**Condition Change: UC ANR contributed to increased ecological sustainability of agriculture, landscapes, and forestry**

*Endemic and Invasive Pests and Diseases*

**Issue**

Endemic and invasive pests and diseases cause widespread damage to agriculture, landscapes, and forests. The spread of invasive pests has increased in recent decades, linked to global travel, produce trade, and climate change. In 2017, the California Department of Pesticide Regulation identified that California used over 205 million pounds of pesticide. Pesticide often used to control weeds, insects, and other pests, when used incorrectly, can cause environmental problems. Growers, land managers, and forestry experts need pest management tools and strategies that minimize impact on natural pest enemies and pollinators, potential for water quality problems, impact on aquatic invertebrates, and endangered species.

**Methods**

UC ANR partners with public, governmental, and private groups to develop and extend new knowledge about integrated pest management (IPM) for growers and land managers. Research and extension is conducted at the Agriculture Experiment Station locations and in the field through UCCE.

Research at the UC Davis Agriculture Experiment Station (AES) location is examining the environmental fate of commonly used agricultural pesticides and informing state water boards, wildlife agencies, and growers about pesticide choices based on persistence and toxicity. The long-term impact is cleaner water while maintaining productive agricultural systems (Ron Tjeerdema).

Projects at the UC Davis and UC Berkeley AES locations address the impacts of pest and disease management to minimize harm to natural populations. For example, research advances on the impact of the fungal pathogen *Batrachochytrium dendrobatidis* on amphibians is being used to develop management actions for the National Park Service (Erica Rosenblum). Other research demonstrated that because aquatic weed beds and decaying weeds benefit invertebrates, they are likely vital to fish productivity. Total weed eradication could reduce fish populations (Erin Marineau and Sharon Lawler).

A project at the AES UC Riverside location is examining more efficient methods to screen for natural insect repellents. These repellents have higher volatility that DEET and were able to repel from a slightly further distance making them excellent candidates to protect plants and people from insects (Anandasankar Ray). Another project focused on large-scale field trials of a slow-release mesoporous pheromone occurred at five sites to test the impacts on California red scale in citrus. Field trials demonstrated that the pheromone dispensers are successfully reducing California red scale populations on leaves, twigs, and fruit by more than 90% in 3 of 5 locations. Use of this product will significantly reduce pesticide use for California red scale in the San Joaquin Valley (Elizabeth Grafton-Cardwell).

Many UC ANR academics conduct pesticide efficacy and crop safety research studies that contribute to the USDA-IR4 program in California. The USDA-IR4 program supports research to aid in registering pesticides (herbicide, fungicides, and insecticides) on minor acreage and specialty crops. Several UC ANR scientists supervise an IR4 Field Research Center, which contribute to the pesticide residue work done in the nine Western Region field centers (Jeff Dahlberg, Brad Hanson, and Peggy Mauk).

University of California Cooperative Extension (UCCE) research and extension includes practices to increase knowledge and reduce the introduction or spread of pests and diseases. Vegetable crops advisors in Fresno, Merced, Stanislaus, and San Joaquin Counties established the resistance-breaking tomato spotted wilt virus scouting team to detect and confirm field grown tomatoes with resistant cultivars that are infected with the virus (Zheng Wang). Surveys and limited trials were conducted to address invasive, non-native Italian white snails and identify where they expanding into ornamental crops and landscapes in San Diego County.  Information is extended through presentations and blog posts (Cheryl Wilen). Scientists work with wine grape growers in Salinas Valley on coordinated control practices between all growers in the county to reduce the impact of mealybug spread of leafroll virus. UC ANR is working closely with the local grower association to provide leadership and technical support to area-wide efforts (Larry Betiga). Scouts in southern California monitored 224 orchards in 5 regions and measured the impact of grower applied insecticides on Asian Citrus Psyllid populations, which threaten the citrus industry (Elizabeth Grafton- Cardwell).

UCCE scientists conduct research and extend research-based pest management practices. Twenty-three field, classroom, and web-based workshops were held for over 1,200 tree care, urban forestry and open space professionals, and UC Master Gardener volunteers to provide education about invasive shot-hole borers (Sabrina Drill, Beatriz Nobua-Behrman and Akif Eskalen). Pest management seminars on ground squirrel, gopher, and rodent management were provided for farmers, small farmers, and UC Master Gardener volunteers in the Santa Clara and San Benito counties reaching nearly 1,000 people. Areas of focus included pest pressures in peppers and Asian vegetables (Aparna Gazula).  Classes, workshops, and field meetings were held for producers where they learned to identify and assess pest damage, identify and evaluate natural enemy populations, and use a variety of methods to manage pests on their farms and orchards (Cindy Fake).

Several UCCE efforts in 2019 focused on pest management practices. One hundred eighty professionals were educated through the West Coast Rodent Academy in 2019 (Niamh Quinn). UCCE scientists worked with park and school agencies to provide guidance to develop IPM plans (Cheryl Wilen). A novel bait delivery method was developed and tested to target Argentine ants in vineyards. The results were shared through a publications and a demonstration event with 23 attendees (Monica Cooper). Trials were conducted to manage Medusahead, an invasive grass species on rangelands (Thomas Ghetts). UCCE scientists organize the UC Riverside Urban Pest Management Conference annually, which typically attracts 200 attendees, as well as the UC Riverside fumigation school, which is attended by 30 to 50 local pest management businesses, pesticide manufacturers, and regulatory agencies. At these events, UCCE scientists provide training on ant control, bed bugs, and wood-destroying insects, and the efficacy of pesticides used in the field (Dong-Hwan Choe). Applied pest management research to control the Sugarcane Aphid in sorghum was shared through educational presentations and meetings with agricultural professional associations (Nicholas Clark and David Haviland).

Tools developed by UCCE scientists are used by the public and decision-makers. For example, Coyote Cacher, a web-based application was developed in 2018, and continues to be very successful with 58,000 visitors, posting 7,991 reports from 596 different zip codes in 2019 (Niamh Quinn).

As a result of UC ANR research, outreach, and education, participants learned and adopted practices that led to increased ecological sustainability of agriculture, landscapes, and forestry. Research and activities that resulted in outcomes with specific measured indicators follow.

**Outcomes**

**Participants learned or intend to adopt pest management practices, including Integrated Pest Management strategies.**

* The effort of the tomato spotted wilt virus scouting team increased awareness of the disease, and growers are avoiding susceptible varieties, scouting fields for the disease more frequently, have easier access to report symptoms, and are more cautious to avoid transmitting virus and disease vector during field work. (Zheng Wang)
* As a result of outreach efforts, stakeholders have identified additional locations that the Italian White Snail has expanded into in San Diego and Los Angeles counties. This knowledge will help PCAs and landscapers take preventative measures to reduce its impact. (Cheryl Wilen)
* Growers in Salinas Valley formed neighborhood groups to coordinate control practices and reduce mealybug spread of leafroll disease between adjacent vineyard properties. (Larry Bettiga)
* A pest management seminar improved skills in identifying and sustainably managing crop pests while minimizing environmental impacts.
  + 88% of the 46 farmer and landscaper participants in a pest management seminar were able to correctly identify key fruit tree and vine pests and their damage using an audience response system.
  + 94% were able to identify appropriate actions to manage those key pests. (Cindy Fake)
* After five workshops on invasive shot hole borers 310 participants reported,
  + increased knowledge about the pest and management of invasive shot-hole borer biology, (49%); proper sanitation, (37%); sampling methods, (42%); and management of firewood and other wood, (51%)
  + 53% expressed intent to properly disposing of wood, and
  + 58% expressed intent to share information with co-workers and the public. (Sabrina Drill)
* As a result of the 2019 Ground Squirrel and Gopher Management workshop, the 46 participants gained knowledge of pesticide labels and regulatory requirements, rodenticides and their impact on wildlife, the use of natural predators as biological control, and the public’s response to ground squirrel and gopher control. Outcomes of note include:
  + 91 % increased their knowledge of ground squirrel control options and of the new technologies available for controlling ground squirrels and gophers
  + 94% increased their knowledge of organic and low secondary impact control options.
  + 63% indicated they would adopt one or more pest management practices discussed during the workshop. (Aparna Gazula)

**Participants adopted recommended pest management techniques.**

* Over 90% of 43 West Coast Rodent Academy participants that responded to surveys indicated they have started or improved behavior changes related to identifying rodents and implementing safe work practices that reduce the risk of contracting rodent-borne disease.
  + Over 85% reported behavioral changes around developing an integrated pest management plan for rodents and communicating with customers about the importance of integrated pest management.
  + 75% reported improvements in following rodenticide label instructions.
  + A majority of respondents believe these changes led to more efficient management, decreased negative environmental impacts, and increased customer satisfaction. (Niamh Quinn)
* In 2019, 10 companies, covering over 5,000 acres adopted the novel method to bait Argentine ants. (Monica Cooper)
* In response to the trials on Medusahead, the manufacturer of Indaziflam, which demonstrated excellent and longer control of medusahead without negative impact to perennial grasses, submitted to the EPA for a grazing label. Based on data from the Indaziflam trials, a National Wildlife Refuge treated multiple acres of medusahead with it to create fire breaks. (Thomas Getts)
* Pesticide manufacturers that attended the urban pest management conference and fumigation school used the information to influence their product development and maximize product efficacy by making novel modifications. (Dong-Hwan Choe)
* New information on Sugarcane Aphid control in California supported the registration of several insecticide labels to be used in California for the management of Sugarcane Aphid in sorghum. (Nicholas Clark and David Haviland)

**Science-based information on pest detection and management influenced policy and decision-making.**

* Coyote Cacher has been successfully incorporated into the Coyote Management Plans of many cities in Southern California and has been adopted by the San Gabriel Valley Council of Governments which governs 30 cities. (Niamh Quinn)
* The pesticide residue data from the USDA-IR4 Field Research Centers are used by the EPA, CDFA, and pesticide registrants to make decisions about registering pest control products on minor acreage crops that would not otherwise have sufficient market justification for the manufacturer. (Brad Hanson)
* Several schools adopted pest management plans such as Head Start in Chula Vista. These plans will ensure a safer environment for the youth, while maintaining a healthy landscape. (Cheryl Wilen)

**Change in condition: Reduced pest incidence.**

* Reports about grower orchard Asian Citrus Psyllid (ACP) monitoring program had the effect of altering the timing and types of insecticides used in area wide treatment programs in two of the regions, resulting in significantly lower ACP populations in 2018-2019 compared to 2017. (Elizabeth Grafton Cardwell)

These measured outcomes can create, improve, and enrich the state’s ability to prevent, control, and mitigate pests and diseases. For example, from 2016 to 2017, the amount of reported pesticide use in California decrease by 2% or 4 million pounds. In these ways, UC ANR contributes to the increased ecological sustainability of agriculture, forestry, and urban landscapes and the public value of protecting California’s natural resources, helping California realize the many benefits of the state’s rich and diverse natural resources.

**Condition Change: UC ANR contributed to increased ecological sustainability of rangeland management and forestry**

*Sustainable Natural Ecosystems*

**Issue**

Nearly 33 percent of California’s land is covered by forest and rangeland covers an additional 57% of the state. Forest and range provide clean air, carbon sequestration, clean water, and habitat for plants and wildlife. There is a critical need for land owners and managers to understand the impacts of a variety of different management practices including restoration and conservation to these services. Identifying methods for ecosystem restoration and ecosystem management practices are needed for California’s plants, wildlife, and other natural resources can continue to thrive.

**Methods**

UC ANR has led collaborative research and extension efforts and provided support to develop new policies in an effort to increase ecological sustainability of forests and rangelands.

UC Agriculture Experiment Station scientists at the UC Davis location have developed a new habitat model called SWAMP, which assesses how changes to agricultural practices, water availability, urban growth, and climate affect waterfowl habitat. This tool informs management decisions to enhance populations of waterfowl and other wetland dependent wildlife species. State and federal wildlife agencies, numerous conservation NGO’s, and agricultural organizations are among the active participants and audiences of this on-going research (John Eadie). Another project at the UC Davis AES location used a reconciliation ecology approach to identify how landscapes designed and created by people can function to support native species and ecosystem services. For example, one study found that approximately three times the number of migrant birds were observed foraging in native, valley oak trees as opposed to non-native tree species, such as London plane trees, despite valley oak only representing 15% of available canopy. This study shows urban foresters the ecological importance of native tree species in the urban landscape(Steven Greco).

At the UC Berkeley Agriculture Experiment Station location scientists developed and disseminated a software tool, called NIMBLE to analyze complex environmental and ecological data. It is being adopted and explored by research groups nationally and internationally to analyze fisheries stock assessment models and wildlife monitoring data at large scales (Perry De Valpine).

University of California Cooperative Extension (UCCE) scientists provide research and extension that leads to adoption of management practices. One collaborative effort with UCCE, UC Davis and UC Berkeley faculty, Plumas National Forest and the Sierra Nevada Conservancy demonstrated and monitored reforestation techniques and improved plantation resilience to fire (Ryan Tompkins).  In cooperation with the California Board of Forestry, research was conducted on the impacts of fire hazard reduction treatments within riparian zones. Policy makers attended field visits to see the results (Rob York). Only 75 groves of native giant sequoia exist. One researcher is conducting studies within and outside of rare native giant sequoia groves, worked with federal scientists, and collaborated with and advised non-governmental organizations on giant sequoia management (Rob York).

UCCE scientists also provided research and extension that aided decision-makers in policy and management decisions. Research on how to manage rangeland for biological conservation provided support for the formation of two coalitions the California Rangeland Conservation Coalition and the Central Coast Rangeland Coalition. The UCCE scientist developed research and outreach projects with the coalition members (Sheila Barry).Ten field trips were hosted over three years for California Assembly Members and their staff to develop understanding of working forests and management practices (Rob York). UC ANR scientists are members of the Environmental Flows Workgroup for the California Water Quality Monitoring Council. In this capacity research and extension activities   focus on the development of a statewide framework for assessing ecosystem water needs and guidelines for managing ecosystem water throughout the state (Ted Grantham).

As a result of UC ANR research, outreach, and education, participants learned and adopted practices that led to increased ecological sustainability of agriculture, landscapes, and forestry. Outcomes with specific measured indicators follow.

**Outcomes**

**Participants adopted recommended practices for sustainable forestry.**

* Research and extension on giant sequoia groves led to the development of a management plan for a grove of giant sequoias that are owned by the Save the Redwoods League. The plan is designed to protect the grove from high severity fire in the future. (Rob York)

**Science-based information was applied to policy and decision-making.**

* UC ANR's research and extension work contributed significantly to the Board of Forestry’s statewide guidelines about how to conduct fire hazard reduction treatments within forest riparian zones. In 2019 these statewide guidelines were given to all professional foresters. (Rob York)
* UCCE research and extension contributed to the formation of the California Rangeland Conservation Coalition and the Central Coast Rangeland Coalition (CCRC), which have successfully advanced rangeland conservation and received national recognition as a result. The CCRC developed a proposal with support from UCCE to restore grazing to some State Park lands, which is being discussed by the Director of State Parks, CDFFA, conservation organizations, California Cattlemen, as a tool to improve state land management in the face of threats from catastrophic wildfire. (Sheila Barry)
* A new set of Forest Practice Regulations were rolled out in late 2018, known as Working Forest Management Plans. Assembly members informed the UC ANR scientist that the field trips were a large factor in the development of the new policies. The regulations will allow smaller forest landowners to develop CEQA certified plans to conduct timber harvests that can benefit many forest management objectives. (Rob York)
* The guidance document prepared by the Environmental Flows workgroup, which include UCCE scientists, is being reviewed for adoption in state policy by the State Water Resources Control Board and Department of Fish and Wildlife. (Ted Grantham)

**Change in condition: Land reforested.**

* Science-based information led to the reforesting of 800 acres of the Plumas National Forest.  Additionally, Plumas National Forest managers used herbicide in a plantation for the first time in three decades, which will improve the survival and growth of planted trees in post-fire restoration projects. (Ryan Tompkins)

As the aforementioned measured outcomes demonstrate, UC ANR supports the implementation of forest and rangeland restoration practices and policy and regulation. Increased ecological sustainability of range and forest landscapes helps California realize the many benefits of the state’s rich and diverse natural resources. Thus, UC ANR contributes to the public value of protecting California’s natural resources.

**Condition Change: UC ANR contributed to increased ecological sustainability of ornamental and edible landscapes**

Sustainable Food Systems and Healthy Families and Communities

**Issue**

California’s growing population of over 40 million people raises environmental concerns for the state’s urban landscapes and urban-rural interfaces, such as effects on pollinator populations, green waste, and water quality and quantity issues. There is opportunity to improve landscape management industry practices. For example, changes in fertilizer and pesticide applications can reduce negative impacts on the environment, especially surface water contamination. There is also the opportunity to conserve water given 50% of residential water consumption statewide is applied to landscapes, and up to 60% of water applied by sprinklers is lost due to runoff, deep percolation, and soil evaporation.

**Methods**

UC ANR translates research into actionable landscape management strategies and extends science-based information about environmental horticulture.

In 2019, over 5,900 UC Master Gardener volunteers offered close to 500,000 volunteer hours in over 50 counties sharing research-based information on environmental horticulture to help the public more sustainably grow home, community, and school gardens (UC Master Gardener Program). For example in San Diego County, the UC Master Gardener volunteers disseminated information about water quality and integrated pest management through the Healthy Gardens, Healthy Homes Initiative. Sixty events were held around the county at fairs, farmer’s markets, and garden events, reaching an estimated 14,465 individuals (Cheryl Wilen).

A UC Cooperative Extension (UCCE) environmental horticulture effort delivered a turf grass Integrated Pest Management (IPM) training to over 130 school landscape clientele at the Weed Management Expos for School sites in Northern and Southern California, co-organized by the UC Statewide IPM Program and the California Department of Pesticide Regulation (Cheryl Wilen and Maggie Reiter).

In Kern County, environmental horticulture classes provide research-based information to horticulture professionals and members of the community. Attendees learn to preserve and enhance the urban environment through planting practices, water conservation, and implementation of IPM methods (John Karlik).

UCCE collaboration of environmental horticulture advisors and specialists conducted a comprehensive state-wide study to determine an appropriate water budget for professionally-maintained landscapes, funded by the California Department of Water Resources. Landscape managers at 30 parks, school grounds, greenbelts, and golf courses in six climate zones across California received intensive hands-on training on irrigation scheduling based on climate and plant water needs, proper irrigation system maintenance, and how to measure and improve the distribution uniformity of sprinkler systems (Janet Hartin).

As a result of UC ANR research and extension, participants learned and adopted sustainable landscaping and gardening practices. Outcomes with specific indicators follow.

**Outcomes**

**Participants learned recommended practices for sustainable landscaping**.

* 97% of the Healthy Gardens, Healthy Homes Initiative participants surveyed in 2019 indicated they learned two or more least toxic/reduced pesticide pest management methods, techniques, or ideas that they would use in the future and 81% indicated that that they learned three or more methods, techniques, or ideas that they would use in the future. (Cheryl Wilen)
* 43% of the 130 of survey respondents reported they planned to incorporate Integrated Pest Management practices and pursue alternatives to conventional pesticides in their management of school landscapes. (Cheryl Wilen and Maggie Rieter)

**Participants adopted recommended practices for sustainable landscaping**.

* Members of the public participating in the volunteer-led UC Master Gardener education events reported the following, through a statewide follow up survey:
* Created and enhanced pollinator friendly gardens; for example, 69% (of 403 respondents) started or improved their use of plants that attract and support pollinators, and nearly 49% started or improved the practice of providing water sources for pollinators. They also learned about creating nesting habitats. They reported applying what they learned to over 900,000 square feet of pollinator habitat. This improves yields in home food gardens and supports local agriculture productivity.
* Used recommended green waste reduction practices; for example, 49% (of 269 respondents) started or improved using finished compost as a soil amendment. This improves soil by recycling organic matter and contributes to less green waste in landfills.
* Adopted improved landscape water use efficiency practices; for example in 2019, 65% (of 549 respondents) started or improved using mulch. In addition, participants reported removing over 145,000 square feet of turf. These practices reduce landscape water use.
* Adopted integrated pest management practices; for example, 73% (of 741 respondents) started or improved monitoring for pests or diseases, which slows their spread and protects natural and managed ecosystems. (UC Master Gardener Program)
* From student evaluations in Kern County, all respondents indicated they were changing at least two horticultural practices, and 14% indicated they would change seven or more practices, the highest value the survey offered. (John Karlik)

**Change in condition:** **Landscaped sites saved water.**

* Water use measurements before and after the hands-on training were compared at each site. Twenty-one of the 30 statewide professionally managed landscaped sites significantly reduced water use without a reduction of plant health, function, or appearance, based on findings comparing pre and post hands-on training. Some sites realized a 50% or greater reduction in water use. Results of the study were also instrumental in providing research-based data that led to statewide water savings through a reduction in the state water budget allocated to urban landscapes. (Janet Hartin)

Together these measured outcomes demonstrate that because of UC ANR’s efforts some landscapes are now more ecologically sustainable – supporting pollinators, reducing and reusing green waste otherwise going to landfills, protecting water quality, and saving water. UCCE research estimates that implementing best management practices for landscapes could save between 1.3 million to 2.9 million acre-feet of water per year in California (Janet Hartin). In this way, UC ANR contributes to the public value of protecting California’s natural resources.