoration ecology, it can be an important part of active management and can enhance the economic as well as environmental sustainability of the operations.

Conservation biology concerns the maintenance of existing populations of organisms. Ideally, conservation biology and restoration ecology should function in tandem. These fields, as applied in agricultural settings, include but are not limited to in-field management changes to protect sensitive migrant and year-round resident species, riparian zone enhancement, protection of adjoining wildlands, roadside and fieldside native revegetation, and management of hedgerows and windbreaks.

The subdisciplines of restoration ecology and conservation biology were reviewed and compared by Young (2000). Restoration ecology has been mainly botanically oriented to date, emphasizing small-scale, replicated, manipulative experiments on re-establishment of native plants from areas in which they have been removed. Several studies have concerned re-establishment of native plants on the edges of farms (Bugg et al. 1997, Bugg et al. 1998, Brown and Bugg 2001).

Conservation biology, by contrast, has focused on protection of existing habitats, communities, and populations. Modifying rice production practices to accommodate waterfowl would be an example of conservation biology in agriculture. In many cases, conservation biology has involved the development and management of natural preserves and has focused on so-called charismatic species that attract much public interest, such as certain large mammals.

Landscape ecology relates geographic features and their modification to behavior, distribution, dispersal, interaction, and survival of species. Concepts of special interest in this field are corridors, connectivity, patchiness, patch size, fine- vs. coarse-grain interspersion of different habitat types (mesh size), mobility, and territoriality. Habitat fragmentation may impair biological control of agricultural pests (Kruess and Tscharntke, 1994), a point of special interest to organic farmers. Corridor and connectivity issues are still poorly researched and understood, as documented in Jodi Hilty's doctoral dissertation (Hilty, in prep.). Usher and Keiller (1998) found that configuration of restored woodlands on organic farms significantly influenced the diversity and abundance of geometrid moths that use understory forest plants as hosts. More compact woodlands were superior to linear woodlands in this respect.

Bioindication is the assessment of population changes in one or a few, select species to infer effects of various practices and pollutants on larger organismal complexes or communities. Bioindicator species are much better understood for freshwater aquatic than for terrestrial systems. The use of arthropod bioindicators in agricultural systems has gotten little attention, although ants have been suggested as likely bioindicators (Peck et al. 1998). Amphibia have been suggested as especially sensitive to environmental perturbation, and several Californian amphibia are believed to be declining in part because of agricultural chemicals, especially organophosphorus insecticides (Davidson et al. 2001, Sparling et al. 2001). Perhaps such species could serve as bioindicators of agrochemical overuse.

A related theme is the use of species assemblages as indicators of environmental heterogeneity. Using multivariate statistics, Kremen (1992) found that butterfly assemblages in the rainforest of Madagascar were good indicators of environmental heterogeneity due to topographic/moisture gradient, of limited value in reflecting human-induced disturbance, and poor indicators of plant diversity. Target taxon analysis, a refinement of the above approach, uses species-rich, closely related groups of organisms to index environmental heterogeneity. This can streamline biotic inventories and aid in conservation planning. In Madagascar, Kremen (1994) found that species in the subgenus of *Henotesia* were as good or better than the entire butterfly fauna in reflecting various environmental gradients. Claire Kremen (personal communication) points out that this approach has yet to be widely tested or applied. In discussing criteria for indicator species, Hilty and Merenlender (2000) wrote that most vertebrates are mobile generalists with unknown environmental tolerances and correlations with ecosystem changes. Most invertebrate taxa lack known correlations to ecosystem changes, but may satisfy other criteria. However, inefficiencies can arise when higher invertebrate taxa comprising many species are often recommended, with varying attributes, and including superfluous species.

Ecosystem services are benefits that humans derive from native biota and the systems that comprise them (Daily, 1997). For example, the Forgotten Pollinators Campaign has centered on the roles of bees, bats, and other organisms in pollinating crops that are important to humans, and the preservation of wildlands to avoid losing or reducing these services (Buchman and Nabhan, 1996; see also Allen-Wardell et al. 1998).

For discussion of varied aspects of biotic diversity in agroecosystems, consult the special issue of *Agriculture, Ecosystems and Environment* edited by Paoletti and Pimentel (1992).

References Cited

- Allen-Wardell, G., P. Bernhardt, R. Bitner, A. Burquez, S. Buchmann, J. Cane, P.A. Cox, V. Dalton, P. Feinsinger, M. Ingram, D. Inouye, C.E. Jones, K. Kennedy, P. Kevan, H. Koopowitz, R. Medellin, S. Medellin-Morales, G.P. Nabhan, B. Pavlik, V. Tepedino, P. Torchio and S. Walker. 1998. The potential consequences of pollinator declines on the conservation of biodiversity and stability of food crop yields. Conservation Biology 12:8-17.
- Brown, C.S. and R.L. Bugg. 2001. Effects of established perennial grasses on introduction of native forbs in California. Restoration Ecology 9:38-48.
- Buchmann, S. L. and G. P. Nabhan. 1996. The forgotten pollinators. Island Press/ Shearwater Books, Washington, D.C./Covelo, Calif.
- Bugg, R.L., J.H. Anderson, C.D. Thomsen, and J. Chandler. 1998. Farmscaping: restoring native biodiversity to agricultural settings. Pp. 339-374 in: Pickett, C.H. and R.L. Bugg [Eds.], Enhancing biological control: habitat management to promote natural enemies of agricultural pests. University of California Press, Berkeley, CA.
- Bugg, R.L., C.S. Brown and J.H. Anderson. 1997. Restoring native perennial grasses to rural roadsides in the Sacramento Valley of California: establishment and evaluation. Restoration Ecology 5:214-228.
- Conover, M.R. 1998. Perceptions of American agricultural producers about wildlife on their farms and ranches. Wildlife Society Bulletin 26:597-604.
- Daily, G.C., ed. 1997. Nature's services: societal dependence on natural ecosystems. Island Press, Washington, DC.
- Davidson C., H.B. Shaffer and M.R. Jennings. 2001. Declines of the California red-legged frog: Climate, UV-B, habitat, and pesticides hypotheses. Ecological Applications 11(2):464-479.
- Franklin, J.F. 1988. Structural and functional diversity in temperate forests. Pp. 166-175 in: E.O. Wilson, ed. Biodiversity. National Academy Press. Washington, D.C.
- Gall G.A.E., G.H. Orians. 1992. Agriculture and biological conservation. Agriculture Ecosystems and Environment 42 (1-2): 1-8.
- Gall, G.A.E. and M. Staton. 1992. Integrating conservation biology and agricultural production - conclusions. Agriculture Ecosystems and Environment 42: 217-230.
- Hilty, J.A. in prep. The role of ecological corridors. In Wildlife Use of Riparian Corridors in the Oak Woodland and Vineyard Landscape. Ph.D. Dissertation, Department of Environmental Science, Policy, or Management. University of California, Berkeley. Berkeley, Calif.
- Hilty, J.A. and A. Merenlender. 2000. Faunal indicator taxa selection for monitoring ecosystem health. Biol. Conserv. 92:185-197.
- Kremen, C. 1992. Assessing the indicator properties of species assemblages for

natural areas monitoring. Ecol. Appl. 2:203-217.
- Kremen, C. 1994. Biological inventory using target taxa: a case study of the butterflies of Madagascar. Ecol. Appl. 4:407-422.
- Kruess, A. and T. Tscharntke. 1994. Habitat fragmentation, species loss, and biological control. Science 264:1581-1584.
- Merenlender, A. M. 2000. Mapping vineyard expansion provides information on agriculture and the environment. California Agric. 54(3):7-12.
- Noss, R. 1990. Indicators for monitoring biodiversity: a hierarchical approach. Conserv. Biol. 4:355-364.
- Paoletti, M.G. and D. Pimentel. (Guest Editors). 1992. Biotic diversity in agroecosystems. Special issue of Agric. Ecosystems Environment. 40.
- Peck S.L., B. McQuaid and C.L. Campbell. 1998. Using ant species (Hymenoptera: Formicidae) as a biological indicator of agroecosystem condition. Environ. Entomol. 27:1102-1110.
- Santer, L. (Editor). 1995. BIOS for Almonds: A Practical Guide to Biologically Integrated Orchard Systems Management. Community Alliance with Family Farmers Foundation, Davis, California / Almond Board of California, Modesto, Calif.
- Sparling, D.W., G.M. Fellers and L.L. McConnell. 2001. Pesticides and amphibian population declines in California, USA. Environmental Toxicology and Chemistry 20(7):1591-1595.
- Usher, M.B. and S.W.J. Keiller. 1998. The Macrolepidoptera of farm woodlands: determinants of diversity and community structure Biodiversity and Conservation 7(6): 725-748.
- Young, T.P. 2000. Restoration ecology and conservation biology. Biol. Conserv. 92:73-83.