

ACADEMIC PLAN 2008-2013

Department of Plant Sciences University of California Davis

SUMMARY

The Department of Plant Sciences engages in teaching, research and outreach in all aspects of agricultural and environmental plant science. Our programs cover the full spectrum of the land-grant university tradition of scholarship, ranging from fundamental discovery to application of research findings.

Seven areas of core competencies are listed below. Maintaining and building the strength of each is essential to our overall missions. Faculty losses through recent and pending retirements and resignations have had severe negative impacts on several of these areas. Faculty renewal is essential if our department is to maintain its leadership position.

- Cropping systems
- Ecosystem management and restoration
- Genetics, genomics, breeding, and biodiversity
- Plant physiology: development, nutrition and reproduction
- Postharvest biology and technology
- Urban forestry and urban horticulture
- Weed science

Criteria for targeting new I&R/AES positions include continuing and further strengthening our core research competencies, moving toward a more balanced demographic composition of our faculty in all areas, strengthening our fundamental and application-oriented research and outreach capabilities, and assuring that present and future teaching responsibilities are met.

Criteria for targeting areas for CE FTE include having excellent prospects for research and extension support, having strong connections to AES faculty and programs, having demonstrated needs at the county level, and having ties to commodity/sector needs.

We support and encourage individual CE faculty to seek professorial series, academic senate appointments where appropriate. In selected areas, we have targeted new joint CE/I&R/AES appointments. In such cases, there must be a demonstrated need for the targeted expertise in our teaching programs. Other opportunities for such appointments may emerge during the term of this plan.

Target areas for new I&R/AES FTE (not listed in priority order)

- Food safety (proposed as I&R/AES/CE joint appointment)
- Integrative plant physiology
- Plant breeding and translational genomics in the Rosaceae (Endowed Chair)

- Plant Physiologist—Reproductive physiology
- Postharvest biology and physiology (proposed as I&R/AES/CE joint appointment)
- Robotics and sensors in specialty crop production systems
- Tree-crop production-systems ecology
- Urban horticulture
- Weed ecology and whole plant physiology
- Tree crop breeding and genetics.
- Genetics and breeding of Poaceae for food and biofuels
- Legume genetic resources conservation, genetics and breeding.
- Genetics, genomics and breeding of Asteraceae specialty crops
- Genetics and breeding of Cucurbitaceae vegetable crops.

Target areas for new CE Specialist FTE

Highest priority areas

- Food Safety (joint CE/I&R/AES)
- Grain Specialist
- Orchard Systems Ecology
- Postharvest (joint CE/I&R/AES)
- Restoration Ecology
- Urban forestry/urban horticulture
- Vegetable cropping systems / Organic production
- Weed science (especially for perennial cropping systems)

High priority areas

- Biofuels
- Corn/forage systems and nutrient cycling.
- Waste water for irrigated pastures

A. INTRODUCTION

The Department of Plant Sciences is, and intends to remain, a leader in agricultural and environmental sciences, with demonstrated academic excellence in fundamental plant science, agronomic and horticultural crop production and handling, and the management of ecosystems along the wildland-urban gradient.

The Plant Sciences faculty has a strong commitment to undergraduate education. The Department's teaching mission is to provide a research-based, integrative undergraduate and graduate educational experience for students in plant sciences and related disciplines, including the biology of agricultural plant species, plant production systems and their management, and plant relationships to other organisms and their environments. The Vice-Chair of Teaching and Curriculum Development provides departmental leadership toward revising undergraduate majors and developing new undergraduate programs in emerging areas.

Department research encompasses the full spectrum of scholarship in the land-grant university tradition, solving agricultural and environmental problems through a continuum from fundamental discovery to application of research findings. The department focuses on interdisciplinary research in plant and environmental sciences that

translates fundamental advances in genomics, genetics, plant physiology, evolutionary biology and environmental science into improvements in crop performance and production, postharvest quality, agricultural sustainability, environmental stewardship, and ecosystem management and restoration. The primary focus of departmental research is on agricultural and environmental issues in California. Many faculty members are also involved in national and international collaborative research programs.

Outreach and Extension are high priorities in the department of Plant Sciences. It is through engagement with our stakeholders that we establish priorities for research and education, and test our research hypotheses. The Vice-Chair of Outreach and Extension provides departmental leadership in coordinating and promoting these activities. The Vice-Chair, in association with faculty, county advisors and public stakeholders, assesses stakeholder needs and develops processes for continued engagement of our stakeholder community, formalizes and maintains relationships with county-based CE Associates and UC county advisors, and administers the seven departmental Research and Information Centers (RIC). These Centers are crucial to maintaining communication with external clientele and assisting with outreach and extension efforts.

Our faculty includes eight members who are located off-campus at ANR Centers and Stations: four at Kearney Agricultural Center (Parlier, Fresno County), two at U.S. Agricultural Research Station (Salinas, Monterey County), and one at West Side Research & Extension Center (Five Points, Fresno County).

B. CORE TEACHING RESPONSIBILITIES

I. Undergraduate teaching

Plant Sciences serves as the lead department for the following majors and minors. Revisions to our majors are pending as described below. We anticipate that these revisions, which establish two new majors—Ecological Management and Restoration and Plant Sciences—will serve to increase our undergraduate enrollments substantially.

Majors:

Agricultural Management & Rangeland Resources - revision to Ecological Management & Restoration approved in Winter 2008.

The Sustainable Production Systems specialization covers food and agriculture production, agroecology, pest ecology and management, crop improvement and propagation. Students may also develop an emphasis in particular production areas such as agronomy, environmental horticulture, pomology, vegetable crops or viticulture. The Range and Natural Resources specialization emphasizes the theory and practice of natural resource management in grazed ecosystems. All students gain practical experience through a combination of internships and practica.

Biotechnology - Interdepartmental, housed in Plant Sciences, no pending changes. Four options, Animal Biotechnology, Plant Biotechnology, and Fermentation/Microbial Biotechnology, and Bioinformatics, provide in-depth training and specialized knowledge in an aspect of biotechnology. Each option has a strong laboratory component to

reinforce the theoretical concepts. Students also do an internship in a biotechnology company or university or government laboratory. A new introductory course (BIT 001) developed and offered in Spring 2008.

Crop Science & Management - revision into Plant Sciences approved Winter 2008. Students take courses in areas supportive of crop science and farm management, such as entomology, weed science, water and soil science, plant pathology, nematology, plant physiology and agricultural economics. Students may specialize by electing courses pertinent to specific crop types (vegetables, fruits and nuts, small grains, or nursery crops).

Ecological Management & Restoration (EMR) - revision of Agricultural Management & Rangeland Resources into the EMR major – approved in Winter 2008

The curriculum provides depth in the ecological and botanical sciences directed toward an integrated understanding of how communities and ecosystems function and how this knowledge can assist in their management and restoration. All students gain practical experience through practical field courses and a required internship.

Environmental Horticulture & Urban Forestry (EHUF) - no pending changes.

Students majoring in Environmental Horticulture and Urban Forestry learn how plants improve the environment and the quality of our lives. The major focuses on the biological and physical concepts and horticultural principles of plant production, management of plants and plant ecosystems in landscape settings and sociological aspects of plant/people interactions in the urban environment. Students may select one of the following four areas of specialization: Urban Forestry, Floriculture/Nursery, Landscape Management/Turf, or Plant Biodiversity/Restoration.

Plant Sciences (PLT) - revision of the Crop Science and Management (CSM) major into the PLT major - approved in Winter 2008.

The curriculum provides depth in the biological and physical sciences and a sound understanding of how plants obtain and utilize resources from their environment to sustain their growth and development. Students will develop an area of specialization with options in Crop Production, Plant Genetics and Breeding, or Postharvest Biology and Technology. The Plant Genetics and Breeding option will be expanded by two new courses “Introduction to Plant Genomics” and second Plant Breeding course complementing the existing PLB 154. An Individual option is also available to match specific subject matter or career goal interests in the plant sciences. All students gain practical experience through a combination of practical laboratory courses and internships.

Revision process - The revisions of CSM into PLT and of EMR into AMR were approved in Winter 2008. We are now able to allow continuing UC Davis students to change majors to PLT and EMR. Fall 2008 new students will enter as AMR or CSM majors; Fall 2009 new students will enter as EMR or PLT, and new enrollment in CMS and AMR will be closed.

Agricultural Systems & Environment - (*No notes in catalog. Is this functioning?*)

Applied Computing & Information Systems - This minor is for students interested in applying modern computer technology to management problems in agriculture, resource management, and other areas. Course work provides knowledge of the use of information technology and the methodology of applied quantitative and systems analysis.

Environmental Horticulture - Students of Environmental Horticulture learn how plants improve the environment and the quality of our lives. Plants are used to revegetate and restore disturbed landscapes, control erosion, and reduce energy and water consumption. The ornamental use of plants to improve the aesthetic quality of urban and rural landscapes, recreational areas, and commercial sites is an important aspect of the study of environmental horticulture.

Landscape Restoration - This minor is of particular interest to students majoring in Wildlife, Fish and Conservation Biology, Environmental Biology and Management, Environmental and Resource Sciences, Landscape Architecture, Evolution and Ecology, Biological Sciences, and Plant Biology.

II. Graduate teaching

Faculty members of the department teach courses at all levels in plant science, ecology, plant biology, international agriculture, and related areas. Members of the faculty belong to one or more of the following Graduate Groups: Ecology, Entomology, Genetics, Geography, Horticulture and Agronomy, Integrated Pest Management, International Agricultural Development, Plant Biology, Biochemistry and Molecular Biology, Food Science, Population Biology, and Soil Science.

Masters with emphasis on Plant Breeding is offered within the Graduate Group in Horticulture and Agronomy housed in the Department and a Ph.D. program in Horticulture and Agronomy with emphasis on Plant Breeding will be developed within the next three years. Fifteen courses in the area of plant Genetics, Genomics and Breeding are needed for Masters and Ph.D. curricula in Plant Breeding. Ten of them are currently in place. The following five graduate courses must be developed: Quantitative Genetics and Selection Theory, Plant Genetics and Crop Evolution, Data Management for Plant Breeding, Line Breeding, and Molecular Breeding. They will be taught by new FTEs in the Plant Genetics/Plant Breeding area.

C. CORE COMPETENCIES

The departmental strengths can be divided into seven core competencies with each faculty member contributing to at least one core and several members contributing to more than one core area:

(1) Genetics, genomics, breeding, and biodiversity. The Department has strong research programs in genetics, genomics, systematics and evolution of field and horticultural crops and their wild relatives; wheat, beans, lettuce, tomato, rice, almond, walnut, citrus, strawberry, gerbera, *Brassica*, alfalfa and forest trees being examples. These and other genetic and genomic programs are nationally and internationally

recognized and supported by NSF, USDA/NRI, state and local agencies, commodity boards, private charities, and endowed faculty positions.

It is generally recognized that training of the new generation of plant breeders is lagging behind the needs in this country and worldwide. This trend is of such a concern to plant breeding and plant biotechnology enterprises that major players, such as Pioneer and Monsanto, are willing to make investments into public training in this area. The Bill and Melinda Gates Foundation is also interested in enhancing breeding for Third World countries. In the U.S., the establishment of the Plant Breeding Coordinating Committee, a forum to increase funding for education, outreach and research for public plant breeding programs, has recently obtained increased public funding for plant breeding education. The Global Partnership Initiative for Plant Breeding Capacity Building (GIPB) is seeking, under the auspices of FAO, to increase food security through the improvement of national plant breeding capacity in the developing world. Because of the erosion of emphasis on plant breeding in the recent past, UC Davis has lost its visibility and competitiveness in this area, despite the importance of breeding field, vegetable and fruit crops in California. A critical mass of geneticists/breeders is required in order to attract students for field-based research and training in plant breeding. Although UC Davis still has a number of plant breeding programs supported at various levels, this critical mass is currently lacking. Moreover, several of these programs will be impacted by faculty retirements in the near future.

Several favorable factors are in place for UC Davis to reverse this situation and rebuild plant breeding teaching and research programs that will attract undergraduate and graduate students both nationally and internationally. The recent founding of a combined Department of Plant Sciences constitutes a broad base for the development and housing of undergraduate and graduate plant breeding programs encompassing virtually all major field and horticultural crops grown in California. Interdisciplinary programs in Nutrition, Food Science and Technology, and Viticulture and Enology will complement the Plant Breeding programs housed in the Department of Plant Sciences. Since plant breeding in the future will heavily rely on advances in plant genetics and genomics, we have the opportunity to translate our current excellence in plant genetics and genomics into the visibility in the area of plant breeding. Our strengths in plant genetics and genomics, if accompanied by vibrant crop improvement programs, will offer student training ranging seamlessly from the lab to the field. The unparalleled diversity of California agriculture encompassing over 300 different crops, provides a breadth in training and research opportunities not offered in any other area in this country or the world. Finally, the Plant Breeding Academy and the Breeding with Molecular Markers short course developed by the Seed Biotechnology Center and targeted toward professional audiences have given UC Davis renewed visibility in teaching in this area.

(2) Plant physiology: development, nutrition and reproduction. Research in this area is directed toward minimizing resource inputs in agriculture while maximizing yield and improving the nutritional, organoleptic or aesthetic value of the output products. Major goals are to better match genotypes with management practices that will maintain and stabilize productivity during environmental stresses or with fewer inputs. Tools and approaches span from molecular biology and biochemistry to integrative development and environmental physiology. More than 20 faculty members have active programs in this area, and due to its integrative nature and range of processes studied, a majority of

faculty contribute to some aspect of this core area of excellence. Research programs are supported by federal and state agencies and commodity boards. Few hires have been made specifically in this core in recent years. Several retirements have occurred recently and several more are anticipated.

(3) Weed science. The program at UC-Davis is renowned for developing many fundamental physiological and ecological weed science concepts, as well as integrated management strategies. The emphasis on sustainable agricultural production systems will mandate the development of novel approaches to weed management. There is also increased pressure to reduce herbicide input by the non-agricultural urban population, and increased effort to control invasive plants on roadsides, and in rangeland and wildland settings. This will require innovation in weed science if food and fiber production is to be maintained using current levels of input. The Weed Science group consists of 13 members including 7 scientists from affiliated programs housed in the department. An important outreach tool is the Weed RIC. Research support is provided by federal agencies, the State of California, commodity boards, and private companies. Over the past 4 years this core lost 3 of its faculty members to retirement.

(4) Cropping systems. This area reflects historical strengths and a long tradition in research, teaching and extension activities in the consolidated departments. A key element of this core area is that research questions are considered within the context of an overall crop production system. Current research programs cover a range of cropping systems including agronomic and horticultural systems under diverse management practices, often using long-term cropping systems to document and model changes in soil, plant and water quality. Increasingly, water quality issues are addressed in horticultural and agronomic systems as well as irrigated pastures, as is integration of production systems with wildlife habitat conservation. Research support is provided by agricultural and horticultural commodity groups, state agencies and from NSF and USDA. Due to recent and pending retirements, faculty involvement in this core will decrease significantly in the next few years without further investment.

(5) Postharvest biology and technology. Research in this area spans the continuum from genomics /biochemistry to basic biology and physiology and postharvest technology. Research areas include postharvest physiology including ripening, senescence, and development of physiological disorders; product improvement through genetic engineering; developing technologies to retain the quality of harvested products; food safety and security; flavor and sensory quality; nutritional benefits of fruits and vegetables in human health; and alternative strategies to control disease and insect pests after harvest. There is a strong outreach and extension effort in postharvest, including the Postharvest Research and Information Center. Research support is provided by USDA, NSF, the State of California, commodity boards, and private companies. While there has been a recent increase in the number of faculty focused on basic biology and genomics in postharvest biology, a number of retirements in postharvest physiology/biochemistry have occurred and more are expected in the postharvest technology area within the next 5 years. The Postharvest Group on the UC-Davis campus has long been a world leader in postharvest biology and technology, but is in danger of being eclipsed by other institutions without future investments.

(6) Ecosystem management and restoration. UC Davis is a world leader in the area of plant ecology in natural ecosystems. Expertise exists in agroecology, rangeland sustainability, grazing ecology, wild land and rangeland habitat management, plant biodiversity conservation, weed science and restoration ecology. In addition to a strong AES research and teaching component, there is also an active outreach program, including a RIC. The expertise within the department is complemented by close association with department affiliates who also focus on management and restoration of rangeland and natural systems. Research support is provided by USDA, NSF, the State of California, endowments and private companies.

(7) Urban forestry and urban horticulture. The appropriate use of plant materials in the urban landscape and in public places requires knowledge of plant growth characteristics and their adaptation to various microenvironments. Development of plant lists for special planting situations, such as xeriscape, energy efficiency, intense shade, and tolerance of harsh soil conditions (boron, selenium, salt), must be based on scientifically derived data. Appropriate pruning and care strategies must also be developed to increase the success rate for landscape plantings. Use of appropriate plant material is even more important today to reduce global warming, reduce heat load in urban cities, reduce energy use in cooling and heating of buildings, and increase carbon sequestration. Sustainable landscape strategies must be developed and implemented to reduce water and chemical inputs to urban landscapes to reduce energy use and environmental impacts. The college recently began the California Center for Urban Horticulture as a focal point for outreach efforts in this area. However, the Plant Sciences Department has very limited expertise in this area and additional faculty are needed, especially in urban forestry/arboriculture.

D. DEPARTMENT DEMOGRAPHICS: IMPACTS ON CORE COMPETENCIES

Plant Sciences has seen modest renewal of faculty since its establishment in 2005; much of this has been in the area of Genetics, Genomics and Plant Breeding. Our department has experienced a decline in faculty through normal attrition in recent years and a large number of retirements are anticipated during the period covered by this plan. Some data on faculty demographics are presented in Appendix 1. Of particular concern is that our smallest programs (weed science and postharvest biology and technology) are the most threatened by recent and anticipated faculty losses.

The following list of target areas for new I&R/AES FTE is based on conservative estimates of future faculty retirements. It is possible that retirements will exceed those estimates, in which case it will be necessary to revisit this plan prior to its nominal five-year term.

E. TARGET AREAS FOR NEW I&R/AES POSITIONS

Allocating new I&R/AES positions to a targeted area will be based on the following considerations:

- (1) Continue and further strengthen core research competencies;

- (2) Obtain a balanced demographic composition of I&R/AES faculty across all areas of core competence;
- (3) Strengthen our fundamental and application-oriented research and delivery in plant sciences;
- (4) Assure that all present and future departmental teaching responsibilities will be met.

Appointments will be for 11 months, split between I&R and AES.

Targeted areas for recruitment of new FTEs in 2008-2013 (not listed in priority order)

Food safety

Teaching: Postharvest classes (PLS 1xx, Postharvest microbiology and food safety, and 2xx, Microbial food safety which are proposed as part of the new Plant Sciences curriculum)

Research: Pre and postharvest microbiology for vegetable, fruit and nut crop production and handling systems

Ideally, this position would be split as a CE/I&R/AES appointment. We propose a 60-70% CE; 30-40% AES/I&R split. Other percentage splits would be appropriate depending on the availability of CE/I&R/AES resources.

Microbial food safety is a critical area of concern for the fruit and vegetable industry in the United States as a result of a number of food safety outbreaks traced back to fresh produce consumption. Because many produce items are consumed raw without a “kill step”, risk-reduction strategies during produce consumption and postharvest handling are essential and require an understanding of plant production and handling as well as microbiology. This is why placement of this position in Plant Sciences, possibly joint with Food Science, is important. There is a tremendous need for research-based information to guide the industry and regulators as risk-management strategies are developed as well as better and faster monitoring tools for human pathogens. The CE component of this position is designed to ensure close cooperation with industry and other stakeholder groups and rapid application of knowledge developed. There are currently only a few food microbiologists on campus and there are no I&R faculty who work on microbial food safety for fresh produce, a unique system because of the lack of a “kill step” for microbial control. Our new Plant Sciences curriculum includes a microbial food safety of fresh produce course, an essential training course for students graduating from the postharvest track, but currently we do not have I&R faculty to teach this course.

Integrative plant physiology

Teaching: PLS 100 series

Research: Source/sink relations and/or modeling plant development

Improving a system requires an understanding of how the system works UC Davis has renewed strength in molecular biology and biochemistry focused on the study of gene function at the molecular level, but our strengths and expertise in understanding how plants work at the crop level has declined. The

most exciting advances in science often occur where disciplines intersect. Recent advances in computer science/computer graphics programming and molecular biology create exciting opportunities for the intersection of both of these disciplines with crop physiology through development of graphics-based, three-dimensional computer simulation models of plant growth to understand the complex interactions between plant architecture and the physical and biological processes that drive plant development at several spatial and temporal scales. A new field of study—Functional Structural Plant Modeling—has emerged to explore these new opportunities. In conjunction with campus strengths in computer science and molecular biology the Department of Plant Sciences has the opportunity to build a strong program in this new field and greatly increase understanding of how crops function at multiple scales of organization.

Plant breeding and translational genomics in the Rosaceae (Endowed Chair)

Teaching: Contribute to the plant breeding track in the Plant Sciences undergraduate major and plant breeding tracks in the Horticulture and Agronomy Graduate Group and the Genetics Graduate Group.

Research: Translational plant genetics and breeding especially in Rosaceae.

This position will develop a research program that supports breeding in one or more members of the Rosaceae with a strong emphasis on taxa of horticultural importance. Rosaceae is a huge family that comprises numerous taxa of importance to California's horticultural and specialty crop industries. The research program should include traditional quantitative genetic and plant breeding components as well as translational genomic elements in an integrated program.

Tree crop breeding and genetics.

Teaching: Any of the seven new courses of the Plant Breeding curricula, including a course or course section specializing in tree and nut breeding.

Research: Breeding, genetics and genomics of tree crops including walnut and pistachio.

California grows over 99% of the walnuts and pistachios produced in the U.S. amounting to annual combined revenue of \$1.1 billion and a ranking among California's top 10 crop and livestock commodities. The UC Davis walnut breeding program is the largest and most advanced in the world, and has an international reputation with many UCD cultivars widely planted globally in most of the major walnut growing regions. Virtually all of the walnuts planted now in California are derived from this breeding program and they represented almost three quarters of the total California walnut production in 2007. One of these cultivars, 'Chandler', has become the gold standard for the industry accounting for over one third of the 2007 crop and more than 90% of all new walnut plantings. There are no private breeding programs in walnuts. The walnut breeding program has been in existence since 1948. It was largely funded by UC through the 1970s, but starting in 1983, the walnut industry, represented by over 5300 growers and about 55 processors, has been increasingly supportive financially of classical breeding, biotechnology, and genomics. The industry annual support for these activities in 2007 amounted to over \$386,000 or about

60% of the industry's annual budget for production research. In addition, the walnut breeding program is partially supported by an industry endowment established in 1995 with a gift to UCD of one million dollars. The endowment and the long-standing partnership with the walnut industry to sustain this breeding program will be lost to UC Davis if the program is not continued after the associated PI retires. The resources, apart from funding from USDA and industry, include the National Clonal Germplasm Repository, the Pomology walnut collection, data collected since 1949, a breeding population and advanced selections. These resources have been used by researchers in several UC Davis departments, UC Riverside, UC Berkeley, and USDA personnel, as well as an enthusiastic cohort in UCCE. The walnut program is unique because it involves a clonal tree crop with needs in both cultivar and rootstock improvement. Pistachios do not have a genetic improvement program at this time but the vulnerability of this crop based on one male and one female cultivar on extensive acreage is obvious.

Genetics and breeding of Poaceae for food and biofuels.

Teaching: Develop and teach one or more of the new Plant Breeding courses and contribute to instruction of existing genetic and genomic courses

Research: Conduct research in breeding, genetics and genomics of agronomically important Poaceae

More than 2.5 million acres of California cropland is covered by crops taxonomically classified in the grass family (Poaceae), with wheat, maize, rice, oats and barley being currently dominant. Grass crops are increasing in acreage and importance, as well as profitability, driven by markets and resource issues, including energy and water issues. Their role is changing, with increasing interest in grain crops for biofuels, as forage crops, and for absorbing urban and feedlot wastes in addition to their traditional role as human food. Grains are the immediate candidates for both starch and cellulosic-based ethanol biofuels. New perennial grass species are being introduced for biomass production. The UC Davis wheat breeding program has a national and international reputation because of its leading role in the US consortium for wheat marker-assisted selection. UC Davis is also a nationally and internationally recognized leader in wheat genomics and has played an important role in the development of a new model for *Brachypodium distachyon*. This model grass is anticipated to play an important role in advancing cellulosic biofuel biology. Increasing importance of corn and other grasses for biomass production, and new interest in the development of malting barley varieties, with rapid implementation of marker-assisted selection and other genomic resources, have created new opportunities for additional breeding programs in this important plant group.

Legume genetic resources conservation, genetics and breeding

Teaching: Develop and teach one or more of the new Plant Breeding courses and contribute to instruction of existing genetic and genomic courses

Research: Conduct research in breeding and genetics of agronomically important Fabaceae with emphasis on their nutritional and biological aspects

On a worldwide basis, more than 300 million metric tons of grain legumes are produced on 190 million ha (or about 13% of total land under cultivation), largely in developing countries. Grain legumes provide about one-third of all human dietary protein nitrogen and one-third of processed vegetable oil for human consumption. In many places of the world, legumes complement cereals or root crops, the primary sources of carbohydrates, in terms of essential amino acid composition. Legumes also provide essential minerals and vitamins required by humans and produce health-promoting secondary compounds that can protect against human cancers and reduce blood cholesterol and sugar levels. Legume crops are also of great significance because they produce substantial amounts of organic nitrogen fertilizer resulting from a symbiosis between the plant and bacterial symbionts and because of their interaction with mycorrhizae. Rapid progress is being made in unraveling the molecular basis of this nitrogen-fixing symbiotic relationship, principally in the three reference legumes, soybean, *Medicago truncatula* and *Lotus japonicus*. Furthermore, plant developmental processes such as modular growth habit, inflorescence architecture and flower type and plant type reflect characteristics unique to or prevalent in legumes. Rapid progress in the development of genomic resources for the reference legumes and the application of proteomics and metabolomics will allow translation of basic research findings to breeding of improved cultivars, through the application of marker-assisted selection and introgression with genetically distant germplasm, such as wild relatives. The global nature of food legumes provides funding opportunities beyond federal government (USDA and NSF) and commodity funding. These include sources in the development community, such as private charities and the US Agency for International Development. Although the international focus is an important component of this position, it will have a strong impact as well for the California Agricultural Experiment Station in areas such as germplasm introduction and adoption of potential new crops.

Genetics, Genomics and Breeding of Asteraceae Specialty Crops.

Teaching: Any of the undergraduate or graduate plant Breeding courses

Research: Genetics and breeding of Asteraceae species with potential emphasis on plant secondary metabolism, adaptation to adverse environments and domestication.

The Asteraceae is one of the largest angiosperm families and among the most successful in terms of habitats colonized. The family has undergone extensive diversification producing a cosmopolitan array of taxa encompassing ephemeral herbs, vines, and trees that thrive in a great diversity of habitats, including some of the world's most inhospitable. Over 40 economically important species have been domesticated within the Asteraceae for a wide variety of uses. Several Asteraceae are renowned for their high-quality edible oils, which are low

in saturated fatty acids and high in mono- and di-unsaturated fatty acids, or for their novel secondary chemicals. Food and non-food Asteraceae are grown annually on over 21 million ha worldwide. Lettuce, sunflower, and safflower are the three most important food crops. Lettuce ranks as one of the top ten most valuable US crops and has a farm gate value of over \$2 billion, the majority of which is grown in California. Oilseed sunflower is produced on 23.7 million ha in 70 countries with a value exceeding \$40 billion. Cultivated sunflower is primarily grown from single-cross hybrid seed, with a value of \$820 million, second only to maize among hybrid seed crops; a large amount of this hybrid seed is produced in California. In addition to food crops, which also includes artichokes, Asteraceae species are cultivated as medicinal (e.g. *Echinacea*; *Artemisia*), ornamental, or industrial crops. Several Asteraceae species (e.g. *Chrysanthemum*, *Dahlia*, *Zinnia*, marigold, *Gerbera*) are ornamental crops due to their showy flowers. California accounts for ~70% of all US cut flowers, and the global annual value of California nursery and flower industry is \$3.2 billion. The application of genomic approaches has provided a wealth of information and tools for basic research and plant breeding in the Asteraceae.

Genetics and breeding of Cucurbitaceae vegetable crops.

Teaching: Develop and instruct any of the new Plant Breeding courses and contribute to instruction of existing genetics and genomics courses in the college, and provide practical plant breeding training in vegetable crops

Research: conduct research in breeding, genetics and genomics of cucurbits

The Cucurbitaceae is a diverse family of tropical and subtropical origin that includes the economically important crops cucumber, muskmelon, cantaloupe, honeydew, watermelon, summer squashes, pumpkin, and winter squashes. The edible fruits of cucurbits are eaten fresh, cooked, dried, or pickled. The seeds of some cucurbit species are high in oil and protein, and yellow- and orange-fleshed fruits are rich in carotenoids and minerals. The California cucurbit crop had a combined value in 2006 of \$387 million. California exported \$42 million in melons in 2006, which is 35% of the US total, making melons an important specialty crop export for California.

Plant Physiologist—Reproductive physiology

Teaching: PLS 100 series

Research: Plant reproductive biology

Enhanced understanding of plant reproductive biology is essential to advances in plant improvement, crop production and ecosystem management. Research needs and research opportunities exist in such areas as flower development, sex determination, pollination biology, incompatibility, fruit development and seed development. The teaching component of this position will include the Plant Sciences 100 series course on organismal plant physiology and an upper-division, general-education course in plant reproductive biology. Research and outreach will focus on selected aspects of plant reproduction that impact crop production and/or ecosystem management. The position will be filled by a plant physiologist however the area of emphasis may range from basic

mechanisms of plant reproduction through population aspects of reproductive biology.

Postharvest biology and physiology

Teaching: Postharvest classes (PLS172B, SAS 90F, PLS212)

Research: Postharvest physiology

Ideally, this position would be split as a CE/I&R/AES appointment. We propose a 60-70% AES/I&R; 30-40% CE split. Other percentage splits would be appropriate depending on the availability of CE/I&R/AES resources.

As much as 35 to 50% of the fruits and vegetables produced in the United States are never consumed due to postharvest deterioration before consumption. Improvement in postharvest handling technology and reduction in postharvest losses could prevent wasting the energy and resource investments made during crop production. A postharvest physiologist will be hired with general knowledge of postharvest biology. Opportunities exist to use modeling of produce response to environmental conditions and subsequent shelf life in the development of improved handling strategies. Many Plant Sciences I&R faculty in postharvest biology have recently or will soon retire, greatly diminishing our capacity in teaching and research in this area. Faculty are needed to participate in teaching undergraduate and graduate courses in postharvest biology, including existing courses such as PLS172B, PLS212 and SAS90F, food distribution in a hungry world, as well as to develop new courses on a variety of postharvest topics to expand curriculum offerings. Tremendous opportunities in international agriculture also exist for postharvest biology and technology. A partial CE appointment for this position is important to assure close collaboration with the produce industry to address issues of concern to commercial practice.

Robotics and sensors in specialty crop production systems

(Possible joint appointment with Bio Ag Engineering)

Teaching: Develop courses on use of robotics in agriculture, nondestructive sensing of crop status and product quality, mechanization in agriculture.

Research: Plant-based research on robotics and sensors in coordination with agricultural engineers.

A primary industry-wide concern among California's specialty crop producers is that availability, skill level, and cost of labor—their single greatest production cost—harms their competitive position internationally. These industries also need tools and technologies that can improve production efficiency, product quality, post-harvest operations, and reduce their environmental footprint. Automation, robotics, precision agriculture, sensors, and other advanced technologies are needed to help their producers become more efficient, productive, and sustainable. There is an immediate need, and immediate research opportunities for a plant physiologist to work closely with agricultural engineers in developing robotics and sensor technologies for use in the specialty crop industries. Research foci may include such production areas as sensing plant water status, activity of insects or pathogens in the field, crop maturity or readiness for harvest, nutrient status; harvest efficiency; postharvest processing and sorting technologies; and energy management.

Tree-crop production-systems ecology

Teaching: Sustainable Agriculture program; PLS 100C

Research: Sustainable agriculture in perennial cropping systems

The development of environmentally sound and economically efficient tree cropping systems is essential for maintaining the viability of fruit and nut crop production and exploring tree-based opportunities for biofuels in California. Using an integrated ecological approach to study tree cropping systems is essential for increasing tree crop production efficiency and sustainability and identifying realistic targets of opportunity for applications of biotechnology. Critical needs exist for improving ecological understanding and mitigation of the impacts of perennial cropping systems on the environment (particularly air and soil) and for anticipating and adapting the same systems to changing environments. Opportunities abound for ecological modeling of perennial cropping systems (including the long-term feasibility of tree-based production of biofuels in California) and quantitative analysis of current and future, tree-based crop production systems as the importance of California's specialty crops are increasingly recognized.

Urban horticulture

Teaching: ENH 6, 101 and 105, taxonomy and identification of horticultural plants.

Research: horticultural plant systematics

A need exists for I&R FTE in plant systematics, taxonomy and phylogenetics with an emphasis in areas relevant to urban horticulture. Teaching assignments would include ENH 6, 101 and 105, which are required as either preparatory/depth subject matter or as part of a specialization option in the EHUF major. Students in Landscape Architecture are required to take one (ENH 6) and asked to take another (ENH 105) as a Restricted Elective. AES research and outreach activities may focus on related areas such as genetic approaches to understanding the relationships among taxa important in woody plant horticulture, or introduction of new and appropriate germplasm for California. The opportunity exists for creating an affiliation involving this I&R FTE with the California Center for Urban Horticulture, the UCD Arboretum and/or the Herbarium.

Weed ecology and whole plant physiology

Teaching: Weed science, weed ecology and the ecophysiology component of the Plant Sciences 100 series

Research: Ecology and ecophysiology of weeds in crop and non-crop systems

There are approximately 200 routinely troublesome weeds requiring some form of management in cultivated crops in California, and many more in rangeland and wildland systems. In addition, there are an additional 200 invasive plants that have been listed as significant problem in the state. In agronomic crops alone, it is estimated that over \$200 million in crop yield is lost to weeds annually. The impact in wildlands is incalculable, and millions of dollars are spent on weed control or mitigation and restoration of infested lands. Weeds are also

reservoirs of arthropods, viruses, phytoplasmas, bacteria and fungi that cause major diseases and crop losses. The research program will focus on identifying ecological and/or ecophysiological processes that regulate weed population sizes, underlie weed-crop competition, determine seed bank dynamics, cause spatial and temporal heterogeneity in weed distribution, determine multi-species weed community dynamics, or underlie the interactions between weeds and other crop pests. Teaching responsibilities will include Weed Ecology and/or Integrated Weed Management, participation in team-taught IPM courses, and a graduate-level course in Research Methods and Analysis and/or Ecological Modeling of Weed Population Dynamics and Weed-Crop Competition.

F. TARGET AREAS FOR NEW CE-SPECIALISTS POSITIONS

Departmental and CAES needs for CE Specialist positions are likely to be difficult to meet during the period covered by this plan. We considered the following criteria in compiling our targeted areas: The area should have excellent prospects for funding to support research and extension programs. There must be strong, existing connections to AES faculty and AES research programs in the department. There is a demonstrated existing needs at the county level. And, issues-based positions should be strongly tied to commodity/sector needs. If new CE resources are not available from ANR, we propose that the CE components of these appointments be funded from intradepartmental changes in appointment status as CE Specialists in our department move toward acquiring I&R appointments with Academic Senate membership.

Priority Positions

We have identified 8 priority positions for recruitment during the next 5 years. Two positions are proposed as CE/I&R split appointments. These positions are described above.

Postharvest (split I&R/CE position, proposed as 60-70% CE, 30-40% AES/I&R. See description above for details.

Food Safety (split I&R/CE position, proposed as 30-40% CE; 60-70% AES/I&R) See description above for details.

Grains for Food and Fuel Specialist

Overview and justification: The position will expand its previous focus on small grains (primarily wheat, barley, oat, and triticale) to include corn and sorghum. The importance of this group of plants to humankind and to the future of agriculture (including agriculture in California) cannot be overstated. We will depend upon this class of plants for food, feed, forage, and biofuel in the immediate and long term future. Corn, which had been reduced to a minor crop in California only a decade ago, is increasing in acreage and rapidly becoming the state's number one crop. Small grains, especially wheat, also are increasing in importance not only for world demand for food, but for forage and biomass. Grains and stovers are likely to be second only to municipal and agricultural wastes as feedstocks for biofuels, and are currently fulfilling an important

cropping-systems role in absorbing and recycling animal and municipal wastes. Due to the higher flexibility with water use, high water-use efficiency, and ability to utilize rainfall, grains as a class will be important to a water-restricted future to allow crop production in irrigated regions. The University of California is a world-recognized center for research in genetics of grain crops, and this position is closely linked with genetic innovation, germplasm development and crop improvement. It is an integral part of University of California's small grain breeding programs (wheat, barley, oats) which have been credited by California's small grain industry for making major advances in productivity and end-use quality of those crops.

How the position will meet statewide needs: This position will provide leadership to coordinate the multiple activities on small grains, corn, sorghum and other grasses used for food and biofuels. Critical current and future issues related to these crops will be addressed by this position, including development of feedstocks for biofuels, farm profitability, cropping systems research, and water quality/waste management. This position also will provide the interphase between basic research and breeding between the University of California campuses, UC farm advisors, growers and industry.

How the position will meet the department's outreach/extension plans: The Extension Specialist is essential to showcase new varieties and technologies to growers and industry. A continuous extension effort is required to keep stakeholders informed of the work the University is performing to address their problems and concerns. The Extension Specialist also provides important agronomic expertise to evaluate the implementation of new varieties and technologies under different cropping and management systems and in different growing environments in California. Biofuels is a complex issue that requires the integration of research, technology and practical agronomic issues. An Extension Specialist will be essential to transmit these complex issues to a broad audience.

How the position will strengthen campus-county continuum: This position is responsible for the organization of the Small Grain Workgroup that links all researchers (including UC research faculty and private industry scientists) and farm advisors in CA working on small grains. This position is critical to maintain the connection between basic research and industry in this area. An example in the small grain area is the Wheat Quality Collaborative Program currently organized by the Extension Specialist that each year brings together researchers, growers, grain handlers, millers and bakers together to discuss wheat quality issues.

Agricultural commodity/crop links: Currently 2.3 million acres of California cropland (estimated >20% of California's irrigated acreage) are grain crops. These crops are linked to: 1) crop rotation benefits and integrated with vegetable and row crop production; 2) key feeds for dairy and beef production (worth over \$7 billion/year); 3) a key aspect of profitability of farming systems for farmers; and 4) have worldwide impact on breeding and crop improvement of staple foods from a Mediterranean climate.

Major Crops:

2006 Acreages:

Wheat	800,000
Corn	700,000
Oats	400,000
Barley	150,000
Triticale	150,000
Sorghum/Misc.	100,000
Total (approx)	2,300,000

In North America and California (and worldwide), grain crops are increasing in acreage and importance, as well as profitability, driven by markets and by resource issues, including energy and water issues. Wheat and corn acreages in California are increasing, and it is likely that in 5-6 years corn will be California's highest acreage crop. Corn-small grain rotations in the Central Valley have become dominant in the past decade for feeding California's nearly 2 million dairy cows and 600,000 beef animals, and for absorbing nutrients (dairy wastes), a major public issue in the Central Valley. More than 25% of the wheat crop in California is green chopped as forage every year. Barley acreage in the United States is shifting to the western states due to devastating epidemics of *Fusarium* headblight in the Northern Plains states, providing an excellent opportunity for California growers and an excellent connection with food science programs on campus. Many believe that these trends reflect a fundamental shift from a cheap grain world to a world full of demand for cereal staple grains. The role of grain crops, however, is changing, with increasing interest in grain crops as feedstocks for biofuels, as forage crops, and for absorbing urban and feedlot wastes in addition to their traditional role of feeding mankind.

Grains are the immediate candidates for feedstocks both for starch-based and cellulosic ethanol biofuels. Wheat and corn are the most important grains for human food production worldwide. UC Davis has played a central role in the United States as a leader in wheat marker assisted selection, bringing grants for more than \$10 million to the University of California. Grain crops, particularly corn, oats, wheat and triticale, are the most important crops for absorption and recycling of dairy wastes. Grain crops (wheat, barley, triticale and corn) are among the most water-use efficient crops, particularly applied WUE, and particularly when the entire plant is used (increasingly the case).

This position has strong financial support. The activities supported by this position have been funded without interruption during the last two decades by the California Wheat Commission and the California Crop Improvement Association. Additional support for this position has been provided by: UC Discovery Grant, ANR Core Issue Grants, Small Grains Work Group, National Stripe Rust Initiative, Barley Cooperative Agricultural Project, ANR Core Issue Grants, Private and public breeding companies that pay a fee for their entries on the Regional testing program. Significant opportunities exist from: 1) biofuels funding for both starchy grain production to feed new ethanol plants, and for cellulosic ethanol production; 2) USDA-ARS Rust Program; 3) National USDA Barley-CAP and Wheat-CAP Programs; and 4) funding for water quality and nutrient management projects which are closely linked with the corn-small grain rotation in the Central Valley.

Orchard Systems Ecology Specialist

Overview and justification: California is the largest producer of deciduous fruit crops in the western world and is almost the sole US producer (>90%) of several crops such as fresh and dried plums, nectarines, clingstone processing peaches, apricots, figs, pomegranates, persimmons, and kiwifruit. In addition, it is a major producer of pears, cherries and fresh market peaches. The value of the California deciduous fruit industry in 2006 was \$6.8 billion. Great economic challenges face the California fruit industry such as increasing production costs due to higher costs for land, labor, fertilizers and fuel. Similarly there are increasing environmental challenges with regard to energy, water, fertilizer and pesticide use as well as water, air and soil quality concerns regarding many aspects of current orchard practices. In addition, marketing of the fruit products is increasingly being based on factors related to the orchard production systems being used to grow the crop in addition to the price, quality and safety of the product.

Until recently most of the production research and extension efforts associated with Californian deciduous fruit production has been focused on crop physiology and horticulture with the goal of either increasing yield or the efficiency of yield with respect to specific inputs like land, labor, water or fertilizer. Recently there has been increasing pressure on farmers to address all of these challenges simultaneously with increasing attention being paid to maintaining or enhancing environmental quality as well as economically producing and marketing the crop. This requires a systems ecology approach to research and extension program. The complexity and multidimensional characteristics of this type of ecological systems approach makes the fruit industries more dependent on engaging the help of research and extension professionals. Currently the Plant Sciences Department at UC Davis has no trained systems ecologists working with deciduous fruit in California. The AES faculty and CE specialists who are currently working on production issues with these industries are all primarily horticulturists/plant physiologists and are within 5 years of retirement. With some important crops such as dried plums, cherries, clingstone peaches, apricots and pears, no CE specialist is even designated to answer calls or address problems related to normal production practices. It is expected that the research and extension program of the person in this position would help growers/industries assess the impact of current production practices on land, labor, energy and water use and overall environmental quality; and focus on development of more sustainable systems of crop production. Relevant commodity groups have been vocal in their support for a position such as this, as have UC Extension Advisors, and AES faculty in Plant Sciences and other departments.

How the position will meet the department's outreach/extension plans: The Department of Plant Sciences has identified Cropping systems and Plant development, physiology, nutrition and reproduction as two of the seven core competency areas, and an Orchard Systems Ecology Specialist in deciduous fruit crops is one of the higher priorities in the current academic plan.

How the position will meet statewide needs: Deciduous fruit crop production employs many people, generates substantial revenue, enhances the health of and quality of life of consumers and occupies a large amount of high quality land in the central and coastal valleys as well as specific foothill locations. Thus optimizing fruit orchard production systems to maintain the economic viability, enhance product safety and quality and protect and enhance ecosystem services and sustainability is in the direct interest of the state and will impact stakeholders in multiple ways.

How the position will strengthen the campus-county continuum: The CE Specialist will work closely with commodity groups, state and government agencies; collaborate with, coordinate and assist Farm Advisors working on fruit crops; and collaborate with faculty in plant nutrition, irrigation, soil science, physiology, horticulture, agricultural engineering, economics, plant pathology, entomology and nematology. There is a great need for statewide leadership in the area of fruit production cropping system ecology, nutrient management, and sustainable production. There are also a number of faculty within the Department and college that work on a variety of aspects related to fruit production. A specialist in this position will have numerous opportunities for collaboration among other faculty and assist in moving research to end users.

Research links/funding opportunities include: 1) strong support by fruit crop commodity boards, with excellent opportunities for funding of applied research; 2) burgeoning need for assessment and improvement of the “carbon footprint” and energy efficiency of fruit crop production and marketing practices; 3) increased need and interest in improving labor use efficiency and safety; 4) new technology and opportunities for use of robotic machine vision and precision guided equipment for thinning, harvesting and pruning of fruit crops; 5) increased need for use of integrated systems for enhancing water use efficiency and nutrient management in fruit crop production; 6) significant opportunities for funding for water quality and air quality projects; and 7) opportunities for funding by the Sustainable Agriculture Research and Education Program (SAREP), Western Regional SARE and the National SARE program.

Restoration Ecology Specialist

Overview and justification: Land degradation is resulting in decreased productivity on almost half of the world’s vegetated surface, and decreased provisioning of ecosystem services upon which humans rely. The United Nation’s Millennium Ecosystem Assessment has named “reversing the degradation of ecosystems while meeting increasing demands for their services” as the top priority challenge for achieving human and environmental well-being. Every \$1 spent on restoration yields an average \$1.50-\$3.00 return generated from enhanced agricultural productivity or provision of services. Ecological restoration is a growing industry in agricultural and environmental sectors. Currently, 93 billion dollars a year are spent world-wide on restoration, with over 1/3 of that being spent in agricultural/range systems. Within the US, each year: \$6.28 billion is spent on contaminated site cleanup, and over a billion dollars is spent on restoration of natural systems by the federal government alone. California is spending hundreds of millions of dollars a year on restoration, and these

expenditures are likely to increase, as large-scale restoration plans come to fruition (e.g. \$20 billion to restore California's rivers and deltas, \$3-10 billion to restore Hetch Hetchy). Despite the increasing money and effort in restoration, fewer than 20% of restoration projects result in persistent improvements to multiple ecosystem components, and even this success rate is inflated by projects with very modest goals. This low success rate is due to poor leadership in learning from the successes and failures of on-going projects. UC is well-positioned to be an international leader in this field. Current UCD I&R/AES faculty are at the cutting edge of restoration research from the genetic to landscape levels. Farm advisors and a diverse range of stakeholders are implementing thousands of restoration projects at the local to international levels. A CE position would strengthen the ties between these communities. This position was previously a top-ranked priority at the AES and ANR level; this position was approved and recruited for, but budget cuts caused hiring to be postponed.

A major focus of the position will be sustainable management through the restoration of multiple goals, including: species (e.g. rare/threatened, agronomically desirable), communities (e.g. diversity, wildlife habitat, control of weeds/pests), and ecosystem services (e.g. water quality, water storage/ supply, erosion control, soil fertility, carbon sequestration, pollination, air quality regulation). Targeted systems include rangelands, forests, croplands, parklands, wetlands, riparian areas and watersheds that have been affected by disturbances such as: fire, erosion, road development, weed invasion, unsustainable management, climate change, pollution, and recreational use.

Addressing these multiple restoration goals has been the key need identified by a broad-range of stakeholders, and legal drivers including the Clean Water Act, Coastal Zone Management Act, Endangered Species Act, CALFED, Surface Mine Control and Reclamation Act, state mining laws, and other state and federal legislation affecting management practices on California lands. Constituencies include: farm advisors (natural resource, range, livestock), federal agencies (e.g. BLM, Fish and Wildlife, Forest Service, Army Corps of Engineers, NOAA), state and local agencies (e.g. State Parks, local National Resources Conservation Service units), non-profit organizations (e.g. Audubon, Nature Conservancy, California Invasive Plant Council, California Native Grasslands Association), private businesses (e.g. seed companies, consulting firms, individual farmers and ranchers), industry organizations (e.g. Cattleman's Association, Community Alliance with Family Farmers) and local restoration groups.

Successful restoration requires an integration of multiple issues, and this position would provide leadership in research and outreach in the integration of: 1) conservation and sustainable land use (including agriculture, urban, forestry, parklands); 2) multiple goals (minimizing tradeoffs in simultaneously restoring species, soils, economics, etc.); 3) how goals and management need to shift due to environmental change (local to global scales). This position will develop active research and education programs in collaboration with a diverse set of clientele group (listed above). Many of these groups are so eager for UCD to take a leadership role in this field, that they had contacted the department's new I&R/AES hire in Restoration Ecology before her arrival, in order to set up collaborations and outreach activities. There are numerous opportunities to extend

information from existing sources as well as from their own research and research from a large number of UCD I&R/AES faculty. In most restoration projects, there is no feedback mechanism to identify restoration failures or other problems that require research and development of new practices. This position would help integrate research, extension, and leadership efforts to determine controls over successes/failures.

Possible research foci include: 1. Development/ testing of restoration practices, materials, and techniques for economic and natural resources objectives; 2. Determination of site characteristics that define restoration potential and which techniques will be most effective; 3. Monitoring of restoration success/failure, identification of possible causes, and investigation into alternative solutions. Managing a system to reliably provide multiple goals is the ultimate test of science, and this applied research will provide critical basic knowledge on the interactions between environmental conditions, community composition, ecosystem functioning, and landscape dynamics.

Funding for research and outreach is available for local, state, national and international projects from a diversity of sources, which have already provided substantial funding to UCD faculty for restoration studies: USDA NRI, SARE, Wildlife Conservation Board (proposition 84), Fish and Wildlife, National Science Foundation, National Park Service, Army Corps of Engineers, Mellon Foundation, Packard Foundation. There is also substantial opportunity to capitalize on the billions of dollars being spent by private groups to monitor and develop improved practices.

How the position will meet the department's outreach/extension plan: The department's main objective is to integrate research in plant and environmental sciences into improvements in crop production, agricultural sustainability and ecosystem management. More than any other single person in the department, this CE position would be able to serve to integrate all pieces of this mission, and integrate 5 of the 6 core areas in the department. This position would build upon the momentum generated by new AES/I&R hires in Restoration Ecology, Sustainable Agriculture and Urban Ecology, and the new Ecological Restoration & Management major. It would also build upon the department's research and outreach expertise in restoration, sustainable agriculture, rangeland management, weedy and invasive species, breeding, watershed protection, conservation, revegetation, soils, and fire management. Our faculty (both federation and senate) are in regular contact with the stakeholders and are well-aware of the research and extension needs in the area of restoration ecology.

How the position will meet campus AES/CE mission and priorities: This will directly advance 4 of the 5 college priorities for programmatic investment, including: water and watersheds; agriculture/ environment/ human health; agricultural/ environmental sensing/ informatics; and science/public/governmental policy. It will also integrate research and outreach deriving from the 5th priority: agricultural/ environmental genomics. This position will be integral to a number of key initiatives and centers at the college level, including: global change, sustainable agriculture, urban horticulture, and regional change.

How the position will meet statewide needs: The relevant DANR priorities addressed by this position include: sustainable agriculture, water quality,

protecting and stabilizing soil, restoring the structure and function of watersheds/ ecosystems/ landscapes and their associated critical habitats, controlling invasive species and pests, and restoring food, cover and nesting habitat critical for fish and wildlife. There are no CE specialists dedicated to restoration ecology in California.

How the position will strengthen the campus-county continuum: Twenty-five livestock and range farm advisors and an increasing number of watershed and water quality farm advisors have established programs that depend on the expertise that resides among the specialists and faculty within Plant Sciences. This position will collaborate with CE, AES and other researchers and educators in such programs as the IHRMP, Rangeland Watershed program, Natural Reserve System, Forestry Center, Sea Grant Extension, appropriate DANR workgroups, and other campuses and their respective centers such as the Center for Conservation Biology at UCR.

Urban Forestry Specialist

Overview and justification: Over the last fifty years, California's population has grown increasingly urban. Today, nearly 95% of the state's inhabitants live in metropolitan areas. By 2030, the California Department of Finance projects the State will be home to 48 million residents – most of whom will live in urban/periurban locations. The impact of the urban population on California's natural resources will be significant and the need for research-based information on how to manage urban green spaces and homeowner landscapes provides an opportunity for the University of California. Two examples illustrate important emerging issues that will require leadership from UC: 1) California has over 1200 miles of key riparian habitat along our levee system, much of which is adjacent to urban or urbanizing locations. In addition, our rivers and other water sources are closely tied to urban and periurban use. California will need to establish systematic management approaches for California's biologically important urban forests along levees and other urban waterways and 2) half of the projected population growth is expected to occur in the drier, hotter Central Valley and Inland Empire regions. This population increase along with larger residential lot sizes will lead to an increase in per capita water demand. It is projected that urban water needs will increase from 8.9 million acre feet (maf) to 11.9 maf. Research and outreach are needed to better manage vegetation for multi-dimensional uses along California's waterways and to optimize urban water use whether from stormwater runoff, in homeowner landscapes, or in other parts of our urban forests, particularly in relation to understanding the future impacts of global climate change.

The importance of Urban Forestry has emerged over the last 15 years and now is fully developed as a profession and an academic discipline. A number of indicators serve as evidence to support this. Many (if not most) cities in California now have urban forestry programs and/or community based urban forestry groups (e.g., Trees Davis). Statewide programs are in place as well (e.g. CA Releaf). The California Department of Forestry (now CalFire) has had an urban forestry program in place for over 10 years. Management of trees for fire prevention is a key issue in urbanizing environments such as the Lake Tahoe Basin. The

Environmental Horticulture Department (now Plant Sciences) added Urban Forestry as a major a number of years ago. The U.S. Forest Service established the Center for Urban Forest Research on campus. One of only a few research-based centers nationwide focused on urban forestry, it is strongly linked to the Department of Plant Sciences and other departments on the UC Davis campus. The CAES has supported the development of the Center for Urban Horticulture which will focus on important issue related to this position. A 2006 independent review of ANR programs noted that the most glaring weakness in the statewide programs was in the area of urban horticulture, including urban forestry.

There is tremendous interest in California, the United States and around the world in “green” programs and ideas. Individuals, community groups, municipalities, parks and other public agencies, for-profit and non-profit organizations, and resource managers are all interested in knowing how to live, work and play in urban settings without contributing to global warming and/or having other adverse impacts on the environment (e.g. run-off water pollution). On a more local scale, cities are striving to be more liveable and sustainable through greening efforts. Recent passage of Propositions 40 and 84 will result in California investing over \$120 million in urban greening projects. This investment will address the serious problems posed by deteriorating infrastructure in California cities and reflects growing awareness of green infrastructure practices as cost effective remedies. Urban greening strategies can sequester carbon dioxide, improve air quality, lower summer peak energy demand, reduce storm water runoff, increase property values, decrease local ambient temperatures, reduce infrastructure maintenance costs, provide psychological, sociological and physiological benefits, and enhance community development. Private sector investment in urban greening is likely to increase with the emergence of markets for carbon and air pollutant credits.

As investments in urban greening grow, there will be increased demand for research-based information to guide those investments. There is no entity in California capable of meeting that demand. Therefore, urban forestry expertise in the Department of Plant Sciences at UC Davis is needed. An Urban Forestry Specialist could: 1) use science and technology to calculate the outcomes of alternative greening strategies; 2) evaluate the costs and benefits of greening strategies as decision support for investment for California cities and counties; 3) develop best management practices for planning and maintaining urban forests; 4) monitor projects after installation and report lessons learned so that future projects are more effective; 5) provide technical assistance and advice to municipalities, State resource agencies, Office of the Governor, and the legislature; 6) develop partnerships to design and implement shade tree programs in different urban environments; 7) engage the community – agencies, non-profit, K-12 education, residents and community groups, such as the Master Gardeners program – with research in urban areas to share lessons learned and incorporate community needs into research; and 8) develop and implement methods to study the role of forests in urban environments and impacts on natural resources

A CE Specialist in Urban Forestry would provide much needed linkage between existing Department programs to Cooperative Extension, county based programs and the Urban Forestry profession (public, private, and nonprofit

entities). Funding is available from well established programs at the federal, state, and professional levels. As examples: 1) One Million Tree Initiative in Los Angeles and Greenprint Initiative in Northern CA (5 mil trees); and 2) \$150,000 Proposition 40 grant for “Quality Nursery Trees for California’s Urban Forest by Urban Tree Foundation with the California Center for Urban Horticulture and UC Cooperative Extension, San Mateo County named as grant collaborators

How the position will meet the department’s outreach/extension plans: The current Academic Plan for the Department of Plant Sciences places urban forestry as a high-priority target area for CE Specialists as well as for I&R/AES positions. The Department recognizes that the appropriate management strategies for the many emerging issues in urban forests requires knowledge of urban planning, vegetation management, ecology and horticulture. The development and application of long-term urban forest management strategies coupled with use of appropriate plant material are even more important today to reduce global warming, reduce heat load in urban cities, reduce energy use in cooling and heating of buildings, effectively manage our water resources, habitat needs and biodiversity, and increase carbon sequestration. Sustainable landscape strategies must be developed and implemented to reduce water and chemical inputs to urban landscapes to reduce energy use and environmental impacts. The College recently began the California Center for Urban Horticulture as a focal point for outreach efforts in this area. However, the Plant Sciences Department has very limited expertise in this area and additional CE faculty are needed, especially in urban forestry.

How the position will meet statewide needs: The ANR Program Council identified 21 core issues in 4 program areas that are of “greatest relevance and importance to California” in the September 2005 report. A CE Specialist in Urban Forestry would be able to address at least 11 of those issues:

- Agricultural policy and pest management program
Invasive species – Provide information on proper species selections to limit the uncontrolled spread of undesired plant species. Assist programs monitoring the health of urban forests to provide the early detection of exotic diseases and pests.
Pest management – Understanding the ecology and epidemiology of pests and diseases can lead to more efficient methods of cultural and biological control.
- Agricultural productivity program
Soil quality - Understanding soils in urban forests and their role in the ecology of the natural resources can improve water and air quality and protect natural systems,
Waste management – Urban forests can generate large quantities of green waste, proper management can reduce and recycle this waste.
- Human resources program
Youth development – Assist in improving youth literacy in the environmental, agricultural, and biological sciences by providing opportunities for outdoor learning activities in urban forests.
Community development - Environmental justice and building of social capital in neighborhoods through greening efforts.
- Natural resources and animal agriculture program

Water quality –This Specialist can assist in the implementation of methods that reduce the pollution from runoff generated from storms and improper water use.

Air quality – Urban forests can improve air quality through particulate removal and other mechanisms.

Land use – Understanding urban forest ecosystem function can assist the planning and development of communities.

Sustainable use of natural resources – The Specialist can develop management practices of urban forests that reduce impacts on resources.

Water supply and allocation – Information on the efficient use of water to maintain urban forests will need to be developed and disseminated.

How the position will strengthen the campus-county continuum: Of the four workgroups involved in the Ornamental Horticulture Extension Continuing Conference (OHECC), two (Landscape and Urban Horticulture) are well-positioned to work with a UC Davis campus-based Specialist in Urban Forestry. These two workgroups are relatively large (45 members in Landscape and 68 members in Urban Horticulture) and many members are involved in both workgroups. Currently, the Landscape Workgroup enjoys the involvement of the Landscape Horticulture Specialist from the Davis campus; the Urban Horticulture Workgroup needs leadership from an Urban Forestry Specialist. The Urban Forestry Specialist will find faculty on the Davis, Riverside, and Berkeley campuses as research/outreach resources as well as county advisors distributed throughout the state, in particular, in the major urban areas of northern and southern California.

Vegetable Production Specialist

Overview and justification: Great economic challenges face the California vegetable industry such as increasing production costs due to higher costs for land, labor, fertilizers and fuel. There are numerous environmental challenges as well for the vegetable industry, including water quality concerns regarding nutrient loss, and air quality concerns regarding emission of dust and volatile organic compounds (VOCs) from use of pesticides and soil fumigants. There are also issues of food safety that are shaking the vegetable industry to its very core. California is the largest vegetable producer in the US, leading in commodities such as onions, carrots, cole crops, celery, lettuce and tomato. The value of the California vegetable industry in 2006 was \$6.8 billion. Organic vegetable production has increased rapidly in the past 15 years due to increased consumer demand for organic produce. Organic vegetables represent one of the more profitable commodities, and in California 90% of organic sales come from vegetables, fruits and nuts. From 1998 to 2003, farm gate sales for organic vegetables increased 65% from \$93.8 to \$154.8 million.

In California there is no statewide coordination or leadership in conventional or organic vegetable cropping systems for crops such as carrot, potato, onions and garlic. Such a position is critical, particularly with the high economic value of these crops and public pressure to reduce environmental impacts of crop production. It is expected that the research and extension program for the person in this position would focus on sustainable methods of

crop production by using precision nutrient management and water quality, improved varieties, reduced tillage, and reduced pesticide usage. In addition, this position will address changes in production technology such as mechanization and methods of production to increase the efficiency of labor and energy inputs. There has been no Cooperative Extension Vegetable Specialist working on these key crops for several years, and the retirement of some key Farm Advisors has further eroded extension activities in vegetable crops. The relevant commodity groups have strongly supported this position, as have UC Farm Advisors, AES faculty, and other representative Specialists and Departments as well as counterparts at UC Riverside.

How the position will meet the department's outreach/extension plan: The Department of Plant Sciences has identified Cropping Systems and Plant Development, and Nutrition and Reproduction as two of the seven core competency areas, and a Vegetable Production Specialist in vegetable cropping systems as one of the higher priorities in the current academic plan.

How the position will meet statewide needs: Vegetable crops for fresh market are grown throughout California to meet the seasonal needs of the market rotating from winter production of carrots and onions in the Imperial Valley in the south, to summer production in the Tule Lake Basin in far northern California. Counties in both the Central Valley and coastal region all have very large vegetable production industries. The CE Specialist will work closely with commodity groups, state and government agencies coordinate and assist Farm Advisors working on vegetable crops; and collaborate with faculty in plant nutrition, irrigation, physiology, agricultural engineering, and other faculty working in cropping systems.

How the position will strengthen the campus-county continuum: Vegetable crops are grown throughout California with Farm Advisor involvement throughout the state. There is a great need for statewide leadership in the area of vegetable cropping systems, nutrient management, and organic vegetable production. There are also a number of I&R faculty within the Department and college that work on a variety of production aspects of vegetable cropping systems. A specialist in this position will have numerous opportunities for collaboration among other faculty and assist in moving this research to the end users.

Agricultural commodity/crop links:	
Major crops:	2006 Acreage:
Asparagus	24,000
Carrots	73,500
Celery	24,300
Cole crops	180,600
Garlic	24,500
Lettuce	232,100
Melons	81,600
Onion	51,000
Peppers	33,900
Potato	41,400

Sweet corn	26,900
Tomato, fresh	41,400
Tomato, processing	282,000

Other significant crops: Artichoke, cucumbers, herbs, snap beans, spinach, squash.

This position is linked to numerous key problems including: 1) the problem of replacing metam sodium as a fumigant for nematode and weed control in carrot; 2) the problem of replacing the role of old vegetable pesticides which are volatile organic compounds (VOC); 3) the need to control nutrient run-off and prevent water contamination; 4) organic production, the most rapidly growing sector of California agriculture; and 5) a growing emphasis on agricultural tourism with less tolerance for pesticide use. Trends in this area include: 1) increasing production costs; 2) decreasing labor availability; 3) increasing need for sustainable crop production that has less of an environmental footprint; and 4) increasing role of robotic systems in vegetables as the technology becomes more available.

Funding opportunities include: 1) development of metam sodium alternatives for vegetable crops; 2) development of robotic machine vision and precision guided equipment for transplanting and harvesting of vegetables; 3) increased water use efficiency in vegetable crop production; 4) improved nutrient management for conventional and organic vegetables; 5) strong support by vegetable commodity boards, with excellent opportunities for funding; 6) significant opportunities for funding for water quality and air quality projects; 7) significant opportunities for funding by the UC Integrated Pest Management (IPM) program, the Western Regional IPM program, and the National IPM program; and 8) opportunities for funding by the Sustainable Agriculture Research and Education Program (SAREP), Western Regional SARE and the National SARE program.

Weed Science Specialist, Perennial Cropping Systems

Overview and justification: California is uniquely suited for the production of a wide diversity of perennial crops such as trees, vines and ornamentals. While a few perennial crops have seen a decrease in planted acres (i.e., avocados, pears, and apricots), the majority have seen increases in planted acres (i.e. almonds, grapes, etc.)

(http://www.cdfa.ca.gov/files/pdf/card/ResDir06_FrtNutGrape.pdf). The wide diversity of these crops creates a challenge for weed managers. Tree and vine crops are grown throughout California and had a 2006 farm gate value of \$11 billion. Weeds are the single most important pest group in these crops. As a result, herbicides represent 72% of all pesticides applied in agriculture. Weed management is rapidly changing in these crops. There have been increasing regulatory and consumer pressures to improve air quality, reduce water use, and reduce pesticide use in California agriculture. Weed management plays a vital role in each of these issues. Dust is a result of cultivation, which is generally used for weed control in perennial crops. Weedy fields result in increased water use. Herbicides are often used to replace cultivation and reduce weed competition, but environmental concerns and consumer demand for pesticide free products

discourages herbicide use. Thus, weed managers are facing competing demands – trying to reduce dust and weed competition, while also reducing fumigant and herbicide use. Increasing fuel and labor cost will add further pressure on weed managers.

Many of the herbicides used in perennial crops target specific enzymes found only in plants. Herbicides with a single site of action are more prone to develop herbicide resistance. The incidence of herbicide resistance among weed species has increased exponentially in the past 10 years. These are the same herbicides used frequently in tree and vine crops. The continuous use of these herbicides will likely result in weed population shifts to species capable of escaping injury through inherent tolerance or herbicide resistance. For example, the first reported case of glyphosate resistance in North America was identified in an orchard weed in California.

Furthermore, the loss of methyl bromide will also require alternative methods for managing weeds in many of tree, grape, and ornamental nurseries. Moreover, introduced ornamental species represent over 60% of the invasive weed problems in non-crop systems. The continued introduction of new potential invasive plants into California has serious implications for our environment and for the survival, distribution, and growth of native plant species.

In California there is no statewide coordination or leadership in weed management within perennial cropping systems. Such a position is critical, particularly with their high economic value and public pressure to reduce pesticide use. Cultural and biological methods of weed management are under utilized in tree and vine crops and would be expected to be a major focus of research and extension for the person in this position. There has been no Cooperative Extension Weed Specialist working on perennial crops for several years, and the retirement of some key Farm Advisors have further eroded extension weed activities in perennial crops. Such a position is critical, particularly with their high economic value of perennial crops. All associated commodity groups have strongly supported this position, as well as UC Farm Advisors, Weed Scientists, and other representative Specialists and Departments.

How the position will meet statewide needs: Perennial crops are grown throughout California – avocados in San Diego and coastal counties to apples in the northern counties, with numerous fruit and nut crops in between. Perennial crops represent a long-term commitment by growers, which indicates there will be stability in the commodities that this position will serve. A CE Specialist will work closely with commodity groups, state and government agencies, coordinate and assist Farm Advisors working on perennial crops, and collaborate with faculty in weed ecology, biology, physiology, agricultural engineering, and other faculty working in perennial cropping systems.

How the position will meet the department's outreach/extension plans: The Department of Plant Sciences has identified Weed Science as one of the seven core areas, and a Weed Specialist in perennial cropping systems as one of its highest priorities in the current academic plan. Weeds are found in every acre in agricultural fields, and nearly every landscape and nursery setting. To prevent economic or aesthetic loss, weeds are generally controlled by a combination of approaches, including chemical, mechanical, cultural, and biological methods.

How the position will strengthen campus-county continuum: There are programs in the experiment station developing precision agriculture techniques, alternatives to methyl bromide, biology, ecology and management of herbicide resistant weeds, and biological control of weeds. There are also a number of I&R faculty within the Department and college that work on a variety of production aspects of perennial cropping systems. A specialist in this position will have numerous opportunities for collaboration among other faculty and assist in moving this research to the end users.

Agricultural commodity/crop links:

Major crops:	2006 Acreages:
Almonds	730,000
Citrus	260,000
Grapes, Raisin, Table, Wine	860,000
Plums (dried)	72,500
Walnuts	241,000

Other significant crops include: apples, pears, persimmons, pomegranates, pecan, pistachio, peaches, nectarines, cherries, olives, dates, avocados, kiwi, fig, blueberry, raspberry, and ornamentals.

This position has linkages to: 1) organic production, the most rapidly growing sector of California agriculture; 2) growing emphasis on agricultural tourism with less tolerance for pesticide use; 3) the problem of replacing methyl bromide as a fumigant for tree, vine and ornamental nurseries; 4) the problem of replacing the role of old herbicides which are volatile organic compounds (VOC). Trends in this area include: 1) few herbicides are in development due to drastic changes in the pesticide industry; 2) the incidence of herbicide resistant weeds are increasing; 3) as costs of land and labor increase, the role of perennial crops will increase as they are more profitable than relatively low-value annual crops such as cotton or grains; and 4) the role of robotic weeding systems will increase as the technology becomes more available.

Funding opportunities include: 1) development of methyl bromide alternatives for perennial crops; 2) development of robotic machine vision and precision guided equipment for weed removal; 3) development of novel biocontrol agents for control of perennial weeds such as field bindweed; 4) water use efficiency in orchards as impacted by weed management; 5) organic-compliant weed management methods; 6) strong support by tree crop, vineyard, and nursery commodity boards, with excellent opportunities for funding; 7) significant opportunities for funding for water quality and air quality projects; 8) significant opportunities for funding by the UC Integrated Pest management (IPM) program (should this program be re-instated), the Western Regional IPM program, and the National IPM program; and 9) opportunities for funding by the Sustainable Agriculture Research and Education Program (SAREP), Western Regional SARE and the National SARE program.

G. Joint CE/I&R appointments

Plant Sciences currently has three active faculty members with CE/I&R/AES appointments. These faculty, along with a recent retiree with a split appointment, have

demonstrated that split academic appointments provide opportunities for faculty to develop highly successful programs that fulfill the diverse missions of campus-based research, teaching and outreach, as well as statewide CE responsibilities. Furthermore, such programs are demonstrably consistent with individuals' career development as UC faculty. There are selected areas of high student interest in our teaching programs that are best met by faculty who have the expertise and experience typical of CE Specialists. We therefore support and encourage additional CE/I&R/AES or CE/I&R appointments in selected areas where department, college, campus and statewide needs can be best addressed by such appointments. To this end, we have targeted two such positions in our priorities, and encourage careful consideration of using such appointments in recruiting for the other CE Specialists as appropriate situations arise.

Our department considers that individual CE Specialist faculty should have the opportunity and option to seek I&R appointments with Academic Senate membership at their discretion. We are aware that few CE Specialists will pursue this option. Those who choose to do so should have a well documented, prior record of excellence in undergraduate and/or graduate teaching sufficient to sustain a tenured appointment as UC Senate faculty prior to being considered for I&R status. Our expectation is that the CE FTE resources vacated by our faculty exchanging CE for I&R partial appointments remain in our department to be used to recruit new faculty with split CE/I&R/AES appointments.

Appendix I

Table: Plant Sciences Faculty Age Distributions and Anticipated Retirements for 2008-2013

Area of Expertise	Median Age	N	Age > 55	Age > 60	Anticipated Senate Retirements	Anticipated CE Retirements
Cropping Systems	56.1	17	10	4	4	1
Ecosystem Mgmt	53.7	10	4	3	2	0
Genetics	53.5	25	9	5	3	
Physiology	60.6	10	9	6	3	
Postharvest	54.0	7	3	2	3	0
Urban Hort/Forestry	54.1	4	1	0	1	0
Weed Science	55.3	5	3	0	0	1
All	55.1	78	39	20	16	2