GROWING Points

Appropriate Plant Selection for Landscapes Using Recycled Water

Appropriate plant selection is one of the more important strategies to pursue in successfully designing and managing landscapes on recycled irrigation water. Unfortunately, reliable, empirical information on salt tolerance levels for the diverse range of landscape plants grown in urban settings is lacking. In response to the concerns of California water purveyors promoting recycled water, a research program was initiated at UC Davis in an effort to address this critical lack of information.

In conjunction with several water agencies, demonstration gardens have been designed to experimentally evaluate tolerance levels of commonly used landcape plants. In addition, controlled screening trials are being conducted in the greenhouses of the Environmental Horticulture Department. This article will focus on the research results from a demonstration garden in Terra Linda, California.

The experimental design of these demonstration gardens and screenings addresses weaknesses in the scholarly literature on salt tolerance for landscape plants. Methodologies for the scholarly studies are often too specific in both the treatments applied and the subsequent plant and soil responses measured, making it difficult to compare results between studies. In addition, 1) rarely has both soil and foliar tolerance been evaluated for the same plant, 2) the salt concentrations used reflect de-icing applications and

FIGURE 1. The demonstration garden in Terra Linda, CA. Signage denotes species and treatments.

Water Quality Guidelines

Salinity. The greater the concentration of salts in the water, the greater its electrical conductivity (EC_w, reported in decisemens per meter (dS/m). Plant damage can occur both from total salinity and the specific ions in the water. A non-saline water has an $EC_w < 0.7$ and a slightly saline water has an EC_w of 0.7 to 2.0. In terms of the effect of this water on soil permeability, the salinity should also be evaluated with respect to the Sodium Adsorption Ratio.

Sodium Adsorption Ratio (SAR). The sodium adsorption ratio is related to the amount of sodium relative to calcium and magnesium in the water. It is a predictor of the impact the sodium ions will have on soil properties. Values lower than 3 are desirable. Values over 9 can cause problems with sodium toxicity and impair soil permeability. However, a water with high salinity levels can increase permeability and minimize the expected permeability problem predicted solely by any given SAR value. At a given SAR, the infiltration rate increases as salinity increases. So SAR and EC_w should be evaluated together.

Specific Ions and Ion Toxicity. Specific ions in the irrigation water will affect plants due to direct contact with the foliage and/or by their presence in the soil solution and subsequent absorption by plant roots. Specific ion toxicity will vary by the concentration of the ion, the method of water application (overhead spray versus soil applied), and plant species. Generally, the ions of most concern in recycled water are sodium, chloride and boron.

Sodium (Na). The symptoms of sodium injury are a marginal scorch on the edges of older leaves. Indirectly, sodium can create nutritional imbalances and negatively affect soil permeability. Problems are less pronounced with root absorption (soil applied irrigation), with critical levels extending from 3-9 meq/L. With overhead irrigation, sodium can be directly absorbed and accumulate in

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are much higher than those in recycled water, often by a factor of 12 or more, and 3) these studies frequently lack both quantitative and qualitative data, information critical to landscapes where plant quality or appearance can be as important than growth rates.

Terra Linda Recycled Water Demonstration Garden

Over the last three years, an extensive demonstration and research garden was designed and constructed in Marin County (*FIGURE 1*). This garden is a cooperative effort between the University of California and the Marin Municipal Water District (MMWD) and was designed to provide answers to three questions: 1) Is there a reduction in how well a landscape plant grows or how good it looks when using recycled water for irrigation? 2) If there is a plant response when using recycled water, is this response dependent on how the water is applied to the landscape? 3) Are there critical changes in physical and chemical soil properties resulting from the use of recycled water for landscape irrigation?

Installed in the spring of 1994, the garden covers over 3/4 of an acre divided into 32 separate blocks, and is planted with twenty-four different plant species (1,184 plants total). Water treatments being applied are potable water versus MMWD recycled water (*TABLE 1*). Methods of water application are overhead spray (applied to both soil and foliage) versus bubbler/drip (applied to soil only). A range of plant and soil responses were subsequently measured in response to the treatments imposed including visual symptoms (% of foliage showing injury), growth measurements (height, caliper, volume), plant ion analysis, and physical and chemical soils analysis.

Plant Evaluation Procedures. To evaluate tree size, both maximum height and tree caliper were measured. To evaluate the size of shrubs and groundcovers, the maximum plant height and width were measured, as well as the width of the plant at 90 degrees to the maximum width, in order to obtain a measure of plant volume. Plant health during this period was evaluated on the same plants (4 per treatment, per species) selected for growth measurements. A plant health rating scale (0-5) was used in which leaf injury symptoms--chlorosis (yellowing) and necrosis (dieback)--were judged as a percentage of the entire canopy. A rating of 5 would indicate that <5% of the canopy is damaged. For a plant to be of landscape quality, it must be rated 3.5 or higher. In this way, appearance is linked to other quantitative parameters such as growth. All data discussed in the analysis of plant response can be found in *TABLES 2* and *3*.

Analysis of Shrub Garden Data. For all species on both potable and recycled water, volume increased from June 1994 to September 1995. Except for *Baccharis* and *Rhododendron*, the mean increase in volume over this period was higher for recycled water. *Baccharis* and *Rhododendron* were the only shrub species exhibiting higher overall growth on potable water. All of the remaining seven shrub species had a higher increase in volume for recycled water. Due to poor plant quality, *Nandina domestica*

SPECIES	VOLUME (% increase[1])			HEALTH (>3.5=yes)	
SHRUBS	**P**	**R**	**%Diff [2]**	**R**	**RO [3]**
Baccharis pilularis 'Twin Peaks'	91.3%	90.0%	-1.4	Yes	Yes
Buxus microphylla var. japonica 'Green Beauty'	57.6%	77.0%	+25.2	No[4]	Yes
Ceanothus 'Concha'	94.5%	96.2%	+1.8	Yes	Yes
Heteromeles arbutifolia	76.4%	87.8%	+13.0	Yes	Yes
Photinia x fraseri	89.1%	91.5%	+2.6	Yes	Yes
Pittosporum tobira	69.1%	70.2%	+1.3	Yes	Yes
Pyracantha koidzumii 'Santa Cruz'	97.2%	97.9%	+0.7	Yes	Yes
Raphiolepsis indica 'Pink Lady'	75.0%	85.0%	+11.8	Yes	Yes
Rhododendron 'Duc De Rohan'	25.1%	20.0%	-20.3	Yes	No[4]
GROUNDCOVERS	**P**	**R**	**%Diff [2]**	**R**	**RO [3]**
Artostaphylos uva-ursi 'Pt. Reyes'	67.4%	72.7%	+7.3	Yes	Yes
Ceanothus griseus var. horizontalis 'YP'	99.1%	99.5%	+0.4	Yes	Yes
Cotoneaster dammeri 'Coral Beauty'	94.0%	96.2%	+2.3	Yes	Yes
Hypericum 'Hidcote'	90.5%	92.2%	+1.8	Yes	Yes
Juniperus horizontalis 'Wiltonii'	76.9%	86.1%	+10.7	Yes	Yes
Rosmarinus officinalis 'Prostrata'	90.0%	93.0%	+3.2	Yes	Yes

[1]Percent increase is a measurement of volume (height and spread) June 1994 to September 1995.
[2] Percent difference between potable and recycled, with (+) = recycled higher, (-) = potable higher.
[3] Recycled water applied through overhead spray.
[4] Plants on potable water (or potable overhead) were also rated <3.5.

TABLE 2. Increase in growth measurements between potable and recycled water for all shrub and groundcover species. Heatlh ratings as noted.

Water Quality Guidelines, cont.

the wetted leaves causing leaf burn. These symptoms on sensitive species can begin to occur with a sodium concentration of between 3-4 meq/L.

Chloride (Cl). Tolerance to chloride varies among plants due to their ability to restrict chloride accumulation in their above ground tissues. Woody ornamentals are generally more susceptible than turfgrasses because periodic mowing reduces accumulation in the plant. Chloride toxicity is evidenced by leaf burn starting at the leaf tip of older leaves progressing back into the leaf blade. Problems are less pronounced with root absorption, with a critical range extending from 2-10 meq/L. With overhead irrigation chloride, like sodium, can be directly absorbed and accumulate in the wetted leaves causing leaf burn. These symptoms on sensitive species can begin to occur with a chloride concentration of between 3-4 meq/L, with some sources citing 10 meq/L as the sensitivity level for trees and shrubs.

Boron (B). While essential to plant growth, boron is toxic at very low concentrations. Both leaf injury (including yellowing, marginal burning and interior spotting) and growth reduction result from high levels of this salt in the water. In irrigation water, boron should not exceed 1 ppm. There is the possibility that some extremely sensitive species might experience marginal leaf burn at 0.5 ppm. In studies with woody ornamentals it appears that concentrations of up to 1.0 ppm are required before marginal tip burn becomes a problem.

Nitrogen (N). The total nitrogen content (NH_4-N, $N0_3$-N, organic-N) of municipal wastewater usually ranges from 20 to 60 mg/L. Applied at every irrigation event, these levels can have the effect of reducing fertilizer requirements.

HCO_3 (Bicarbonate). In waters containing high bicarbonate, calcium and magnesium can precipitate out increasng the relative proportion of sodium. This can cause a reduction in permeability due to a breakdown in soil structure. There is also a problem if HCO_3 is the principle anion, or if it exceeds 3-4 meq/L. High levels can increase the chances of problems with high soil pH. Bicarbonate can be a problem with overhead sprinkler irrigation at levels exceeding 1.5 meq/L, causing a white deposit of calcium carbonate on the leaves of plants. The adjusted sodium adsorption ratio (adj. SAR) takes into account the concentration of bicarbonate in the water.

pH (Hydrogen ion activity). This represents the degree of acidity or alkalinity of a water. The pH of irrigation water affects the solubility of nutrients in the soil and, if the recycled water has an elevated pH relative to the soil, it can increase the soil alkalinity.

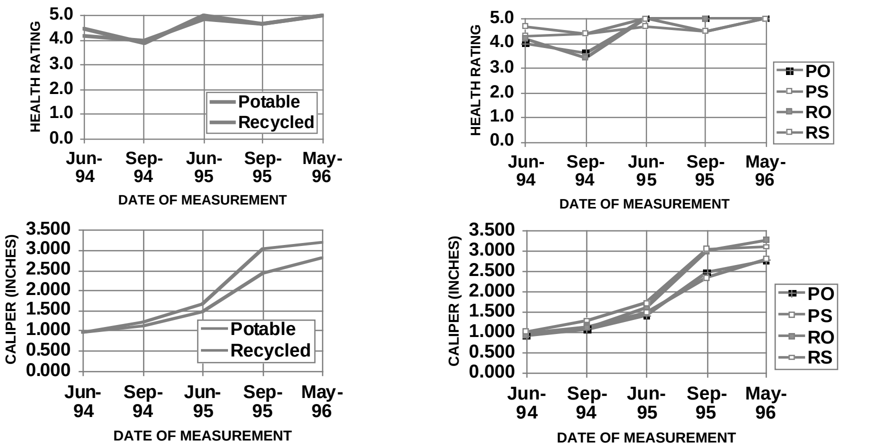

FIGURE 2. Effect of treatment on caliper and health of Platanus x acerifolia 'Bloodgood'. Graphs on the left for each parameter examine overall response between recycled water (R) vs. potable (P). Graphs on the right separate water quality out by method of application, overhead spray (O) or soil applied (S).

between overhead (RO) and soil applied (RS) irrigation water.

The percent increase in height from this period was higher for those plants grown with recycled water, with the exception of *Pyrus*. For the date of May 1996, only *Platanus* had a significant response between recycled and potable water, with the mean height of recycled water being higher (169.0" to 148.9") with no significant difference in response between overhead and soil applied irrigation water.

By May 1996, all tree species on recycled water had a health rating above 3.5. In addition, all species on RO also had a health rating above 3.5. There were no significant differences in health ratings for each species between the two water treatments and among the methods of application. Graphs for *Platanus x acerifolia 'Bloodgood'* are presented in *FIGURE 2.*

SPECIES	**CALIPER** (% increase)[1]			**HEIGHT** (% increase)[1]			**HEALTH** (>3.5=yes)[2]	
TREES	**P**	**R**	**%Diff**[3]	**P**	**R**	**%Diff**[3]	**R**	**RO**[4]
Cedrus deodara	36.1%	45.8%	+21.2	17.6%	24.1%	+27.0	yes	yes
Liquidambar styraciflua 'Palo Alto'	41.0%	44.2%	+7.2	11.1%	11.7%	+5.1	yes	yes
Pistacia chinensis	63.1%	62.9%	-0.3	13.0%	17.0%	+23.5	yes	yes
Platanus x acerifolia 'Bloodgood'	60.3%	68.2%	+11.6	31.1%	38.0%	+18.1	yes	yes
Pyrus calleryana 'Bradford'	42.1%	39.5%	-6.2	33.0%	24.4%	-26.1	yes	yes
Quercus agrifolia	41.3%	46.8%	+11.7	11.2%	15.8%	+29.1	yes	yes
Quercus lobata	49.4%	54.8%	+9.8	19.7%	31.2%	+36.8	yes	yes
Sequoia sempervirens 'Altos Blue'	73.8%	79.9%	+7.6	61.5%	72.0%	+14.6	yes	yes

[1] Percent increase is a measurement of growth (caliper and height) from June 1994 to May 1996.
[2] Health ratings reported here are for May 1996.
[3] Percent difference between potable and recycled, with (+) = recycled higher, (-) = potable higher.
[4] Recycled water applied through overhead spray.

TABLE 3. Increase in growth measurements between potable and recycled water for all tree species. Health ratings as noted.

Health ratings for all 23 plant species on recycled water were equal to or higher than those on potable irrigation water .

Parameter	1993	1995
pH	6.9	7.6
EC (dS/m)	1.6	1.03
SAR	6.59	5.21
adj.SAR	5.89	4.97
Sodium (meq/L)	9.78	6.78
Chloride (meq/L)	9.02	4.97
Calcium (meq/L)	1.72	1.65
Magnesium (meq/L)	2.9	1.94
Bicarbonate (meq/L)	1.36	1.58
Nitrate, Nitrite (mg/L)	23.9	21.1
Boron (mg/L)	0.3	0.3

TABLE 1. MMWD water quality.

was replaced in the spring of 1995 and was not included in this evaluation.

By September 1995, the trend was towards higher health rating for plants on reycled water, although this difference was not significant. In addition, all species at this time were rated above 3.5 for recycled water and for recycled water overhead (RO) except *Buxus* and *Rhododendron*. *Buxus* and *Rhododendron* however, also had health ratings less than 3.5 for potable water and potable overhead (PO) respectively.

Analysis of Groundcover Garden Data. For all species on both potable and recycled water, volume increased from June 1994 to September 1995. The mean increase in volume over this period was higher for recycled water for all species. Overall, there was not a significant difference in volume between potable and recycled by September 1995. Health ratings were equal to or higher than those for potable water in September 1995. On this date, there were no significant differences among species in heath ratings between potable and recycled, and between method of application, except for *Artostaphylos*.

Analysis of Tree Garden Data. For all tree species on both potable and recycled water, caliper and height increased from June 1994 to May 1996. Except for *Pistache* and *Pyrus*, the mean increase in caliper over this period was higher for recycled water. Within each species, for the date of May 1996, there were no significant differences in caliper between potable and recycled water and no significant difference

Landscape Soils Data. There have been some changes, over time, in the chemical properties of the sandy loam soil in the garden relative to water quality. Though salinity values in the recycled water blocks from 1994-96 were approximately twice that of the potable water blocks, all values were below critically limiting levels, <2 dS/m. Likewise, sodium and chloride levels were up to 2-1/2 times higher in the recycled water blocks, yet well below critically limiting levels, <5 meq/L. Other parameters such as pH, adjusted SAR, and B, remained constant across all blocks.

Summary. Though there were growth differences among species relative to overall water quality and application method, these differences were rarely significant. Most importantly, the health ratings for all 23 species on recycled water were equal to or higher than those on potable water on the last survey date. Future issues of GP will address the results of the screening trials. For a review of the research on salt tolerance of ornamental plants, please contact the editors. *Patricia Lindsey*

Planting Trees For Solar Control

Increased Human Comfort and Reduced Energy Consumption

Day after day, the temperatures of this past summer reinforced our devotion to air-conditioned spaces. For those pondering a landscaping project, whether as homeowners or landscape design professionals, the vision of a garden respite canopied by cooling foliage may have inspired plans to include a shade tree or two in the landscape. But how many are aware of the ecological and economic benefits derived from planting trees? Unfortunately, in many cases, trees are selected and located with little consideration of their potential to reduce indoor space conditioning costs.

The benefits of informed tree placement are significant--improved human comfort in structures without mechanical cooling, reduced peak load demand on utilities, reduced dependence on foreign imports, and reduced energy consumption with mechanical cooling systems are derived from shading. Moreover, investment in trees for cooling the urban landscape results in relatively short payback periods and sizeable long term savings. In short, keeping cool with trees is environmentally and economically smart.

Initial findings of a research project conducted by the USDA Western Center for Urban Forest Research and Education document the value of these benefits. According to the *Sacramento Urban Forest Ecosystem Study*, "Sacramento's existing urban forest reduces electrical use by approximately 234 GWh (gigawatts) annually, saving $25 million, or about 18% of the total amount of electricity used for air conditioning." Based on results of detailed computer simulations of solar radiation reduction from tree crowns, and of building energy use, results of this recently completed study estimate that about 40% of the savings is due to direct shade on individual buildings.

How Trees Cool

Trees provide a form of passive cooling by two means. First, their shade reduces the conversion of radiant energy (heat from the sun's rays) to sensible heat (heat that can be felt), thereby lowering the surface temperatures of shaded objects. Second, evapotranspiration (the conversion of liquid to vapor through release of heat) at the leaf surface cools the leaf and adjacent air, thereby reducing heat transfer to interior spaces. The resulting lowered surface temperatures of roofs, windows, and exterior walls, along with cooler ambient air, results in reduced heat gain indoors. Depending on a tree's architecture and its arrangement in the landscape with respect to the location of the sun, as much as 60% to 90% of incident solar radiation (the suns' rays) can be intercepted.

Locating Trees in the Landscape

The design professional or homeowner should first identify the time period when shading is needed. Generally speaking, mechanical cooling for indoor comfort becomes necessary when outdoor temperatures reach 21C/70F. (This is not a hard and fast rule, however, because relative humidity affects human comfort. In drier climates such as those found in Arizona, for example, cooling may not be needed until temperatures reach 24C/75F or higher.) Since many landscapes are limited in the number of trees they can accommodate, it is necessary to determine the time of year and day during which the greatest benefit, both in comfort and energy savings, can be achieved from a given number of trees.

Because the angle of the sun changes throughout the course of the summer, the amount of solar radiation received at a given site will vary. A "design date"--the date during this time when air temperatures are expected to be hottest and peak air conditioning demands greatest--should be determined, along with peak energy use time of day. This information can be obtained from the utility company servicing your area.

Additionally, lagtime, or the time required for interior spaces to become uncomfortable, will affect the time when shading is needed most. In Sacramento, for example, the peak energy date is August 1 and peak energy use time is around 5:30 p.m. Wood construction (common throughout California) creates a lagtime of about one hour. Therefore, shading of windows and exterior walls where solar radiation is greatest should optimally begin at 4:30 p.m. and continue through early evening.

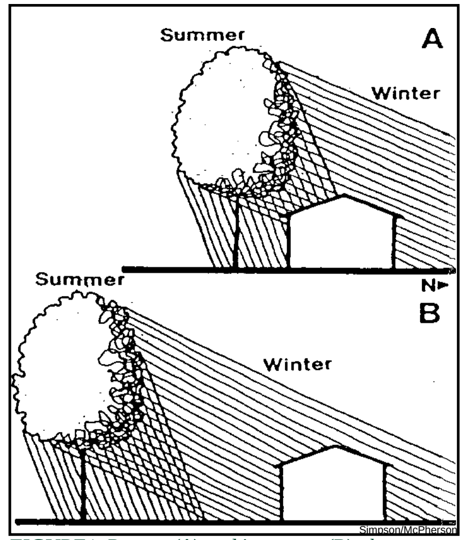

FIGURE1. Proper (A) and improper (B) placement of trees to the south of a home relative to the sun's angle.

Once design date and hour are determined, it is necessary to prioritize structural shading requirements. The greatest heat gain occurs through windows, then roofs and exterior walls. Those facing west receive the greatest amount of solar radiation during summer, followed by east-facing, then south-facing surfaces. In addition, the relative need for cooling in different living spaces must be considered. Infrequently used rooms, such as bathrooms and utility rooms, have a lower cooling requirement than do kitchens and living rooms. Therefore, frequently used rooms situated in high heat gain areas have the greatest need for cooling. Granted, use of interior spaces fluctuates over time, as does air temperature. But a determination of design date and time, along with knowing where cooling needs are greatest gives the designer or homeowner the best possible information for locating trees for cooling.

In addition to the above considerations, thought should be given to placing trees at the correct distance from the structure (See *FIGURE 1*). According to Jim Simpson and Greg McPherson of the Western Center for Urban Forestry: "The closer a tree is located to a structure, the sooner energy savings will be realized. Trees located to the south should be relatively close to the structure and pruned high enough to allow maximum insolation (exposure to the sun's rays) during the underheated period. Trees located to shade east and west elevations will provide more daily shade for a longer period if they are closer to the wall." They explain the correlation between distance and shading effect in this way: "A tree 25 feet high and 15 feet wide planted 10 feet from the west wall shades 47% of the exposed surface between the hours of 3 p.m. and 7 p.m. An identical tree placed 20 feet from the wall shades only 27% of the wall during these hours." In cases where available planting space is less than 10 feet, trees with upright forms, such as pyramidal hornbeam (*Carpinius betulus fastigiata*) can be substituted for those with wider canopies. It is also advisable to shade air conditioning units, if possible, without restricting airflow to the unit.

Selecting the Best Species

In addition to the traditional criteria used by homeowners and design professionals when selecting trees for the landscape, the following specific tree characteristics should be considered: canopy density, foliation period, height-to-canopy bottom, size and form, growth rate, and life span. Each is an essential factor in achieving maximum structural cooling.

Canopy Density. One of the most important characteristics to consider is canopy density--the compactness of the cover formed by the upper branches of a tree. For purposes of data comparison, canopy density is expressed as the shading factor, as shown in *TABLE 1*. The shading factor simply indicates the shading effectiveness of a tree by virtue of how much solar radiation its canopy blocks in both summer and winter. By consulting the table, a comparison can be made among various species. As an example, European hackberry (90%, summer) blocks more solar radiation in summer than does sweetgum (82%, summer). Therefore, the hackberry would be a better choice for cooling in summer. But bare-branch canopy density is also important in terms of the desirability of winter solar access. The hackberry, with a winter shading factor of 47%, would allow some penetration, but not as much as would the sweetgum, whose winter shading factor is 27%. So a decision must be made as to when it is most important to control solar effect for a given location. It should be noted that canopy density factors are derived from trees which have not been pruned to markedly alter their natural growth patterns. Obviously, such trees would have different shading factors.

Foliation Period. Foliation period (See *TABLE 1*) is equally important in determining a tree's effectiveness for solar control The best situation is one in which the tree's leaf season can be closely matched with the overheated period for the region in question. The overheated period for Los Angeles, for example, spans from June 15 to November 15. So the foliation period of English oak (May into December) would make it a suitable choice for that area. From the data contained in *TABLE 1*, similar matches for optimal solar control can be made. As with canopy density measurements, variables come into play. Microclimatic changes, such as the onslaught of cold winds, as well as variations in watering and fertilizing will affect the foliation period.

Height-To-Canopy Bottom. The issue to be addressed with regard to height-to-canopy bottom is one of making sure that the selected tree will not block solar access during winter months. At maturity, trees such as littleleaf linden begin to branch much lower than do species such as the American elm, preventing solar access to exterior walls. It follows that the elm would be a better choice with respect to allowing solar access, particularly if planting will be on the south side of the structure. Of course, pruning can be done to open the lower canopy. But it is easy to select trees with the appropriate mature height-to-canopy bottom with advice from a knowledgeable nursery person.

Size And Form. Just as adequate height-to-canopy bottom allows for maximum solar access, ample size and form at maturity allow for the greatest solar blocking--the larger and fuller the tree, the larger the shadow cast. Assuming good placement with respect to the sun, maximum cooling results.

Growth Rate. But what about growth rate? While faster seems better, it may be less

	Shading Factors (% blockage)		Foliation Periods	
Botanical and Common Name	**Summer**	**Winter**	**Foliation**	**Defoliation**
Albizzia julibrissin Silk Tree	83	32	A	A
Betula pendula European Birch	83	38	A	A
Catalpa speciosa Western Catalpa	76	32	L	A
Celtis australis European Hackberry	90	47	E	A
Fraxinus holotricha 'Moraine' Moraine Ash	78	50	E	A
Ginkgo biloba Maidenhair Tree	81	37	E	A
Gleditsia traicanthos inermis Honey Locust	57	33	E	E
Juglans nigra Black Walnut	90	37	L	E
Koelreuteria bipinnata Chinese Flame Tree	90	30	E	L
Liquidamber styraciflua Sweetgum	82	27	A	A
Liriodendron tulipifera Tulip Tree	90	27	A	A
Parkinsonia aculeata Jerusalem Thorn	85	73	A	L
Pistachia chinensis Chinese Pistache	85	62	E	A
Platanus acerifolia London Plane Tree	84	55	A	A
Platanus racemosa California Sycamore	90	48	E	L
Populus deltoides Cottonwood	85	32	E	A
Quercus robur English Oak	81	17	L	L
Sapium sebiferium Chinese Tallow Tree	83	37	E	A
Sophora japonica Japanese Pagoda Tree	78	65	A	E
Tilia cordata Littleleaf Linden	88	41	A	E

Foliation: E=March 1-31, A=After April 1, L=After April 15
Defoliation: E=Sept.-Oct. 31, A=Nov. 1-30, L=After Dec. 1

TABLE 1. Shading factors and foliation periods for trees commonly found in the landscape.

desirable for several reasons. Rapid growers make for a shorter payback period, but tend to produce weak wood and invasive roots--hazards to both people and structures. Utilizing large transplants of moderate growers, on the other hand, can result in immediate solar blocking, while mitigating these hazards. But large transplants are costly. The best solution might be to intersperse long-lived, but slow-growing transplants with some fast growers that could be thinned as the slower-growing specimens fill in. Reduced cost, more immediate shading, and a shorter payback period would result. Since slow-growers tend to have greater life spans, trees planted to shade permanent structures (with an estimated life span of 50 years) would be the smartest investment.

Again, increasing demands on energy sources and the increasing cost of those sources call for landscape design informed not only by an aesthetic sensibility, but an ecological one as well. Toward that end, the purposeful arrangement of trees in the landscape is a necessary consideration.

Susan Imboden

For Your Information:

E. Gregory McPherson, Ed., *Energy-Conserving Site Design*, Washington, D.C.: American Society of Landscape Architects, 1984. (For information or reprints of articles, contact Dr. McPherson at: 916-752-5897.)
Moffat, A.S., Schiler, M., and the Staff of Green Living, *Energy-Efficient and Environmental Landscaping*, Vermont: Appropriate Solutions Press, 1993.
Simpson, J.R. and McPherson, E.G., (1996) *Potential of Tree Shade for Reducing Residential Energy Use in California*, Journal of Arboriculture 22(1): 10-18.

Research Update

Nursery Production Methods for Improving Tree Roots

Arborists continue to cite poor root sytems as a major reason for tree decline and death. New alternative nursery production methods are continuing to improve the root systems of trees by reducing root kill during production, encouraging the production of more fibrous root systems, reducing root circling, and better acclimating roots prior to transplanting to urban conditions. Whenever possiblelandscape professionals should supply information about these new production alternatives to those who are writing tree planting specifications, and those who are actually purchasing trees for transplanting in order to obtain the best trees and tree roots available.

One new in-ground container, the Geocell, is made from Biobarrier, a product composed of Typar geotextile and Treflan herbicide (Reemay Inc., Old Hickory, TN), known for its use in redirecting tree roots to prevent pavement buckling. While this new in-ground fabric container still allows for the lateral exchange of water between the native soil in and surrounding the container, it differs from previous in-ground fabric containers in that the herbicide keeps the roots from growing through the fabric into the surrounding soil. No root loss should occur at harvest with the use of this container, whereas up to 20% of roots may be lost using the previous in-ground fabric containers. Unlike other in-ground fabric containers, the Geocell is not used for root ball protection and tree shipping and marketing.

Until now, no in-ground production systems have been commercially available to facilitate growing multiple plants in the same production unit. Such a unit, the CELLUGRO System, has been developed at a nursery in Maryland to reduce labor, production space, and water, herbicide and fertilizer use. In addition, the unit provides winter cold and summer heat protection (primarily to the root system), helping to extend the growing season and accelerate growth. Blow-over problems that occur with container production are prevented, harvesting is easy, and post-harvest use possibilities are increased.

The CELLUGRO System unit is installed in the ground in an 8 ft. x 20 ft. area. Each unit has 561 approximately one gallon size cells, in which trees and other plants can be grown. Appleton's unit has been in the ground and planted at Hampton Roads Agricultural Research and Extension Center in Virginia Beach, VA for 6 months. Despite record setting heat during this period of time (summer, 1995), the unit has been watered only four times with less than 5 in. of water, as compared to equivalent-sized pots containing the same plants on a conventional container bed that are irrigated daily with approximately 0.5 in. of water per irrigation. Several of the species in the CELLUGRO System are now taller and/or fuller than the equivalent plants in conventional containers.

According to Atherton, preliminary results of testing support the above claims. She advises that, with careful planning of species positioning, more than one species can be grown in the unit together if the growth rate and harvest time of each is considered. For some ornamental grasses and perennials multiple crops can be harvested within one growing season.

Two above-ground production alternatives have been modified. A relatively new container, the EFC (Environmentally Friendly Container), has drain holes that are approximately 2.25 in. up on the side wall above the bottom of the container. This is different from standard containers that have drain holes in the bottom. The intent of the higher drain holes is to maintain a water reservoir in the bottom of the containers to improve water use, and possibly also to help acclimated plants that might be transplanted into wetland or poorly drained soil sites. Added advantages that were seen when these containers were tested were accelerated growth, reduced drought stress, reduced nutrient leaching, and root pruning that reduced root circling.

A new double plastic pot system designed for above-ground use is the AGS (Above Ground System). A major problem of producing plants in single plastic pots above ground is thermal heat loading. Temperatures that are lethal to roots (above 40C, 104F) can develop within the medium in the containers due to the sun hitting the containers. The AGS helps to prevent thermal heat loading due to the buffering air space between the two containers, thereby reducing root kill. During the winter, temperature buffering occurs that can reduce the need for more costly over-wintering measures and increase root survivability. Also, the AGS helps to reduce container blowover, especially of large trees. It has been tested in winds of up to 55 mph without blowing over, thereby reducing labor, plant damage, and keeping fertilizers and herbicides that might be top dressed from spilling out of the container. For more information contact Appleton at: (804) 363-3950.

(Adapted from: Bonnie Lee Appleton, 1995. Nursery Production Methods for Improving Tree Roots - An Update. Journal of Arboriculture. 21(6):265-270.)

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.

Greg McPherson, Research Forester and Project Leader

USDA Western Center for Urban Forest Research and Education, Pacific Southwest Research Station

As we face a multitude of environmental issues within our growing urban areas, it is important to understand the function and value of vegetation in the urban landscape. Toward this end, the USDA Western Center for Urban Forest Research and Education conducts research that looks at the interactions between urban-related lands uses and the structure and function of forest and woodland ecosystems.

Through his research as project leader with the Center, Dr. McPherson is attempting to better understand the effects of various management actions on the benefits and costs of the urban forest. By attributing a monetary value to benefits (improved visual quality, energy savings, removal of atmospheric carbon dioxide, creation of wildlife habitat and personal safety), the tradeoff with costs (root damage to sidewalks, water use, production of green waste, pesticide and herbicide use, and emission of biogenic hydrocarbons that can contribute to ozone formation) can be measured. This information assists landscape architects and their clients in making design decisions that are cost-effective in the long term. The end goal, he says, is to find ways to create healthier and more productive urban forest ecosystems.

In addition to conducting research, Dr. McPherson teaches an introductory course to a new major being offered by the department—*Environmental Horticulture and Urban Forestry*. The Urban Forestry specialization within this undergraduate major is geared for students interested in learning about the management of populations of trees and shrubs in urban and suburban environments.

In 1987, after earning his Master of Landscape Architecture from Utah State University, he completed his PhD. studies in Forestry at the College of Environmental Science and Forestry, SUNY-Syracuse, New York. He joined the faculty of the Department of Environmental Horticulture as Research Associate in 1994. For information about the Western Center for Urban Forestry or the EH&UF class, or to receive a free newsletter, contact him as follows:

Telephone: (916) 752-5897 or (916) 752-7636.
FAX: (916) 752-6634.
Email: egmcpherson@ucdavis.edu

Heiner Lieth, Associate Professor of Environmental Horticulture, Cooperative Extension Specialist

Many ornamental greenhouse crops, such as roses, petunias, chrysanthemums, bedding plants, pointsettia, and Easter lilies, are grown here in departmental greenhouses as part of projects designed to study and develop horticultural practices.

One area of study aims at the development and use of new technological tools for greenhouse production. Toward this end, Dr. Lieth is working to develop mathematical models which express relationships between growth environment and productivity— a pursuit that he says "will eventually result in greenhouse environmental control software that will automatically optimize greenhouse environments for production."

Coordinating the production of ornamentals with peak sales periods requires careful control of growth and bloom time. In one project, he is developing models for precise production of Easter lilies. Guidelines provided by his model for determining correct greenhouse temperature will assist growers in achieving the desired flowering date.

Many growers now use a bud meter to produce flowering lilies in time for the Easter holiday. This simple device can be used to track the elongation of flower buds and identify the temperatures which will result in flowering on particular dates. The most recent version of the bud meter, along with directions for its use, can be obtained by contacting Dr. Lieth or by downloading it from his WEB site: http://envhort.ucdavis.edu/jhl/lieth.htm.

He is also conducting studies to determine optimal irrigation practices in greenhouse and nursery production, with the goal of helping growers increase the production level of various ornamental species.

After earning his graduate degree in Applied Mathematics from North Carolina State University, he received a PhD. in Biomathematics, also from NCSU. Since joining the departmental faculty in 1984, he has taught courses in greenhouse and nursery production and math modeling of horticultural systems.

To obtain information about any of the above projects, contact him as follows:

Telephone (916) 752-7198
FAX: (916) 752-1819
Email: jhlieth@ucdavis.edu.

Departmental Notes

On November 19, 1996, Dept. of Environmental Horticulture faculty and staff hosted the first meeting of the Environmental Horticulture Advisory Council (EHAC). In an effort to develop a vision for the department's research, teaching and outreach missions, EHAC was formed to identify the needs of the horticulture industry by providing a forum for exchange of information between industry and the university.

Representatives from the fields of floriculture/nursery, landscape/turf, and urban forestry studies, as well as affiliates of statewide professional organizations and government agencies gathered here for an overview of the Department, the College of Agriculture and Environmental Sciences and the University. In addition, faculty members presented an overview of teaching and outreach programs, including information about graduate and undergraduate programs offered by the Department and Cooperative Extension activities. A tour of departmental facilities, lunch, and open discussion concluded the meeting.

Plans are currently being made for the next meeting, to be held this Spring. Anyone interested in being considered for appointment to the Environmental Horticulture Advisory Council may contact Dave Burger, Dept. Chair, at 916 752-0398. (Email: dwburger@ucdavis.edu)

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.

Dept. of Environmental Horticulture

The Department of Environmental Horticulture , a department in the College of Agricultural and Environmental Sciences here at UC Davis, offers various academic programs which include studies in the fields of ornamental horticulture, landscape horticulture, floriculture, nursery management, urban forestry and plant biotechnology.

Information about faculty and staff, course requirements (undergraduate major and minor, graduate, and postdoctoral scholar programs), and career options for these programs, as well as on-line publications, news, and links to other sites are available on the home page: http://envhort.ucdavis.edu.

SelecTree

This is an interactive program taken from TreeFinder, a database composed by PG&E. It is designed to match specific tree species to particular sites based on compatible characteristics. Presently, it searches a database of 1,156 trees.

By selecting a general characterisitic, such as foliage type, you can access a list of trees meeting that criterion. From that list you can select the ones for which you want to know other information, such as recommended climate zone, soil and water conditions, fruiting habit, flower and foliage color. Some other criteria on the list are known health hazard, deer palatability, and root damage potential, to name a few. At present, 47 selection criteria are provided and each of these can be used as a starting point in your search. Access this site at:
http://urbanfor.cagr.calpoly.edu.

Subscription Information

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 95688. Email: growing@ucdavis.edu. Telephone: (916) 752-0130.

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