GROWING Points

The Use and Future of Recycled Water in Landscape Irrigation in California

In the face of soaring population growth, pressures to allocate more water to environmental restoration projects, and growing agricultural demand, California will continue to struggle with chronic water shortages in the coming decades. The competition and cost for increasingly limited water resources has encouraged the use of recycled water for landscape irrigation in the urban landscape.

Recycled water is water that has been previously used, suffered a loss in quality and then treated to a point where it is of suitable quality for additional uses. Water recycling is not a new concept.

In California, water recycling was practiced in Golden Gate Park as early as 1889. The first reclamation plant, used solely for recycling and reuse, was built in San Francisco in 1932. Currently, wastewater is recycled at over 300 locations throughout the state for agricultural and landscape irrigation, groundwater recharge, industrial use, and several other lesser-used purposes. Recycled water production in California is expected to double by the year 2000. It is estimated by California WateReuse that by the year 2010, landscape irrigation will account for the second largest use of recycled water (groundwater recharge being the first).

The use of recycled water in landscape irrigation can, however, pose problems. Water always contains measurable quantities of dissolved substances, collectively called salts. The suitability of a water for irrigation purposes will depend on both the amount and the kinds of salts present in the water. Typically, as compared to potable (drinking) water, recycled water in general will have higher total salt levels, and specific ions, especially sodium and chloride, may be present at higher concentrations. Because of this, the use of recycled water can have an adverse affect on plant appearance and health and soil properties. However, through appropriate plant selection, irrigation technology and site management practices the potential impact of using recycled water can be effectively minimized.

Regarding plant selection, however, the effect of recycled water on most ornamental woody plant species is currently unknown. An extensive review of the literature to identify woody ornamental plants tolerant of recycled water uncovered two major concerns regarding our current knowledge.

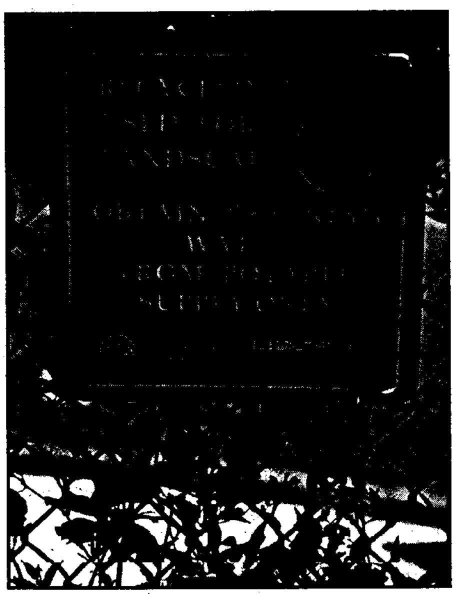


Figure 1. Signage required in landscapes utilizing recycled water in Marin County.

First, only a limited amount of empirical information is available for woody ornamental plant species. Plant lists for tolerance or sensitivity to the salts found in recycled water are composed primarily of agronomic crop species or turfgrasses. Much of the research being conducted to identify ornamental plant species tolerant to elevated salt concentrations has been in response to the large amounts of sodium

New Beginnings

Welcome, (or welcome back) to Growing Points! This newsletter has a new look, an expanded size and most important, a more inclusive approach to issues in environmental horticulture. As forces impinging on the landscape become more urgent and complex, our approaches to sustaining the landscape must integrate the forces of public perception, policy, planning, design, and the science of growing and sustaining plants.

While the 21st century presents horticulturists with increased regulation and limited resources, the demand for our many products and services will be greater than ever. We hope to provide our readers with an integrated, multi-disciplinary perspective in understanding the opportunities and resources available for meeting these challenges.

The format will include in-depth research articles, feature stories, research summaries, reviews of books and web sites, professional profiles, and whatever else we think may be of interest to you. It will be published quarterly, in the summer, fall, winter and spring, and will originate from the Department of Environmental Horticulture, UC Davis.

We welcome contributions from our readers, in the form of suggested topics for future issues that would fit into any of the formats mentioned above.

the Editors

Contents:

What is Recycled Water?

Title 22, state regulations governing recycled water, refer to four levels of recycled water - each with a specific use. Most of the water being produced for landscape irrigation is "disinfected tertiary recycled water." The process for treating this water is very similar to that for treating potable water. Recycled water has been proven to be free from viruses and other pathogenic organisms that could be injurious to humans. By law, it is suitable for all types of use - irrigation of parks, playgrounds, residential landscaping, food crops eaten raw, nonrestricted recreational impoundments (full body contact water sports), fire fighting, car washes, and cooling towers.

Technologies required to treat today's wastewater to a level at which it can then be reused has advanced to the point where we can duplicate, improve and even increase many of nature's cleansing processes. Treatment capabilites range from the basic levels to the highly advanced levels required to reuse wastewater as recycled water. There are a number of terms that are used interchangeably and are thought to have the same meaning. These terms are gray water, reclaimed water, recycled water and repurified water. Only reclaimed and repurified mean the same thing. The following definitions will help clarify these terms.

Gray Water

The untreated wastewater from various acceptable household sources such as showers, bath tubs, bathroom sinks, and washing machines.

Reclaimed Water

Domestic water which, as a result of treatment, is suitable for a range of uses, depending on the level of treatment. Disinfected tertiary is the highest level of treated water appropriate for non-potable use, and is what is used for landscape irrigation in California.

Recycled Water

Same as reclaimed water. A more politically acceptable term for reclaimed water. Through legislation all reference to reclaimed water in documents of the state has been changed to recycled water.

Repurified Water

The result of further treating recycled water with reverse osmosis and blending with a potable raw water source prior to conventional potable water treatment. Repurified water is suitable for drinking.

-Ken Feils, Reclamation Specialist
Marin Municipal Water District

Recycled Water, cont'd.

chloride spread as a de-icer on highways and streets in snow prone parts of the country. The plant list for tolerance or sensitivity to salts generated from this research rarely mentions species more common to the western states, and much of it is observational in nature.

Second, the lack of uniformity in research protocols in more controlled studies makes it difficult to interpret and compare results, even within the same plant species. The parameters used to measure plant response can vary considerably from study to study. This has led to a situation where plants frequently have appeared on conflicting tolerance lists. This lack of uniformity has also made it difficult to derive accurate diagnostic procedures to be used in the field. Of equal importance, these studies often do not distinguish between plant response to salts that are soil applied as opposed to those that are soil and foliage applied. It has been observed in the field that plant tolerance to recycled water seems to differ depending on the method of water application.

Damage to some woody plant materials has been observed following the conversion of new and existing landscapes to recycled irrigation water in California landscapes. It is not yet clear if this damage can be attributed to reduced water quality, poor site cultural conditions and water management, or all of these factors. However, given the rapid rate of landscape conversions, it becomes imperative to separate out the relative influence of these factors. It is important to develop a list of recommended plants for new landscape sites on recycled water. Likewise, it is critical to have an idea of the magnitude of potential problems with specific plant species and a better understanding of management issues when converting existing landscapes to recycled water.

In response to these identified needs, a project, entitled *Recycled Water and Ornamental Plant Compatibility Study* was developed in cooperation with the University of California, Marin Municipal Water District and the City of Sunnyvale Water Pollution Control Plant. This ongoing project has four major objectives:

1. To design and construct regional demonstration gardens where the long-term effects of recycled water on plant health and soil properties could be monitored and assessed. Given the similarity in the experimental design of these gardens, information on plant and soil response can be compared and used statewide. Information is collected on plant health (visual appearance), plant growth (height, caliper, width), concentrations of salts in plant tissue, and a complete range of soil physical and chemical properties. Treatments include potable vs. recycled water combined with overhead spray vs. soil applied irrigation.

2. The development of a procedure for analyzing existing sites (or proposed landscape plans) that will be utilizing recycled water and assessing the potential risk. This involves standardizing the type and quality of information collected, and the organization and subsequent analysis of this information relative to an analysis of the properties of the recycled water.

3. To conduct controlled greenhouse plant screenings that would provide objective and accurate data on the effect of recycled water on ornamental plant health. Treatments applied and data collected are similar to that in the demonstration gardens.

4. The survey of landscape sites that have been on recycled water for at least five years. An analysis is made of all the species on the site, including plant health and growth. This information is then coupled with plant tissue analysis, soils analysis, water quality, and management practices (water, fertility, etc.). In this way a complete picture of plant response is obtained

5. The design of a curriculum and resources for a horticultural training program to be offered to municipal personnel and landscape professionals on the successful use of recycled water in landscape irrigation. Topics include the production of recycled water, regulations and guidelines, site analysis for risk assessment, water management, site maintenance and plant selection.

To date, one 3/4 acre garden has been constructed in Marin County, one is now being designed for Sunnyvale, with a tentative installation date of fall 1996, and another garden is being proposed for the City of San Jose. Analysis of the data collected last year in the Marin garden on 24 woody ornamental plant species shows little difference in plant health or growth between potable and recycled water. The first controlled greenhouse screening of 12 plant species (at three water qualities - low, medium and high salt concentration) was concluded this fall with little impact observed on plant health and growth for the low and medium water quality treatments in soil applied irrigation water. Differences were observed for foliar application, with several species heavily impacted by foliar application of medium and high water quality. Results of these studies will be fully detailed in the fall issue of GP, along with a recommended plant list derived from a comprehensive review of scholarly literature.

A new screening of 20 plant species is now underway with results to be available this winter. To be put on a mailing list for future recycled water research updates and related aspects of this study, please fax, phone, or e-mail your name/address to the Editors.

Pat Lindsey

The Design of Healing Gardens

Since the Middle Ages, healers have acknowledged the therapeutic effect of plants. At the People Plant Symposium held in March, 1994 at UC Davis, researchers, educators and practitioners of various horticultural fields shared information about the kinds of created green environments that appear to be of measurable benefit to people. One such environment is the healing garden.

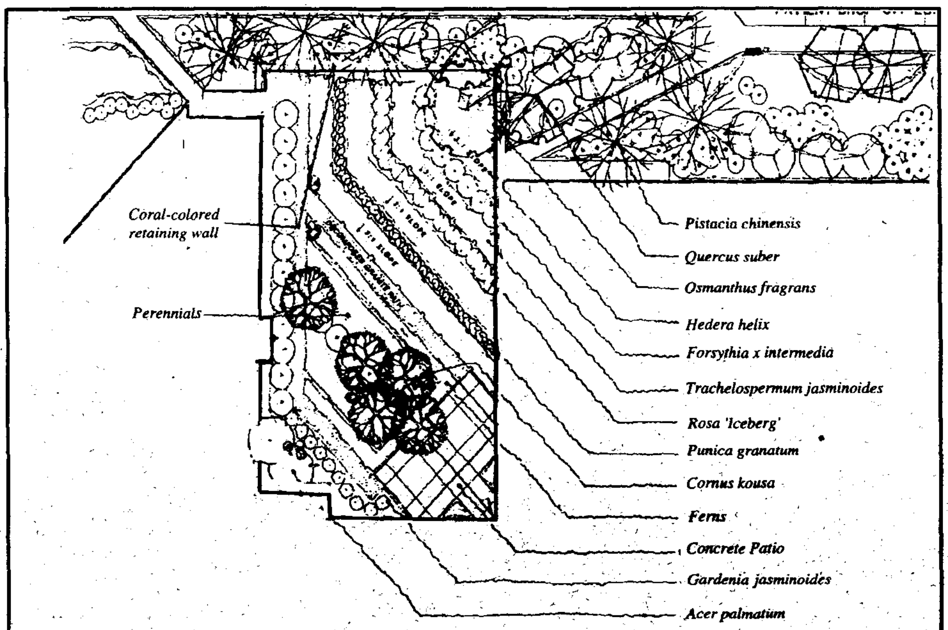


Figure 1. Kaiser Hospital Healing Garden

While well-designed gardens, in general, evoke feelings of aesthetic appreciation and physical and mental relaxation, healing gardens go a step further, in that they purposely incorporate elements of design and material believed to relieve stress, restore hope and promote healing. Modern hospital and health care facilities nationwide are placing increasing importance on the garden as a component of the healing process.

At the symposium, participant Cheryl Ware, a landscape architect working with The Spink Corporation of Sacramento, submitted a detailed plan for designing and implementing a healing garden as part of a new hospital setting. Her interest in the concept stems from her personal experience with illness.

In 1991, shortly after her firm was commissioned to design the grounds for the new Kaiser Permanente Medical Center in Roseville, an illness required that she spend time in a hospital room that offered only a meager view of a park across the street. Feeling trapped and overwhelmed during her recuperation, she became acutely aware of the solace she received from that tiny view of nature, and began thinking about ways that the project waiting on her desk could speak to the needs of people recovering from illness. "As the garden blossomed in my imagination, I became eager to return to work," she explains, "and translate that vision into reality."

The 60,000 square foot Kaiser healing garden (*Figure 1*), is bounded on three sides by the multi-story inpatient wing. A coral-colored concrete wall defines its northern boundary, rising in a geometric pattern from the height of one to two stories, setting the healing garden apart from the surrounding landscape and defining it's character as a place with special purpose.

One distinguishing design characteristic of a healing garden is its accessibility. Many gardens adjacent to facilities intended to serve the public don't provide physical access. At the Kaiser facility, doorways off of main corridors invite entry by patients, visiting family members and hospital staff, for strolling or just sitting. Additionally, wide pathways constructed of smooth concrete within the garden accommodate the walkers and wheelchairs to which patients are often confined.

Through careful design, visual access can be provided for those unable to physically access the garden, without sacrificing the sense of privacy sought by those who are. In the Kaiser garden, Ware has achieved this balance by incorporating a row of sweet olive along the west wall that will reach a mature height of 10 feet, and podocarpus along the south windows of the main wing corridor. Both are intended to accomplish a sense of enclosure without impeding the view from upstairs rooms. Likewise, the widely-spaced dogwood "forest" within the central perennial area is intended to be visually pleasing without obstructing the view from above.

In addition, roombound patients will view a prominent terraced planting of (from bottom to top) dwarf pomegranate (*Punica granatum*), rose (*Rosa 'Iceberg'*), star jasmine (*Trachelospermum jasminoides*), forsythia (*Forsythia intermedia*), ivy (*Hedera helix*), and sweet olive (*Osmanthus fragrans*). A cork oak (*Quercus suber*), set against the northeast wall, crowns the area. From a functional standpoint, the terraced area—divided into geometric "steps"—serves as a transitional structure that accommodates the elevation change inherent in the sloped site. It's visual effect is one of organization and order.

Among landscape professionals, opinions about effectiveness of design pattern vary. An informal configuration is thought by some to be more soothing, but San Francisco landscape designer Topher Delaney supports the idea of some sense of order: "There should be lots of botanical complexity, but it should be ordered, not sloppy. Disease represents disorder, and that's the last thing a patient needs more of."

While the combination of order and botanical complexity employed in the Kaiser design creates visual interest, the symbolic meanings that distinguish healing gardens are accomplished by the incorporation of particular plants.

In Ware's opinion, seasonality—a metaphor for the cyclic nature of life—represents optimism for those in the recuperative process. Plants that exhibit obvious seasonal changes—summer flowering perennials and trees that drop their leaves in autumn, sprouting new ones in spring—are a subtle reminder to patients that their "season of illness" will be followed by one of being well. For Ware, even bloom time suggests meaning; the early-blooming forsythia represents, she feels, a "coming out of the winter of illness," for those in the process of getting well.

Current research supports the time-held belief in the restorative properties of green environments. One such study by behavioral researcher Roger Ulrich, Associate Dean for Research for the College of Architecture at Texas A&M, concluded that patients exposed to naturalistic settings recover faster than do those who are not. Specifically, this and other studies conclude that the sensory stimulation provided by

Healing Gardens, cont'd.

such things as natural views and water sounds promote the healing process.

For this reason, healing garden designers seek to incorporate plants that provide a variety of textures, sights and smells. Utilized by many cultures of the past and present to cure sickness, medicinal herbs such as lavender, sage, germander and rue are placed in the healing garden where their textured leaves can be touched and their pungent aromas smelled by those whose senses may be dulled. Also, the flowers of these and other plants, such as buddleia, attract garden "wildlife"—birds and butterflies—that can be observed from a garden bench or an upstairs window. Ware hopes that, as the Kaiser healing garden evolves, these and other sensory stimulating elements such as fountains and waterfalls that produce the meditative tones of running water will become part of this project.

According to Dr. Craig Green, Physician-in-Chief of the new hospital, development of the healing garden will be an ongoing project that he and Ware hope will involve hospital staff, not only in choosing meaningful plants, but in planting and maintaining them as well. Recently, a dozen staff members, along with Ware and her son, planted 700 daffodil bulbs in the perennial area of the garden. Green fully expects staff, along with patients and family members, to utilize the garden.

While most healing gardens easily accommodate passive uses like strolling and sitting, others are designed for active uses, such as yoga and exercise classes. Horticultural therapy programs, in which patients actively tend plants as part of their recuperative process, are currently operating in about 100 health care facilities nationwide.

Decisions about the Kaiser healing garden's future use will be a group effort, guided by Ware's belief in the efficacy of the healing garden.

Susan Imboden

For Your Information:

People Plant Council, Diane Relf, Director, Dept. of Horticulture 0327, Virginia Tech University, Blacksburg, VA 24061-0327 (540) 231-6254. (free quarterly newsletter)

American Horticultural Therapy Assn., Steven Davis, Executive Director, 362A Christopher Ave., Gaithersburg, MD 20879 (301) 948-3010.

Relf, Diane, ed., *The Role of Horticulture in Human Wellbeing and Social Development*, Portland, Oregon: Timber Press, 1992. (may be ordered from the People Plant Council at address shown above)

Francis, Mark and Patricia Lindsey and Jay Stone Rice, eds., *The Healing Dimensions of People-Plant Relations: Proceedings of a Research Symposium*, Davis, California: Center for Design Research, Department of Environmental Design, University of California, 1994. To obtain the Proceedings , call CDR at (916) 752-6592.

Research Update

Effect of Organic Amendments on Tree Performance

The incorporation of organic amendments on a whole site basis into extremely impoverished substrates can be beneficial to soil development. However, much of the use of organic amendments for tree planting is in planting pits on otherwise uncultivated sites.

In a research project funded by the U.K. Department of Transport, three experiments were established in 1991 on contrasting roadside sites (clay, chalk and silt) to investigate the effect of seven organic soil amendments on soil characteristics and the performance of pit-planted *Quercus robur* transplants. The following amendments were mixed with the backfill: Fisons 'Tree Planting and Mulching Compost', a blend of milled sedge and peat moss with added fertilizer; Hensby Biotech 'Natgro Tree Planting and Mulching Compost', a composted blend of coir fibre, animal manure and straw; Trident 'Arborlyte', a composted blend of coir fibre, straw and vegetable wastes; Goldengrow Ltd 'Goldengrow', composted chicken manure; Walker Organics 'Walker Pure Worm-Cast', worm digested organic matter derived from farmyard manure, straw and sewage sludge; E J Godwin Ltd 'Fruit of the Earth', composted fruit fibre; and Sinclair Horticulture and Leisure Ltd 'Peat Free Tree and Shrub Planting Compost", a blend of composted timber residues, bark and paper pulp with added fertilizer.

All three sites were moderately fertile for the purpose of establishing trees. Only on the clay site did any of the seven organic amendments tested significantly improve tree survival compared to the control: worm-cast, fruit fibre and wood residues. The only positive growth effect relative to the control occurred in the third growing season on the chalk site where the peat based amendment and worm-cast significantly increased third year leading shoot extension compared to all other treatments. Two of the amendments, coir/straw/vegetable waste and chicken manure were detrimental to tree survival on all three sites, a result of their extreme electrical conductivity (an indication of salt concentration) caused by high concentrations of essential elements. On the chalk and clay sites, the use of wood residues resulted in reduced stem diameter increment after three years.

Doubling the application rate of amendments reduced tree survival on the clay and chalk sites, but tended to increase survival and growth on the silt site, although there were still no performance benefits compared to the control. Rooting beyond the pit had occurred within two years on all three sites, including heavy clay. The structural discontinuity of the planting pit wall appears not to have been an impediment to root spread and, on the silt site where growth was rapid, most trees had lost their dependency on the resources of the planting pit by the end of the second year. Doubling the size of the pit had no effect on tree survival but increased growth on the clay site, which was the wettest and most compacted of the three sites.

The value of whole site amendment on infertile and degraded substrates has been demonstrated by a number of researchers. However, with disturbed soils there seems to be increasing evidence that the use of bulky organic amendments in planting pits is often of no more benefit than the structural improvement caused by back-fill removal and replacement. Worm-cast may be an exception on impoverished sites, probably because it is more akin to a soil than an organic amendment. Where soil compaction is severe, root growth outside the planting pit will be restricted and whole site cultivation is needed to provide the rooting volume necessary for tree growth towards maturity. Where site infertility is a problem, the use of inorganic fertilizers or sewage sludge are likely to be the most cost effective methods of supplying essential elements.

(Adapted from: Simon J. Hodge, 1995. The Effect of Seven Organic Amendments on Planting Pit Soil and Tree Performance. Arboricultural Journal. 19(3):245-309.)

An Investigation to Assess the Impact of Street Infrastructure Improvements on the Roots of Adjacent Cork Oak Trees

Cork oaks *(Quercus suber)* are a commonly planted tree species on the University of California Davis campus. Native to the Mediterranean region, they are well adapted to the hot dry summers and mild wet winters in Davis. Used primarily as street trees, their large and rounded evergreen canopies provide a dramatic tunnel effect over many campus roadways.

The streets in the original part of campus enclose a large open greenspace called the Quad, and were planted with cork oaks over 70 years ago. Now mature, these trees ring the outer edge of the Quad, effectively defining and articulating this historic greenspace, which now serves as the heart of campus life. However, over time the aging asphalt roadways have degraded and been frequently patched. In many cases the curbs and gutters are being displaced by the substantial trunks of these mature oaks (many with diameters in excess of 1.2 m (4')). In addition, the existing antiquated storm water removal system is incapable of providing needed drainage for the greenspace and roadways.

In the fall of 1993, a renovation plan for these older roads was prepared by the Architects and Engineering Services at UC Davis. Although the renovation plan was specifically developed for the West Quad Roadway, it was intended that this plan serve as a prototype for the subsequent renovation of the remaining roadways around the Quad and possibly for all campus roadways. There were several objectives of this renovation project: 1) to improve the growing conditions for the trees, 2) to increase the drainage capability of the Quad and the roadway, and 3) to provide a circulation system that more clearly separated pedestrians, bicyclists, and vehicles. To accomplish this, a new storm water removal system was to be constructed underneath the road with lateral drainage collection lines installed to facilitate drainage of the adjacent open greenspace. Because of damage to the curbing from the mature trunks, the total road diameter was also to be reduced an additional 1.2 m (4'). Finally, a new unit block paving detail would be installed on the Quad side of the roadway in order to architecturally define the edge of the Quad and better direct pedestrian traffic.

The protection and continued preservation of these oaks during this renovation project was considered vital to maintaining both the unique character of the Quad and the overall grand stature of the campus urban forest. The UC Davis Grounds Department was given responsibility for the design and implementation of a plan which would minimize harm to the existing trees. To choose the least disruptive plan and address concern over the potential impact that this renovation project might have on these trees the following questions needed to be addressed: 1) where were the tree roots? 2) what percent of the total root system would potentially be impacted by the project? and 3) what would be the probable effect on tree health relative to the percent of tree roots impacted? To answer these questions specific and accurate information on the location of the existing tree roots was needed.

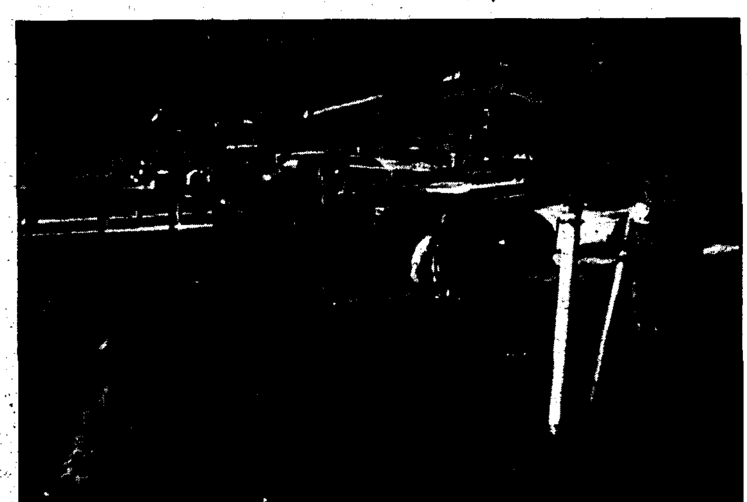


Figure 1. Trenching around trees using hydraulic excavation.

Research on tree root distribution patterns for forest sites and for field production systems has been documented and critically reviewed for applicability to landscape trees. This research is currently reflected in many tree preservation guidelines, such as protecting the area underneath the drip line of the tree canopy or staying 1 foot per inch of trunk diameter out from the trunk of the tree. However, it is not at all clear that these guidelines are especially useful for urban trees. The variety and site specificity of urban factors affecting root growth - soil compaction, the presence of anthropeic materials, stratification, soil infertility, limited soil volumes due to underground infrastructure, impervious paved surfaces and surfaces with a high heat exchange capacity, as well as site management practices such as irrigation, fertilization and pruning make the prediction of root distribution highly problematic. For this project, an investigation was undertaken to physically locate and assess street tree root distribution.

Materials and Methods

Tree Selection. West Quad Road, with a width of 8.5m (28'), is one of four roads encompassing the Quad and has a planting of 26 cork oak street trees and 1 valley oak (*Quercus lobata*), in variable health. Two trees (Tree 1 and Tree 2) were selected for root excavation in March of 1994. Project timing prevented the excavation of all the trees on this site, subsequently the trees selected bracketed extremes in size and health. Percent dieback in the crown, leaf color, annual twig growth, caliper and radial trunk growth were the factors considered in assessing health. The assumption made was that root growth and distribution relative to site conditions could differ depending on tree health.

Trench Layout, Site Preparation, and Excavation. The surface treatment immediately adjacent to these trees consisted of either asphalt or decomposed granite, and further away, turfgrass. Two trenches were placed under the asphalt, two under the decomposed granite and one under the turfgrass. The trenches were positioned parallel to the street curbing, 2.7m (9') and 5.4m (18') from the trunk on the asphalt side and 2.7m (9'), 5.4m (18') and 8.2m (27') from the trunk on the decomposed granite/turfgrass side. In addition, the root crown of each tree would be excavated to a 0.6m (2') depth. It would not be feasible, from either a structural or physiological perspective, to excavate the entire rootzone of any tree, especially a mature one. The assumption being made here is that the roots present in the excavated areas, while representing only a sample of the total root system, accurately reflect the overall trend in root size distribution for the tree relative to surface treatment..

In general, physically locating roots in the field has been accomplished mechanically, carefully excavating the soil by hand or machine- a laborious and time consuming method resulting in less than accurate measurements of fine roots. However, the increasing use and refinement of a relatively non-intrusive technique for examining roots in situ, hydraulic excavation, has shown great promise and was selected for use in this study. Hydraulic excavation involves eroding the soil away from the roots with the application of pressurized water, with the resulting slurry then drained downslope or vacuumed up and deposited for later disposal in a sump truck. When the slurry is removed the roots are fully exposed. Excavation can be quick and damage to tree roots is generally considered to be minimal. The term "hydraulic excavation," first mentioned in scholarly literature in 1955, was used to facilitate the study of root systems of chaparral plants along roadsides. More recent

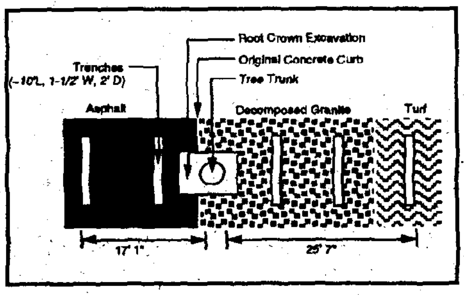


Figure 2. Layout of the trenches around each tree.

applications of this technique include the removal of toxic soil and compacted soil around around tree roots.

On March 21st, the UCD Grounds department removed the two asphalt strips and the curbing in front of each selected tree. Two 1.3cm (1/2") flexible plastic irrigation pipes with mist heads were used to pre-irrigate the areas to be excavated 48 hours prior to excavation. A preliminary study conducted on the campus in the fall of 1994 on the effect of soil moisture content on soil erodibility found that pre-irrigating a silty clay loam to field capacity increased the rate of soil removal by a factor of seven - 0.04 m^3 (1.46 $ft.^3$) of soil eroded per minute for the wetted soil as compared to 0.006 m^3 (0.21 $ft.^3$) of soil eroded per minute for the dry soil.

The five trenches and root collars of each tree were hydraulically excavated on March 23, 1995. For the soil excavation process UCD hydrant water was used, supplied at 4.34 Kg/cm^3 (62 pounds per square inch). Fire hoses obtained from the UCD Fire department that measured 4.4cm (1-3/4") in diameter were used with a KK "Thunder Fog" nozzle with a pistol grip. A Camel brand vacuum trunk removed the resulting slurry. Following excavation, each trench measured approximately 0.30m (1') wide by 3m (10') long, by 0.6m (2') deep. The entire root collar was also excavated to a 0.6m (2') depth.

Collection and Analysis of Root and Soil Data. Root counts and diameter analysis were limited to five categories: fine (0.5-1mm), small (2-5mm), medium (5-10mm), large (10-20mm) and very large (>20mm). Due to the difficulty of separating and accurately counting very fine roots (<0.5mm), these were not included in the final analysis. Following excavation, the fine, small and medium roots were pruned off one wall of the turf trenches and the curbside of the root crown, separated in the lab and measured with an electronic caliper (Mitutoyo Corp., Japan). The large and very large roots were measured directly in the trenches. For the asphalt and decomposed granite trenches, all measurements were taken directly in the field.

Soil samples in each trench were collected along with a sample of the decomposed granite for textural analysis. Bulk density was obtained using a 5.1cm (2") diameter, 10.2cm (4") deep core sampler (AMS, American Falls, Idaho). All soils were dried for 24 hours at 105 C, then weighed or sieved for particle analysis.

Results and Discussion

While the pattern of root size distribution was the same for both trees, overall, Tree 1 had almost twice as many roots as Tree 2, primarily in the fine, small and very large root size classes (only Tree 1 in Figure 2 is shown). The biggest increase was within the root crown area, increasing from 16.5% of the total to 35.1%. This could be due to the declining health of Tree 2.

For both trees, root size distribution varied considerably both by distance from the trunk and by surface treatment. Most of the large and very large root size classes and all of the buttress roots were found in the root crown area. The turfgrass and root crown areas had the highest percentage of fine and small roots. It was also observed (these roots were not actually counted) that the very fine non-woody roots, those less than 0.5 mm, were concentrated in the turf area and at the root collar of both trees. Given that the turf was frequently irrigated, and accounting for rain through fall at the trunk, this would not be unexpected.

The total percent of roots in the asphalt trenches was 13.9% and 14.6%, respectively, for Tree 1 and 2. In the root crown area of each tree it was observed that several large roots angled down sharply underneath the road. These roots did not reappear in either of the asphalt trenches. A visual examination of the utility trench later excavated for the storm water drain, constructed 3.6m (12') from the original curb and running parallel to that curb to a depth of 1.8m (6'), confirmed an almost total lack of root development in that area. Because the soil was a sandy loam, aeration would probably would not have been limiting. Bulk densities also decreased slightly with increasing depth and were not critically limiting (Table 1). Given these factors, it was assumed that the roots were occurring at much greater depths underneath the roadway and that the impact from the installation of the storm drain would be minimal.

Knowledge of the location of tree roots is

Sample Location	Depth	Bulk Density (Mg/M^3)	Soil Texture
Turf	0-4"	1.41	sandy loam
Turf	4-8"	1.42	sandy loam
DG	0-4"	1.93	gravelly sand
DG	4-8"	1.53	loamy sand
Road	0-4"	1.60	loamy sand
Road	4-8"	1.58	loamy sand
Road	8-12"	1.52	loamy sand

Table 1. Soil physical properties, by depth

critical to investigating and assessing the impact of infrastructure improvements prior to construction. Importantly, with this information, effective changes in the project design can be made and additional protective methods speci fied. More research needs to be conducted in order to develop a better understanding of root growth and distribution in urban areas. Clearly the hydraulic excavation of carefully located trenches for the two street trees in this project gave an informed and useful understanding of the existing root distribution. The presence of a substantial number of roots less than 0.5 mm in diameter in the turf trench would confirm also that this procedure, within the water pressure used, also resulted in minimal root damage. More in-situ research needs to be conducted in order to develop a better understanding of root growth and distribution in urban areas.

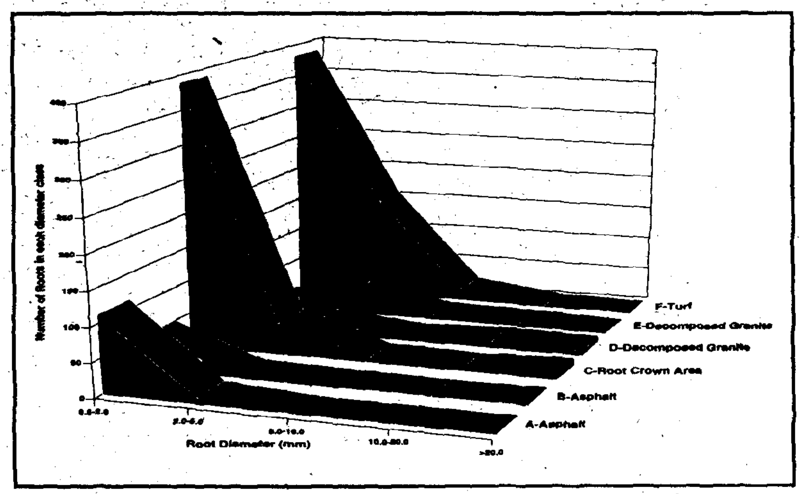
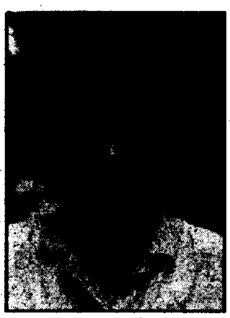


Figure 3. Root size distribution data in the different trenches and for the root crown for Tree 1.

Pat Lindsey

Profiles in Environmental Horticulture

The contemporary human environment includes many interactions with plants, ranging from beautification of the interiorscape to the use of plants in controlling various characteristics of the landscape, such as energy and water consumption. The teaching, research and extension goals of the Department of Environmental Horticulture are to increase the efficiency and sustainability of environmental plant production systems, and to increase our basic understanding of the horticultural and biological processes of plants in the human environment, as shaped by social, economic and environmental needs. In an effort to provide information about specific projects, Growing Points will profile the various faculty members and extension specialists who are working toward meeting the goals of the department.



Alison Berry, Associate Professor Environmental Horticulture

As our natural landscape soils are increasingly disturbed by human activity, methods of successfully revegetating these areas become critical. Replenishment of soil nitrogen, an important element of a sustainable landscape, is a crucial component of those methods. Toward that end, Dr. Berry's research deals with increasing the potential of shrubs and trees as nitrogen-fixing plants in the landscape.

In an ongoing research project in Mesa Verde National Park in Colorado, she is looking at the role of bitterbrush as a nitrogen fixer in the pinyon pine forests. Another study on leguminous cover crop residues in woody systems assesses the effect of nitrogen-fixing alfalfa as a cover crop in almond orchards.

Several other projects contribute to her current research: Under a UC Faculty Research Grant she is working on tissue culture and genetic transformation with *Datisca glomerata* (a California native perennial) root nodules. The results are expected to provide an interesting modeling system to examine questions concerning carbon and nitrogen metabolism using molecular genetic approaches. With funding from a grant through the National Science Foundation she is working with lipids from *Frankia,* a nitrogen-fixing bacteria. This study will reveal important information about gas diffusion regulation.

Another project focuses on the urban landscape. The California Tree Failure Program was implemented in 1988 to accumulate scientific information which could be used to reduce tree hazard in urban forests. Its success has spurred Dr. Berry and others in various forestry fields to create a nationwide database of this type. Currently in the organizational stage, the National Tree Failure Program will provide a Web page that she hopes will enable participants to develop tree safety management practices, on a daily basis.

Dr. Berry received her Ph.D. in botany from the University of Massachusetts and completed a postgraduate fellowship at Carleton University in Canada in 1983. The following year she joined the faculty at UC Davis where she teaches courses in landscape management and tree physiology and development.

To obtain information about participating in the Tree Failure Program, contact her at Dept. of Environmental Horticulture, UC Davis, Davis, CA 95616. Fax : (916)752-1819, E-mail address : amberry@ucdavis.edu.

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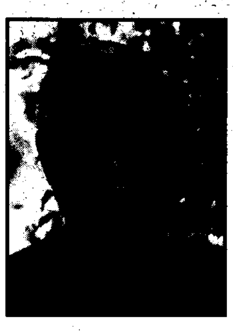

Seymour M. Gold, Professor of Environmental Planning

Dr. Gold's research has encompassed many areas in environmental planning: risk management of public recreation areas, hazard inspection of playgrounds, non-use of neighborhood parks, recreation standards and open space preservation, community development and urban horticulture. He is the author of *Recreation Planning and Design* and *Urban Recreation Planning,* as well as over 250 other publications on these topics.

Each year more than 200,000 children nationwide receive emergency room treatment for playground injuries and about 15 of those accidents are fatal. Dr. Gold's research on hazard management in public parks describes the standard of care used to prevent such accidents in public and private recreation areas. He has served as a consultant to the U.S. Consumer Products Safety Commission, the National Safety Council and many federal, state and local park and recreation agencies.

Currently he teaches classes in *Urban and Regional Planning* and *Recreation Planning* and has taught others on subjects such as urban horticulture, recreation behavior, park and recreation management, and open space preservation and risk management in the past.

Also included in his 35 years of professional experience are: preparation of the nation's first statewide comprehensive outdoor recreation plan (Illinois), drafting the California Playground Safety Law (SB2733), election to American Academy of Leisure Sciences, serving as Regent of the Pacific Risk Management School, and the development of new park, recreation and open space standards now in common use. He has received numerous awards for service in his field, including the Professional Honor Award from the National Recreation and Park Association, for "outstanding contributions to the park and recreation movement in America."

After earning graduate degrees from Michigan State University in park administration and from Wayne State University in urban planning, he went on to complete his Ph.D. in urban and regional planning at the University of Michigan before joining the faculty at UC Davis in 1969.

To obtain guidelines for playground safety inspection, call him at (916) 752-2844, or send fax to (916) 752-1819.

New Publication

Trees & Building Sites

In the urban environment, trees must share vital space with other necessary urban infrastructure such as buildings, roads, sidewalks and utilities. Unfortunately, the biological needs of the tree and the structural requirements of the built environment often conflict, with ensuing damage to either or both of these elements. Adequately protecting existing soils during site development, sustaining newly planted trees on disturbed soils, and avoiding tree-related damage to urban infrastructure requires a multidisciplinary approach.

To address the issue of effectively managing trees in urban sites, the Morton Arboretum held a conference in the spring of 1995, bringing together scientists, practitioners, and an enthusiastic and well informed audience. The intent of the conference and proceedings was to provide a scientific basis for managing trees in proximity to buildings. Comprised of 20 papers, the proceedings cover research and the experience of practitioners in four general areas: tree damage, building and infrastructure damage and tree protection and preservation.

The book is available from the International Society of Arboriculture, P.O. Box GG, Savoy, Illinois 61804. The price is $25 for members, $35 for nonmembers.

World Wide Web Sites

The World Wide Web is a part of the Internet where computer users, through the use of interface software, can access "home pages"--sites where organizations of all kinds place information of interest. Following is information on two such home pages.

Integrated Pest Management Project

The UC Statewide Integrated Pest Management Project's home page (http://www.ipm.ucdavis.edu) currently contains information about the project, a Pest Management Guidelines database and the Pest Notes series of leaflets. Pest Notes provide up to date information regarding pest management in the home, the landscape and the nursery. The twenty-four notes cover a range of pests such as aphids, elm leaf beetle, fleas and white flies in the greenhouse. Additional topics will be added over time. These notes are also available as hard copy from your local University of California Cooperative Extension office.

WateReuse Association of California

The WateReuse Association of California is a non-profit organization whose primary mission is to actively promote water reclamation and recycling as a valuable supplemental source of water for the state. To this end, WateReuse is working for the adoption of legislation and regulations that allow for the safe use of recycled water; to facilitate the development of technology aimed at improving water recycling; to promote legislation that would increase funding available for water recycling projects; and to increase public awareness and understanding of related water problems and solutions.

It's home page (http://www.webcom.com/h2o) contains a database on recycled water use issues, answers to frequently asked questions regarding the use of recycled water, and a listing of current legislation. Keep informed on where California (and even your own community) is heading in the area of water reclamation and recycling.

Contacting The Editors

Anyone wishing to receive Growing Points may be placed on our mailing list by writing to Growing Points, Dept. of Environmental Horticulture, UC Davis, Davis, CA 95616, sending an e-mail to palindsey@ucdavis.edu, or calling 916-752-0130. We also welcome comments and suggestions.

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