# GROWING Points

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## Biotechnology in Horticulture and Forestry: Essential Research Tools for the 21st Century

***by Linda Dodge***

The US Senate designated January 2000 as "National Biotechnology Month". Senate Resolution 200 states that "biotechnology is increasingly important to the research and development of medical, agricultural, industrial and environmental products" and that "it is important for all Americans to understand the role biotechnology contributes to their quality of life". The resolution declares further that "biotechnology contributes to crop yields and farm productivity and enhances the quality, value and suitability of crops for food and other uses which are critical to America's agricultural system". In addition, biotechnology "promises environmental benefits including protection of water quality, conservation of topsoil, improvement of waste management techniques and reduction of chemical pesticide usage".

UC Davis has been on the cutting edge of biotechnology research since the 1970s. Many faculty researchers, including several affiliated with the Environmental Horticulture Department, are currently using these powerful tools to address basic questions and applied research in their areas of interest. According to the publication *Biotechnology at UC Davis*, published by the Division of Biological Sciences, "biotechnology, in the simplest and broadest sense, is a series of enabling technologies which involve the manipulation of living organisms or their subcellular components to provide useful products, processes, or services". Included within this broad definition are such technologies as recombinant DNA techniques, gene transfer, plant regeneration, cell culturing and bioprocess engineering. EH researchers are using these and other methods to address questions in improvement of citrus cultivars, manufacture of botanically-derived pharmaceuticals, landscape ecology, disease resistance in forest trees and postharvest handling of cut flowers.

***"Portrait of a DNA Sequence" by Roger Berry. Sculpture displayed in the Life Sciences Addition on the UC Davis campus. Photo by Perry Johnson.***

### *Genetic Engineering Basics*

Genetic engineering of plants involves the transfer of the DNA of interest into the DNA of the target plant cell (transformation) followed by regrowth of an entire plant from the transformed tissue (regeneration). Scientists take advantage of the naturally occurring mechanism of plant infection used by the bacterium *Agrobacterium tumefacens*, responsible for the crown gall disease of many plant species. This pathogen has a tumor-inducing plasmid (minichromosome located outside the nucleus) within each cell that is capable of entering a wounded plant cell and incorporating its DNA into that of the cell. This pathogen DNA signals the cell to divide repeatedly and the result is the uncontrolled growth we recognize as the crown gall tumor. The DNA of a desired trait can be incorporated into this plasmid within the *Agrobacterium* cell, along with DNA "markers" (usually resistance to a particular antibiotic) that will allow selection of only the transformed plant cells. The *Agrobacterium* "vector" is mixed with wounded plant tissue from the species of interest to allow for transformation of individual cells by the bacterium's natural mechanism. The plant tissue is transferred to a culture medium containing hormones to stimulate callus and shoot growth. The medium also contains the antibiotic so the only tissue that will grow is that containing the resistance DNA which also contains the desired trait. Once shoots have developed, the tissue is transferred to a medium with rooting hormones or micrografted onto seedling rootstocks. When entire plantlets have developed, they are transferred to soil and allowed to grow in a greenhouse until large enough to transplant and evaluate for the newly introduced (transgenic) trait.

**In This Issue...** 

### *Citrus Research*

In 1997, California growers produced 89% of the lemons harvested in the US. Current trends of residential development of agricultural lands and mandated reductions in the use of pesticides may begin to reduce this market share. The lemon industry has turned to biotechnology for addressing such issues as yield, quality and insect resistance. Dr. Dave Burger of the Environmental Horticulture Department and Dr. A. M. Dandekar of the Pomology Department at UCD are collaborating to develop genetic engineering technologies for the improvement of lemon cultivars for traits of enhanced growth architecture, resistance to sap-sucking insects and reduced seediness.

Burger and Dandekar are currently working on the tissue culture system for regenerating lemon plants after cell transformation. The main obstacle here is the characteristic of lemon to have a prolonged juvenile phase before being able to produce fruit. Seedling tissue is most commonly used for transformation and so the resulting transgenic lemon plants would be juvenile and take 10-15 years to evaluate for some of the transgenic traits of interest. Burger and Dandekar will also be testing mature tissue from stem segments for the process of transformation and regeneration. If mature cells can be regenerated into plants, evaluation of transgenic traits may take only 5-7 years.

The next step is "vector construction" in which the genes encoding the traits of interest are inserted into the plasmid DNA of *Agrobacterium* along with "reporter" genes that enable detection of transformed tissue. To change lemon tree structure, Burger and Dandekar plan to use genes from *Agrobacterium* that have been shown to reduce internode length and apical dominance and to induce early flower set. To enhance resistance of lemon to sap-sucking insects, they plan to incorporate a gene from *Galanthus* (snowdrop) that produces a substance toxic to sucking insects and will include genes that allow the expression of the toxic trait only in phloem tissue and not in the fruit. To reduce seed set in lemon fruit, they will introduce genes which produce substances within seed cells only that stop protein synthesis thereby causing seed abortion. If successful, this genetic engineering system for lemon may be applicable to other species of *Citrus* and, therefore, be beneficial to all of California's citrus industry.

## *What Is Biotechnology?*

***(an excerpt from "Biotechnology at UC Davis", published by the Division of Biological Sciences, UC Davis, December 1999. Download the full text at the URL: http://www.biotech.ucdavis.edu)***

*Biotechnology is a discipline in which technology is applied in the production or modification of molecules, or manipulation of living organisms, to develop useful products, processes, or services. Biotechnology encompasses a wide range of fields, including biological science, chemistry, computer science, medicine, veterinary medicine, agriculture, environmental science, and engineering. The umbrella of biotechnology also encompasses a broad array of technologies, including recombinant DNA technology, gene transfer, embryo manipulation and transfer, monoclonal antibody production, and bioprocess engineering.*

*The foundation of biotechnology is DNA (deoxyribonucleic acid), the basic genetic material that regulates cell composition and growth in all living organisms. Particular sequences of genetic information contain instructions that determine specific characteristics or functions, such as the type of tissue or organ each cell will help compose as well as the enzymes, hormones, and other substances it will manufacture. The universal nature of DNA has enabled scientists to remove strands containing specific genetic coding from an organism and recombine that material with DNA from the original organism or from another organism- a process named "recombinant DNA technology." This technology is one of many used in biotechnology to modify the genetic machinery of organisms and falls under the broader heading of genetic engineering.*

*Biotechnology is far from new. For thousands of years, microbes have been used for fermentation processes to make bread, brew alcohol, and produce cheese, and genetically modified organisms have been introduced into the environment using techniques such as selective breeding. What is new are the tools that scientists use to modify organisms. Advancements now enable researchers to alter an organism's DNA with much greater precision, paving the way for many new applications of biotechnology.*

### *Plant-derived Drug Research*

The use of medicines derived from plants is as old as human culture itself. The techniques of biotechnology have brought this practice to a high level of sophistication and efficiency. The manipulation of plant cells to increase production of medicinal compounds is an active area of interest for Dr. Don Durzan's research group in the Environmental Horticulture Department at UCD. The current focus of their efforts is the drug paclitaxel (commercially known as Taxol™) which is produced by cells in the bark of the Japanese yew tree (*Taxus cuspidata*). This compound inhibits cell division and is used in the treatment of ovarian and breast cancer. The extraction of Taxol™ from harvested yew trees is impractical due to low yields and slow growth of the species. Growing cells of *Taxus* suspended in a liquid culture medium has proven a viable means of efficiently producing compounds called taxanes, one of which is paclitaxel. Dr. Durzan's interest is in providing conditions for cell culture that result in overproduction of these compounds to increase the yield of the drug and make it less expensive.

Durzan's novel approach has been to study the effects of gravity on taxane production in *Taxus* cell cultures. He has tested the effects of both low (microgavity) and high (hypergravity) gravitational forces on the types and amounts of taxanes produced by suspended yew cells. The conditions of microgravity were achieved by placing the cell culture suspensions in slowly rotating glass vessels (bioreactors). Hypergravity conditions were accomplished by growing the cultures on a semi-solid medium and spinning them in a centrifuge. Yew cells grown under low gravity conditions were larger and produced a larger fraction of paclitaxel than those subjected to normal or high gravity. Through techniques involving antibody binding, the taxane production was localized on the surface of stressed or

dying cells. The conclusion of this study was that low gravity conditions, such as on a space shuttle or space station, could be used to scale up the biomass of a *Taxus* cell culture, thus increasing the yield of Taxol™.

Dr. Durzan's work has led to several patents for UC on the recovery of taxanes. He has also been appointed by NASA to the Scientific Working Group for the Biotechnology Facility for the International Space Station.

***Landscape Ecology Research***

Dr. Alison Berry has investigated the phenomenon of symbiotic nitrogen fixation for over twenty years. The system she is interested in is not, however, the widely-known partnership between legumes and the *Rhizobium* bacteria in their roots. She is interested in the symbiosis between the filamentous actinomycete bacterium, *Frankia*, and the roots of such plant genera as *Alnus* (alder), *Ceanothus* (California lilac), *Casuarina* (Australian she-oak) and *Elaeagnus* (silverberry). This symbiosis serves the same purpose as the legume/*Rhizobium* combination; the bacteria fix atmospheric nitrogen into compounds that the plant uses as nutrients and the plant modifies its root growth to form nodules in which the bacteria can live on carbon compounds produced by the plant. Plants able to act as hosts for *Frankia* bacteria are often considered pioneer species, able to survive in extreme environments such as nutrient poor soils, sand dunes and disturbed sites. This process contributes to the overall cycling of nitrogen in the environment and can be adapted to aid in land reclamation, forestry and management of sustainable ecosystems.

Dr. Berry is interested in understanding the events that take place during the establishment of the *Frankia*/root symbiosis. In particular, she and her students are investigating how the bacterial cells "infect" root cells and how the root cells respond by the formation of nodules. As their experimental system, they have chosen not to work with the slow-growing, woody genera listed above but with a little known California native plant, *Datisca glomerata*. This *Frankia* host plant is an herbaceous perennial with a short generation time, a small number of chromosomes and self-fertile flowers producing abundant seed; characteristics that make it a good candidate for molecular genetic studies. Dr. Berry and her students grow out *Datisca* seedlings in a greenhouse and inoculate the roots with *Frankia* by crushing nodules from other plants and washing them into the soil of the *Datisca* pots. The roots and nodules along with other plant parts are harvested at various time intervals after inoculation.

***Symptoms of white pine blister rust on sugar pine (Pinus lambertiana) showing bark discoloration (yellow to orange) and blisters containing spores.***

In order to investigate which genes are expressed at each time interval, the mRNA is extracted from the tissues and analyzed. These mRNA compounds are the chemical "messages" from the DNA in the chromosomes encoding the sequences of amino acids that make up various proteins produced in cells. Berry's group isolated a particular mRNA that was abundant in *Datisca* nodules early in their formation but not found in any other tissues. They were able to reconstruct the gene's DNA from the mRNA and determine its sequence of nucleotides. They then compared this sequence to other known genes using powerful computer programs and the World Wide Web. They discovered their gene had 83% of the same sequence as a gene from soybean, known to be expressed early in *Rhizobium* nodule development.

This is the first report of a gene from a *Frankia* host showing a strong similarity to a gene expressed in a *Rhizobium* host and is evidence for a common ancestor for nitrogen-fixing plants. The function of the compound encoded by this gene in the process of nodule formation is also of great interest to Berry's research group.

***Forestry Research***

Dr. David Neale and Dr. Lorraine Sheppard of the Institute of Forest Genetics, a research unit of the U. S. Forest Service, are affiliated with the EH Department at UC Davis. One of their current projects involves identifying the genetic basis of resistance to the disease white pine blister rust. The group of species known as the white pines is of great economic and ecological importance in North America. The sugar pine (*Pinus lambertiana*) is one of the Pacific Coast's most valuable timber trees and individuals can produce up to 40,000 board feet of durable, evenly-grained lumber. Sugar pine, western white pine (*P. monticola*) and the ancient whitebark pine (*P. albicaulis*) provide habitat for countless species of birds and mammals. White pine blister rust is a fungal disease endemic to Asia that was accidentally introduced into western North America in 1910 where it has now caused more damage than any other conifer disease. The extent of devastation is approaching that of chestnut blight experienced in the eastern U.S. Attempts to control the disease through chemical applications or eradication of its alternate hosts, currants and gooseberries, have proven unsuccessful. Genetic resistance seems to be the best hope for reducing the impact of white pine blister rust.

Sugar pine trees resistant to white pine blister rust have been found in nature and breeding studies have shown that resistance is controlled by a single dominant gene (R), which has been genetically mapped. Drs. Sheppard and Neale plan to clone the R gene by comparing DNA sequences from sugar pine with those of known plant disease resistance genes. Once the DNA sequence of the R gene is known, methods can be developed to identify resistant parent trees for breeding and resistant seedlings as young as eight weeks old.

***Floral Research***

Dr. Michael Reid's research is devoted to keeping the California floral industry competitive in the global marketplace. One of the means to this end is improvement in the postharvest longevity of cut flowers and potted plants. Dr. Reid and his students have been investigating the cellular mechanisms involved in the process of flower senescence. They are using daylily (*Hemerocallis* spp. and hybrids) as a model system

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# Nurturing Science That Helps Us See the Forest for the Trees

*by Dr. Greg McPherson, Western Center for Urban Forest Research and Education*

After another field season studying street trees I'm reminded of how strong the bond can be between people and trees. Most people hate to see their trees threatened. Of course, some residents are equally passionate in their dislike of trees: the street tree that lifts their sidewalk, drops leaves on their lawn, or plugs their sewer. For local urban forestry groups and municipal tree managers this passionate connection between individual and tree can be both a blessing and a curse.

On one hand it is the emotional wellspring of stewardship, on the other hand it can undermine efforts to manage community forests for the civic good. This article describes how science can be used to capture and focus the public's interest in trees so as to strengthen support for urban and community forestry. Motivating people who are passionate about their trees to see the "forest for the trees" is no easy task. It means broadening the discussion from my tree to our trees and from now to the future. It implies that we all share a civic duty to manage the community forest to benefit not only ourselves, but our children. At the recent National Urban Forest Conference in Seattle, Janice McDougle (Deputy Chief, State and Private Forestry, US Forest Service) said credible research expands the public's understanding and this helps narrow the debate. I'd like to share one example of how this has happened.

We recently completed a benefit-cost analysis of Modesto's municipal urban forest and found that for every $1 spent on Modesto's 92,000 city-owned trees, residents receive nearly $2 in benefits. We also pointed out some looming problems, such as the preponderance of Modesto ash that are 40 or more years old. These trees comprise 14% of the population and account for 22% of total benefits. We noted that as these trees near the end of their life cycle there is an increasing risk of losing substantial tree canopy cover and associated benefits if disease, drought, or budget cuts accelerate their mortality.

Ten years ago the city was removing 300 to 400 trees a year, and refused to remove healthy trees that were damaging sidewalks or driveways. However, in an effort to increase the forest's age and species diversity they relaxed the removal policy and began removing, upon residents' request, Modesto ash trees that were conflicting with sidewalks and power lines. Currently the city replaces about 1,300 trees per year, 10% of which are Modesto ash. In 10 to 15 years more of the Modesto ash will need to be removed because most were planted from 1940 to 1955 and are declining in health and structural condition due to mistletoe, anthracnose, and limb breakage.

Shortly after the Modesto Bee published an article on our findings a flier was circulated locally by an irate citizen that read, "WARNING!! The city wants to cut down the tree in your front yard!" City Hall fielded dozens of calls from worried residents and assured them that their neighborhood was not going to be "clear-cut." A follow-up article in the Bee cited several residents' desire to retain their neighborhood's tree canopy cover. Eighty-six year old Louise Dunham said, "Its like an outdoor cathedral. The leaves are golden and the light shines through. I'm glad I got to experience it."

In the spotlight of public scrutiny, city tree managers held a series of meetings with local residents, elected officials, and the news media to explain their approach to managing this aging urban forest. Our research findings were used to focus the public's passionate response to incomplete information on perpetuation of the community forest.

1.) On average the city spends $29 per tree on management but residents receive $55 a year in benefit for a net annual benefit of $26 per tree. The largest benefits are from air pollutant uptake, air conditioning energy savings, and aesthetics, while 74% of all expenditures are for mature tree care.

2.) Although the community forest appears stable and permanent due to the many old Modesto ash, hackberry, and plane trees, it is really very fragile. These "at-risk" species require and receive intensive care. Without continued program funding to maintain the health of these trees, the benefits they produce will be lost prematurely. For example, if loss rates increased four-fold during the next 10 years, annual benefits are estimated to decline 28% as compared to benefits produced assuming current loss rates.

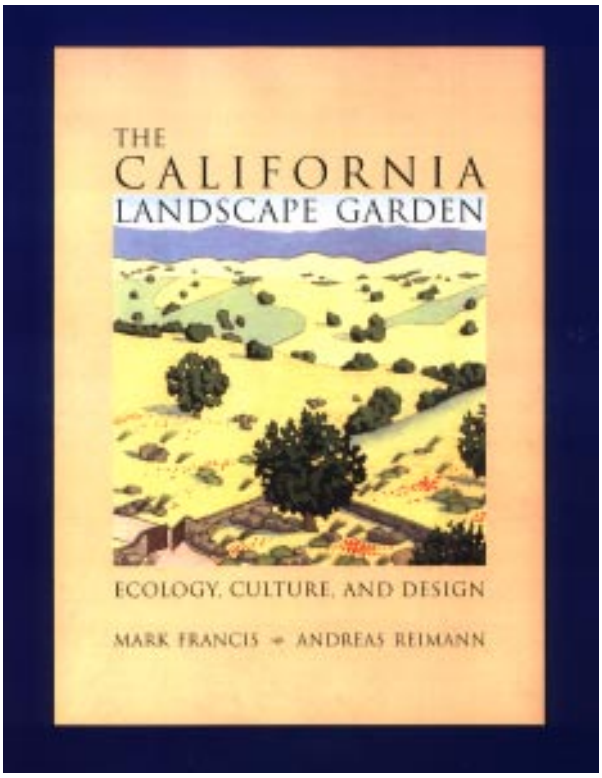
3.) Maintaining a stable amount of canopy cover requires shifting from a forest dominated by Modesto ash to one that has a more even distribution of benefits among species. Efforts to increase species diversity include development of improved cultivars such as the 'Pearl Street' pistache. We are working with tree managers to monitor the performance of other new introductions (e.g., Texas red oak, Chinquapin oak, and hybrid thornless mesquite).

4.) Because 14% of the current tree management budget is spent on sidewalk repair, current studies examining strategies for reducing sidewalk damage have potential to save residents a substantial amount. These strategies include: a) directing tree roots away from paving such as propagating trees with vertical rooting patterns, b) engineering hardscapes that are less costly to repair, and c) providing more space for tree roots through design and planning.

Cries of "timber" raised an alarm in Modesto. Although a false alarm, it gave voice to the community's deep sense of loss should many of the old Modesto ash have to come down. At the same time the community came to realize that its forest is surprisingly fragile and in an era of transition. Research information helped tree managers explain why maintaining program funding can make it possible to retain neighborhood tree cover while at the same time transitioning to a more diverse and stable tree population. The benefits of selectively removing and replacing unhealthy trees compared to clear-cutting neighborhoods were made tangible. The Modesto example illustrates how scientific information can help tree managers concentrate the public's passion for trees on issues central to the future health of community forests. As funding for research becomes increasingly limited it is important to realize that nurturing urban forest science can help us see the forest for the trees.

*Taken from:*
*California Trees: Exploring Issues in Urban Forestry 10(3): 5,9. 1999.*

# Campus Authors Win ASLA Award




Mark Francis, FALSA, Professor in the Landscape Architecture Program and Director of the Center for Design Research at UCD and Andreas Reimann (formerly of the University of Dresden in Germany) and currently serving with Marilu Carter as Landscape Extension Specialist in the Department of Environmental Horticulture at UCD recently won the 1999 Award of Honor for Communications from the American Society of Landscape Architects for their book, *The California Landscape Garden: Ecology, Culture and Design*. The ASLA states: "A testament to the growing popular interest in ecological gardening and garden design, this book brings the beauty, resources and natural processes of the California landscape to the home garden."

The book was published by the University of California Press in June 1999. The following excerpts from a review by Iain Robertson, chair of the Department of Landscape Architecture at the University of Washington, that appeared in the September 1999 issue of *Landscape Architecture* summarize well Francis' and Reimann's intent for the scope of the book and the intended audience.

*The California Landscape Garden: Ecology, Culture, and Design* sets for itself the daunting task of redefining the meaning of the word "garden", both as a noun and a verb. As authors Francis and Reimann state: "When we understand that nature and culture in fact inform each other in the making of a sustainable and regenerative garden, we forge a new environmental ethic, a garden ethic, that allows us to create ecologically vibrant and culturally rich environments." While the concepts of ecological design are not new to landscape professionals, they have yet to significantly affect the practice of gardening and garden design in the United States, a fact that can be confirmed by the briefest drive through any urban, suburban, or exurban residential neighborhood. The public's perception of gardens derives, on one hand, from glossy picture books displaying impossibly beautiful, exuberantly flourishing plants, typically with a vaguely "English" look to the scene; on the other hand, the public view appears strongly influenced by garden center aisles loaded with chemical fertilizers, herbicides, fungicides, and pesticides.

This is the large and potentially receptive audience for whom Francis and Reimann's book will provide revelation and inspiration. At its heart, *The California Landscape Garden* is about using garden design principles to learn how to relate positively to one's home environment, ecosystem, and place: "The transition from a traditional garden to an ecological one requires knowledge, feeling, insight, and creative flexibility. By keeping the central issues of the new garden paradigm in mind-namely, sense of place, diversity of form, meaning, and fitness- the designer or gardener will more easily be able to make critical decisions."

Throughout the book's six chapters, the authors employ broad brush strokes to introduce and interweave ecological ideas with landscape design principles in a non-technical and poetically engaging manner. The book's "landscape garden" ideas and goals are also lovingly illustrated by beautiful photographs and through Yan Nascimbene's beguiling drawings. Illustrations include an array of Californian natural scenes and many photographs of successful landscape gardens. The book is augmented by short and discriminating appendices that provide lists of periodicals, books, natural history and garden organizations, nurseries, public gardens, and designers.

The book's message is reaffirmed in a compelling epilogue, "Healing Landscapes", which reminds us that the processes of developing landscape gardens may simultaneously help residents of raw and ravaged suburbs develop more enduring ecological roots in the land and "heal" their own lives.

Like the state itself, *The California Landscape Garden* is a sumptuous and varied feast for the eye and the mind. If this book inspires new approaches to garden design or other publications on landscape gardening, it will serve two immensely valuable functions.

*The California Landscape Garden: Ecology, Culture and Design* may be ordered on the Web at the URL: http://www.ucpress.edu/books/pages/8376.html

## Dave Burger Wins 1999 Distinguished Service Award

Dave Burger was among 12 individuals singled out by their peers for outstanding contributions to the teaching, research and public service mission of the UC Division of Agriculture and Natural Resources. He received the 1999 Distinguished Service Award in the "Outstanding Faculty" category. The award recognized Dave's leadership activities that brought a sense of structure to the Environmental Horticulture program, were instrumental in improving communication among CE advisors and helped develop the Ornamental Horticulture Research and Information Center (http://ohric.ucdavis.edu). OHRIC is intended to be a state-wide Cooperative Extension resource providing research outreach, news, and information on the California horticulture industry.

# TMDLs: The Next Generation in Water Quality Regulation

"TMDL" is one of the latest acronyms that those in the green industry have added to their vocabulary. Short for "Total Maximum Daily Load", it is the battle cry of a new trend in water quality regulation. It signals the empowering of a previously-ignored portion of the federal Clean Water Act of 1972 requiring states to assess the actual quality of their bodies of water and establish pollutant limits that cannot be exceeded. This may have profound implications for generators of nonpoint sources of pollution, such as runoff from nurseries and urban stormwater runoff.

Following is the executive summary, reprinted with permission, from a document entitled *TMDLS: The Revolution in Water Quality Regulation* by Jennifer Ruffolo of the California Research Bureau. Published in April 1999 by the California State Library, this report is an overview of the status of water pollution control in California and how recent litigation and implementation of TMDL requirements may significantly alter the way many industries and municipalities conduct business in the future. The complete text of this report is available on the World Wide Web at:

www.library.ca.gov/crb/99/05/9905.pdf

Congress enacted the Clean Water Act in 1972. In the Act, Congress created two overlapping approaches to regulating water quality. One, familiar to all who follow water quality issues, regulates discharges from sewers, factory pipes, and other "point sources." The other, which lay quiescent for almost 12 years, requires states to establish quality standards for their lakes, rivers, and other water bodies, and to do whatever is required to meet those standards. Since pollution from point sources has been largely (though not completely) cleaned up, this requirement leads in the direction that states regulate and clean up water pollution from all other sources. This may include runoff and irrigation return flows from farms, runoff from forestry operations, and runoff from urban areas. It is an understatement to characterize this as a major escalation of water quality control efforts.

This "new" approach to water quality stems from Section 303(d) of the Clean Water Act. Section 303(d) requires states to identify all the water bodies that do not meet applicable water quality standards, and for those "impaired" water bodies, states must establish TMDLs, or total maximum daily loads. TMDLs define how much of a pollutant a water body can tolerate on a daily basis and still meet the relevant water quality standards. All of the sources of the pollutant in the watershed combined, including nonpoint sources, are limited to discharging no more than that total limit. The TMDL is supposed to be an objective, quantitative standard against which water quality can be measured.

This section of the Clean Water Act was essentially ignored for years. The EPA and the states were fully occupied with developing the standards and permit program for point sources, known as the National Pollutant Discharge Elimination System, or NPDES. However, environmental lawsuits and the courts breathed life into §303(d), beginning in 1984 with *Scott v. City of Hammond.* In this case, the Seventh Circuit ruled that EPA had to develop TMDLs if the states failed to do so. In a series of similar lawsuits across the country, what became known as the "theory of constructive submission" was used to force EPA to issue lists of impaired water bodies and establish TMDLs. Another landmark decision, *Sierra Club v. Hankinson,* showed that the courts were prepared to force EPA and the states to develop TMDLs on specific schedules, and even to require EPA to review recalcitrant states' NPDES permits and programs. EPA is under court order in 13 states to produce TMDLs; in 16 additional states, complaints have been filed seeking orders to force EPA to produce TMDLs. In 11 more states, notices of intent to sue have been filed seeking EPA action on TMDLs.

Types of pollutants requiring TMDL calculations for impaired water bodies:

| | |
|---|---|
| ***pesticides*** | ***metals*** |
| ***bacteria*** | ***pathogens*** |
| ***sediment*** | ***trash or debris*** |
| ***nutrients*** | ***low dissolved oxygen*** |

Not surprisingly, this wave of litigation has not passed California by. A growing number of California's water bodies are either subject to consent decrees to develop TMDLs, or are the subject of notices of intent to file lawsuits that may have that outcome. These include:

· Eighteen north coast watersheds including portions of the Garcia, Gualala, Lower Klamath, Upper Klamath, Albion, Mattole, Eel, Mad, Trinity, and Ten Mile Rivers;

· Newport Bay and San Diego Creek;

· Several watersheds in Los Angeles and Ventura Counties, including portions of the Los Angeles, Santa Clara, and Ventura Rivers, Malibu Beach, Venice Beach, and Santa Monica Bay;

· San Francisco Bay and the Sacramento/San Joaquin Delta.

A great deal about the full meaning of the TMDL requirements is yet unclear, evolving, and somewhat unpredictable. Litigation has thus far determined where and when TMDLs will be developed in California, and more lawsuits are possible, if not likely. There are not yet any statewide policies or regulations guiding TMDL development, and the State Water Resources Control Board has no TMDL program or budget.

There are other problems with TMDLs:

· California lacks sufficient data to determine which water bodies are clean and which need TMDLs, and must rely in many cases on regional board staff's best professional judgment.

· Various interest groups differ on how to define polluted water bodies.

· There are no prescribed rules for establishing and implementing TMDLs, so regional boards are making them up as they go along.

· Because of the uncertainty of the outcomes, both point source and nonpoint source representatives are taking issue with every step of TMDL development and implementation. This opposition leads to delays in establishing TMDLs, which leads to more lawsuits.

California is caught between tectonic forces. Federal law demands that the Regional Water Quality Control Boards and the State Water Resources Control Board develop TMDLs. Yet they have received little additional funding to carry out these mandates. At the same time, delays in estab-

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# Notes From the Chair... By Dave Burger

As you have probably guessed, the EH Department made it through Y2K with flying colors. The only thing close to a glitch that occurred was when **Michael Reid's** Palm Pilot refused to synchronize appointment files with his desktop computer. Apparently, it felt no one human being could attend that many meetings in a single day.

We are starting off the new millenium with two new employees in the department. We welcome **Jan Allen** as our new personnel wizard and grants guru. She comes to us from the Chemical Engineering Dept. at UCD so is familiar with our brand of office madness. We also welcome **Peggy Fain** as the newest member of the greenhouse crew. Peggy received her Master's Degree in the EH Department in 1994 and ran a landscaping business in Chico. She currently teaches plant identification and other horticulture classes at Consumnes River Community College in Sacramento. She will be our all-important weekend greenhouse staff and work two days during the week as well.

Speaking of the greenhouse crew, **Ron Lane** (Principal Superintendent of Agriculture), **Jianguo Chen** (Senior Agricultural Technician) and **Mitch Bunch** (Nursery Technician) won a College-Wide Staff Recognition Award for their efforts in modifying the EH greenhouses and storage facilities (the infamous B-6) to accommodate research plants and equipment from the Agronomy Department and the Department of Land, Air and Water Resources (LAWR) while their facilities are being relocated. Ron, Jianguo and Mitch installed 3300 square feet of rolling benches in three EH greenhouses to provide room for Agronomy's research plants without reducing space for EH research. In addition, they overhauled the B-6 facility to furnish 1500 square feet of storage space for LAWR equipment, removing thirty trailers of junk and displacing countless rats and black widow spiders in the process. Congratulations to Ron and his staff!

More visiting scholars have arrived this quarter to keep the Department's international flavor invigorating. **David Chagne** is from the Institut National de la Recherche Agronomique in Bordeaux, France. He is a Master's student and will be working on comparative gene mapping of conifers in Dave Neale's lab for six months. **Antonio Ferrante** is from the Scuola Superiore di Studi Universitari e di Perfetionanenio S. Anna in Pisa, Italy and is spending a year with **Michael Reid** and **Don Hunter** studying postharvest biology of cut foliage. Antonio will be using molecular approaches to investigate the control of senescence in the leaves of short-lived foliage. In keeping with his country of origin, he started his studies in Davis with a brief investigation of molecular changes during the maturation of olive fruits. He and Dr. Hunter have isolated the genes encoding chalcone synthase (involved in the synthesis of the purple anthocyanin pigments in olives) and expansins (proteins thought to be involved in fruit expansion and softening). We hope our new visitors have an enjoyable and productive time in our department.

Congratulations to **Nathan Lange** on the completion of his Ph.D. dissertation, "Molecular changes during the expansion and senescence of ethylene-insensitive daylily flowers", in December 1999 under the supervision of co-major professors **Mike Reid** and **John Labavitch**. Nathan would also like to thank **Dr. Carolyn Napoli** and **Dr. Rich Jorgensen** for their intellectual support.

The Elvenia J. Slosson Research Endowment for ornamental horticulture has awarded funding for the 2000-2001 cycle to the following faculty and county advisors: **Dave Burger** for "Selection and propagationn of deep-rooted ornamental trees for urban environments"; **Larry Costello, Greg McPherson** and **Ed Perry** for "Strategies to reduce infrastructure damage by tree roots: A symposium for researchers and practitioners"; **Linda Dodge** and **Dave Burger** for "Support for the OHRIC: Extending Slosson-supported programs and providing administrative infrastructure"; **Pam Geisel** and **Dennis Pittenger** for "Horticulture Notes for home, landscape and garden"; **Lynda Goff** and **Brett Hall** for "Selection and display of California flora for the home gardener and landscape designer in the Monterey Bay Region"; **Rose Hayden-Smith** and **Nicolas Sakovich** for "Junior Master Gardener Program"; **Chuck Ingels** and **Judy McClure** for "Fair Oaks Horticultural Center"; **Harry Kaya** for "Molluscicidal nematodes for biological control of pest slugs"; **Antoon Ploeg** and **Steve Tjosvold** for "Bio-fumigation/solarization for the control of nematodes and weeds"; **Mike Reid, Ellen Zagory** and **Wes Hackett** for "Grafting for production of environmentaly tolerant rhododendrons, azaleas and grevilleas"; **Giles Waines** and **Stephen Morgan** for "Ornamental selections of South African origin with educational interpretive displays"; and **Lin Wu** for "Studies of recycled water irrigation and performance of landscape plants under urban landscape conditions". Congratulations to all the recipients. The Slosson Endowment now has a Web site where research reports can be viewed and research proposal applications can be downloaded. The current URL is:

http://slosson.ucdavis.edu

**Dr. Greg McPherson**, Project Leader for the Western Center for Urban Forest Research and Education, received the California ReLeaf Urban Forestry Achievement Award at the Statewide Annual Meeting, Jan. 25, 2000. The award recognizes his outstanding support of grassroots urban forestry efforts at the local, state, and national levels through research and public outreach, and for the spirit and enthusiasm he brings to the cause. California ReLeaf coordinates a network of 65 community-based tree-planting and stewardship groups.

**Glen Forister**, staff research associate and department webmaster, was recognized for 25 years of service to the university. He received a 25-year pin and congratulations from **President Atkinson**. Glen was also recognized by the **Boy Scouts of America**, an organization to which he has devoted many years. He recently received the Silver Beaver Award, bestowed by the BSA National Court of Honor for distinguished local service to the Scouting movement. Glen was recognized for his outstanding service to youth in his community through his activities as a Scoutmaster and leader of his BSA District.

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and are identifying genes expressed during the one day life of this flower by isolating and characterizing the mRNA produced at various time intervals during opening and senescence. They hope to identify one or two genes controlling key steps in the senescence process that could be modified and re-introduced into daylily resulting in flowers with increased longevity. Their findings may be applicable to other monocot flower crops such as the popular, but ephemeral, Dutch iris.

Another area of interest for Dr. Reid's research group is temperature control during shipping and handling of cut flowers. Many California flower growers depend on cross-country shipment of their highly-perishable products and quality at the receiving end is contingent on maintaining temperature close to the freezing point during transport. An application of biotechnology research now makes temperature tracking of all boxes of flowers in a shipment possible and economically feasible. This technology is based on the action of the enzyme lipase, which breaks down triglycerides in a solution into fatty acids. The resulting acidity of the solution and thus the action of the enzyme can be detected by chemicals that change color, in this case from green to yellow. The rate of the enzyme's action is dependent on temperature; the higher the temperature, the faster the breakdown of trigycerides into fatty acids and the faster the solution changes from green to yellow. Virtually any combination of time and temperature is possible, resulting from precisely varying the concentration of enzyme and substrate. Manufactured in the form of inexpensive adhesive strips, these time/temperature indicators can be mixed to change color after one, two or four days above 32ºF. They can be placed in each box of flowers and activated at the start of shipping. When the boxes are opened at their destination, the receiver can judge the condition of the flowers by how many green or yellow dots are seen. This same technology is being used in the food industry and may one day be as commonplace as the expiration date on many perishables.

*Continued from page 6*

lishing TMDLs bring about more lawsuits, and courts are ordering EPA and California to prepare TMDLs on extremely tight schedules. These schedules force regional boards to "just do the numbers" and issue the TMDLs, without preparing implementation plans.

California has no choice but to establish TMDLs for its impaired water bodies. However, there are many unanswered questions about how the state will develop and implement TMDLs. The key unknowns are as follows:

- What is an impaired water body?
- What is the appropriate level of scientific knowledge to establish that a water body is in fact impaired?
- When will TMDLs be prepared? And how long will it take to prepare them?
- What happens during the time between the listing of a water body and the establishment of a TMDL? Can the Regional Boards issue new NPDES permits or permits for expanded facilities?
- Who is responsible for establishing TMDLs: the EPA or the state?
- Should all Regional Boards pursue the same approach to TMDLs? Or should different approaches be employed for different watersheds?
- Will TMDLs include implementation plans? Or will TMDLs be simply the allocations?
- Do TMDLs really cover nonpoint sources?
- When and how will TMDLs be implemented?
- How should the state pay for TMDL implementation?
- What will it cost to develop and implement TMDLs?

Depending on how these issues are resolved, TMDL requirements may prove to be the most important change in environmental law in California since the Endangered Species Act, and the most significant change in water quality control since the Clean Water Act itself.

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