WINTER 1997 VOLUME 3.1

COOPERATIVE EXTENSION • DEPARTMENT OF BOTANY AND PLANT SCIENCES • UNIVERSITY OF CALIFORNIA, RIVERSIDE

CO-HORT

A NEWSLETTER FOR TURFGRASS, LANDSCAPE, AND NURSERY ISSUES.

NURSERY NARRATIVES

by Ursula K. Schuch

Summaries of Research Papers Presented at the Ninth Annual Conference of the Western Plant Growth Regulator Society in Santa Barbara, California, January 22-23, 1997

Growth Responses of 24 Cultivars of New Guinea Impatiens to Paclobutrazol

U.K. Schuch, J.N. Kabashima, and C. Adams

The objective of this study was to determine the effects of paclobutrazol on vegetative and reproductive growth of 24 cultivars of New Guinea Impatiens (*Impatiens* sp. hybrid). Seven cultivars from the Pure Beauty Series (Aglia, Anaea, Dark Delias, Kallima, Marpesia, Melissa, and Prepona), and 17 cultivars from the Paradise Series (Anguilla, Antigua, Aruba, Bonaire, Bora-Bora, Grenada, Guadeloupe, Lanai, Martinique, Moorea, Pago Pago, Papete, Samoa, Tahiti, Tanna, Timor, and Tonga) were used in this experiment. Rooted plugs that were transplanted into 4-inch pots were treated with foliar sprays of paclobutrazol at concentrations of 0, 2.5, 5, 10, or 15 ppm on July 6, 1995, and on February 26, 1996. Plant height, canopy width, number of lateral shoots, number of flowers at anthesis and flower buds, flower diameter, and shoot dry weight were determined when all plants had started to flower. Time to flowering was determined as the number of days after transplanting when the first three flowers were fully open.

Cultivars responded differently to paclobutrazol concentrations and responses were different each year. Plant height, width, canopy volume, or all three variables were reduced with increasing concentrations of paclobutrazol except for two cultivars in 1995, and six cultivars in 1996. Leaf, stem, or total shoot dry weight were reduced for all cultivars except one in 1995 and four in 1996. Untreated plants grew 2-6 cm taller in 1996 compared to 1995 and less control of stem elongation occurred with increasing concentrations of paclobutrazol in 1996. Plants flowered on average 71 days after transplanting in 1996, but took only 49 days in 1995. Flowering was delayed no more than 5 days for some cultivars treated with paclobutrazol, while others showed no delay.

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Two cultivars flowered 10 days later, and three flowered earlier than untreated plants in 1995. Flowering in 1996 was delayed for five cultivars up to 5 days. Flower diameter averaged 5.6 cm for all plants in both years. Paclobutrazol reduced flower diameter up to 0.6 cm in 1995 for 11 cultivars and up to 0.4 cm in 1996 for 4 cultivars.

In 1995, paclobutrazol at 2.5 or 5.0 ppm provided sufficient height reduction for most cultivars, while some did not require any growth regulator. Higher concentrations resulted in severe reduction of stem elongation for most cultivars in 1995, and would not be desirable from a grower's point of view. In 1996, concentrations up to 15 ppm paclobutrazol provided modest growth regulation and in no case retarded growth as much as the highest concentration used in 1995. Cultivars did not fall into distinct groups in terms of their response to paclobutrazol with respect to canopy size, stem dry weight, days to flowering, or bud and flower number.

Paclobutrazol Performance on Geraniums

David J. Barcel
Uniroyal Chemical Co., Salinas, California

Rooted plugs of seed geraniums, *Pelargonium x hortorum* 'Mavrick Red' were treated with foliar sprays of paclobutrazol at 0, 4, 8, or 12 ppm or drench applications of paclobutrazol at 0, 0.25, 0.5, 1, 2, or 5 ppm. Foliar sprays of chlormequat chloride at 750 or 1500 ppm were utilized for comparison as a standard treatment used in the bedding-plant industry. Zonal type (cutting) geraniums, 'Americana Red', 'Americana Coral', and 'Eclipse Salmon Orange' were treated with foliar sprays of paclobutrazol at 0, 2, 4, or 8 ppm. Growth responses of seed geraniums were evaluated 2, 4, 7, and 9 weeks after treatments, vegetative growth of zonal geraniums was evaluated 1, 4, and 7 weeks after treatments.

Height of seed geraniums treated with paclobutrazol was reduced within one week after treatment, and increasing rates resulted in proportional growth reduction (Table 1). Drench applications with 1, 2, or 5 ppm paclobutrazol reduced height significantly, while the 0.25 or 0.5 ppm treatments resulted in the most desirable growth response. Foliar spray with 12 ppm paclobutrazol or spray applications with 750 or 1500 ppm chlormequat produced desirable, well-proportioned plants (Table 1).

All cultivars of zonal geraniums responded similar to paclobutrazol. The best treatment was a spray application at 8 ppm which resulted in 27% height reduction (4.3 inches) compared to the control plants (6.0 inches) 51 days after treatment.

Table 1. Plant height of seed geranium 'Maverick Red' treated with different growth regulators.

Treatment	Rate (ppm)	Application	Height (inches) 29 DAT*	Height (inches) 70 DAT	Height reduction (%) 70 DAT
Paclobutrazol	4	spray	3.4 b**	9.5 b	17
Paclobutrazol	8	spray	2.5 c	8.0 c	31
Paclobutrazol	12	spray	2.6 c	6.4 def	45
Paclobutrazol	0.25	drench	2.4 c	5.9 ef	48
Paclobutrazol	0.5	drench	2.3 c	5.4 f	53
Paclobutrazol	1	drench	1.7 d	3.5 g	70
Paclobutrazol	2	drench	1.5 de	2.7 gh	77
Paclobutrazol	5	drench	1.1 e	2.5 h	79
Chlormequat	750	spray	2.4 c	7.2 cd	38
Chlormequat	1500	spray	2.5 c	6.5 de	43
Control			4.0 a	11.5 a	0

*DAT = Days after treatment.
** Means within a column followed by different letters are sign. different at $P < 0.05$, Duncan's MRT.

Paclobutrazol Performance on Flowering Kale

David J. Barcel
Uniroyal Chemical Co., Salinas, California

Three tests were conducted to evaluate the efficacy of paclobutrazol on flowering kale. The first test was conducted in winter 1995 on plants growing in 6-inch pots. Nine-week old seedlings of kale, *Brassica oleracea* 'Red Chidori', 'Red Pigeon', 'Red Peacock', 'White Chidori', 'White Pigeon', and 'White Peacock' were treated with drenches 0, 10, 20, or 30 ppm paclobutrazol. Height and color response were measured six weeks after treatments. In the second test the following kale varieties were used: 'White Pigeon', 'Red Pigeon', 'White Kamome', and 'Red Chidori' in 6-inch pots, and 'White Kamome', 'Red Chidori' 'Pink Beauty', 'White Peacock', and 'Red Peacock' in 4-inch pots. Drench applications of 0, 10, 20, 30, or 40 ppm paclobutrazol were applied to seven-week-old kale seedlings.

Height was reduced by approximately 42% with rates of 20 ppm in winter and 10 ppm in the spring trial. Rates greater than those resulted in excessive height reduction and undesirable, stunted plants. Color response was similar for both trials, that is, both the red and white varieties treated with paclobutrazol produced darker, more intense color than control plants. Of interest was the white types producing a very white center, almost a 'snowball' effect.

In the third test mature kale was treated with paclobutrazol or ethephon to determine color and growth responses. Six-inch 'Red Pigeon' and 9-inch 'White Feather' kale plants were treated with paclobutrazol at 20 ppm as drench or at 200 ppm foliar spray, or with ethephon at 125 or 250 ppm sprays once, or a repeat spray applied 13 days later. Height growth of plants treated with 20 ppm paclobutrazol was reduced 23-35% compared to the control 37 days after treatment. 'White Feather' plants were not affected by any other treatments. Height growth of 'Red Pigeon' plants was reduced 13-15% with 200 ppm paclobutrazol spray, or one or two applications of 125 ppm ethephon. Paclobutrazol-treated plants had darker, more intense colors than control plants. Ethephon had no effect on color of any of the cultivars.

FLOODING FACTS

Ursula K. Schuch

Recent floods in Northern California may impact performance and survival of landscape plants in the coming year, because most woody plants are poorly adapted to cope with flooded soils. The good news is that flooding occurred during the dormant season which is usually much less harmful to trees than flooding during the growing season. Following is a brief review of how flooding affects soil and plant growth.

Tree species with a great tolerance to flooding are most likely established in riparian areas that are frequently subject to flooding. Unless physically damaged by floating debris, these trees should not suffer any consequences from several days of flooding, but should resume normal growth in spring. Following is a list of flood tolerant woody plants in the contiguous United States that withstood 180 or more days of water covering the soil under trees (Whitlow and Harris, 1979).

Botanical Name	Common Name
Acer negundo	Box Elder
Acer rubrum	Red Maple
Acer saccharinum	Silver Maple
Carya aquatica	Water Hickory
Carya illinoensis	Pecan
Carya ovata	Shagbark Hickory
Cephalanthus occidentalis	Buttonbush
Cornus stolonifera	Red-osier Dogwood
Crataegus mollis	Red Hawthorn
Diospyros virginiana	Persimmon
Eucalyptus camaldulensis	Red Gum

continues on page 4 . . .

Botanical Name	Common Name
Forestiera acuminata	Swamp Privet
Fraxinus pennsylvanica	Green Ash
Gleditsia aquatica	Water Locust
Gleditsia triacanthos	Honey Locust
Ilex decidua	Deciduous Holly
Liquidambar styraciflua	Liquidambar
Nyssa aquatica	Water Tupelo
Planera aquatica	Water Elm
Platanus X acerifolia	London Plane
Platanus occidentalis	Sycamore
Populus deltoides	Eastern Cottonwood
Quercus bicolor	Swamp White Oak
Quercus lyrata	Overcup Oak
Quercus macrocarpa	Bur Oak
Quercus nuttallii	Nuttall's Oak
Quercus palustris	Pin Oak
Salix spp.	Willow
Salix alba var. *tristis*	Golden Weeping Willow
Salix exigua	Narrow-leaf Willow
Salix hookeriana	Hooker Willow
Salix lasiandra	Pacific Willow
Salix nigra	Black Willow
Taxodium distichum	Bald Cypress
Ulmus americana	American Elm
Washingtonia robusta	Mexican Fan Palm

What happens in the soil during flooding?

Flooding depletes soil oxygen rapidly, whereas this process is much more gradual during soil compaction. As the water fills the previously gas-filled pores, gas exchange between soil and air is limited to diffusion in the soil water. Oxygen remaining in the soil is used by microorganisms within a few hours of flooding. Aerobic organisms are replaced by anaerobic organisms. The rate of decomposition of organic material is considerably slower in the presence of anaerobic bacteria. Anaerobic bacteria in flooded soils produce potentially toxic compounds, including gases, hydrocarbons, alcohol, volatile fatty acids, nonvolatile acids, phenolic acids, and volatile sulfur compounds.

What conditions, timing and duration of flooding are most harmful to plants?

Plants are affected by flooding at all stages of development. In general, adult trees tolerate flooding better than overmature trees or seedlings of the same species. Seedlings are often killed in floods because they are uprooted, pushed over, or buried in mud. In stagnant versus moving water, less oxygen is present and plants are more seriously injured. Flooding during the dormant season is much less harmful than during the growing season. When dormant deciduous trees are flooded, their weakened or injured root system have time to recover until leaves emerge and before transpirational demand increases. Evergreen trees, especially conifers, are less tolerant of waterlogged soil than deciduous trees.

Duration of flooding has a profound impact on plants, but tremendous differences in sensitivity to waterlogging of closely related species, and even different rootstocks has been reported in the literature. For example, mature valley and blue oak have grown on alluvial fans in areas with little or no summer rain and are able to survive 100 days of flooding each year. By contrast, interior live oak will not survive two weeks of wet soil around their trunks.

How is shoot growth affected by flooding?

Anaerobic conditions in the soil inhibit internode elongation, formation and expansion of leaves, and induce chlorosis, premature senescence, or abscission of leaves. During premature leaf shedding, older, basal leaves are usually dropped first, with the younger, upper leaves following. Flooding of the soil can lead to increased stem diameter. Changes in xylem and phloem increments have been observed as well as increases in bark thickness.

How are roots affected by flooding?

Root growth of flood-intolerant species is greatly reduced or arrested under waterlogged conditions. Rooting depth of these species is therefore often correlated with the depth of the water table. Flooding predisposes roots to attacks by *Phytophthora* fungi, which are attracted by root exudates of sugars and amino acids and a weakened defense system of the plant. Sometimes woody roots will survive flooding, while non-woody roots will die. No new roots are produced in flooded soils. The net effect of this can be reduced surface area of roots which limits water and nutrient absorption. Partial dieback of a root system will greatly reduce the stability of trees, making them prone to windthrow. Prolonged waterlogging will eventually kill most woody plants, depending on their tolerance to anaerobic soil conditions.

How quickly can flooding damage be assessed?

Trees that are sensitive to flooding may grow for some time after they are first flooded, but then they can die suddenly without many warning signs. Some species may loose their foliage, or exhibit various degrees of leaf chlorosis.

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TURFGRASS TOPICS

by Victor A. Gibeault

RECENT NEWSLETTER SUMMARIES

The following releases are from a recently initiated newsletter "Better Turf through Agronomics," which is an activity of the University of California Riverside Turfgrass Research Advisory Committee. The intent is to present summaries of turfgrass research results and topical information of interest to the Southern California turfgrass industries. The newsletter is edited by Vic Gibeault and Deborah Silva.

Putting Turf in a Retractable-Roof Baseball Stadium for the First Time -- A Novel Challenge

'De Anza' zoysiagrass, a newly patented UCR release, outperformed other varieties tested in the simulated traffic and light-restricted conditions of the new ballpark.

UCR Superintendent of Agricultural Operations **Steve Cockerham** is spearheading research to figure out for the first time how to put natural turf in a retractable-roof stadium that can withstand restricted light and still provide a durable, playable, and attractive sports turf surface for the future baseball games of the Arizona Diamondbacks, a new franchise.

The new stadium, Bank One Ballpark, which is under construction, will have a retractable roof, allowing open air in spring and fall and air-conditioned comfort for fans during the hot Arizona summer, which presents some novel problems and opportunities with respect to turf selection.

UCR scientists have built a field structure to provide the same shade restrictions as the stadium, with tenebrous periods representing homestands for a simulated baseball season.

"The first phase of our experiments showed that zoysiagrass would have the adaptability to low light while having good traffic tolerance. Zoysias performed better in restricted light than Tifgreen 419 bermudagrass, the standard in outdoor baseball fields, and better than Manhattan II perennial rye. 'De Anza' zoysiagrass, a newly patented UCR release, was selected for its quick establishment, rapid growth rate, and recovery from injury. It outperformed a pretty zoysia from Texas A&M, DAL-Z 8502, in our simulated traffic and light restriction studies," Cockerham said.

During the second-phase of experiments this year, Cockerham and colleagues are investigating minimum light requirements of turf used for baseball; if artificial and reflected light can supplement light needs; how air movement or the lack of it affect turf growth; and how recovery from injury can be enhanced under the playing conditions at the new stadium. Results are expected before the turf is installed in the ballpark.

UCR researchers have been at the forefront of sports turf research and traffic tolerance for a decade. The "Brinkman traffic simulator" was developed at UCR in the 1980s to simulate the wear and tear of football and baseball games, thereby providing critical information about how different turf species and varieties stand up to the punishment of cleats.

Cockerham is cooperating with **Vic Gibeault**, UCR Cooperative Extension Environmental Horticulture Specialist, **Mike Henry**, Cooperative Extension Turf Advisor in Riverside and Orange Counties, and UCR staff. Gibeault and former UCR scientist **Matt Leonard** patented 'De Anza' zoysia in 1995.

Black Turfgrass Ataenius Damage Thresholds

Since bentgrass greens in desert golf courses are vulnerable to injury from black turfgrass ataenius (BTA) beetles (*Ataenius spretulus*), UCR entomologists have determined when damaging populations are likely to be present and have identified an economic injury level superintendents can use to implement control measures.

"The threshold levels for damaging populations of BTA on bentgrass in the low desert region of California are 5-7 larvae per square foot, which is much lower than in other parts of the country. Our results may be related to the extremely stressful conditions of the desert in mid-summer and the limited ability of the plant to acquire the moisture it needs with insect-damaged roots," said **Ken Kido** and **Tim Paine**, UCR entomologists.

Depending on temperature, 2 to 3 generations of BTA occur per year in the desert. The first generation can appear as early as April or as late as July, they said. Three generations were recorded in 1994 and two in 1995.

Beetle larvae feed on turf roots, limiting the turf's ability to absorb water and to maintain an adequate moisture balance under stressful conditions. Stressed turf becomes wilted and dies in irregular patches.

Early detection and control are vital. Selected insecticides combined with good cultural practices will minimize damage, they said.

The first reports of injury to turf in California by BTA occurred in 1987 in Coachella Valley golf courses. Since then, damaging pest populations have spread to all Southern California counties.

Two New Products Show Promise for Chemical Edging of Turf

Cimectacarb and glufosinate were effective in experimental trials.

Results of preliminary research at UCR show that glufosinate (Finale) and cimectacarb (Primo) provide promise as chemical alternatives to repeated mechanical edging and hand removal of aggressive, stoloniferous grasses, such as bermudagrass, zoysiagrass, St. Augustinegrass, and kikuyugrass, which often extend their growth into ornamental beds, tree wells, and sidewalks in landscaped areas.

Glufosinate is a rapidly acting "contact" foliar herbicide not yet registered in California. Cimectacarb is a turf growth regulator.

"It appears that both of these products may have a place in chemical edging -- glufosinate for a quick burn back and cimectacarb for slowing regrowth after an initial mechanical edging. A second mechanical edging should not be necessary when using cimectacarb," said **Dave Cudney**, Cooperative Extension Weed Scientist at UCR.

Glufosinate reached its maximum effect in 5 days and the effect persisted for 45 days. Cimectacarb stopped turf growth throughout the 50-day trial period with little discoloration.

Experimental trials began last year at UCR, one day after the 'Santa Ana' hybrid bermudagrass was mowed to a uniform height of 0.75 inches. Treatments were the commonly used rates of diquat, cacodylic acid, glyphosate, glufosinate, and cimectacarb. Phytotoxicity (burn back) ratings were made over a 50-day period.

For the past 20 years, glyphosate (Roundup) has been the product of choice for chemical edging, but dieback usually occurs beyond the desired location, Cudney said.

Growth and Development of Kikuyugrass: An Invasive Weed on Golf Courses and Lawns

The success of unwanted kikuyugrass in golf courses and lawns is not due to lack of management skill; rather, it is the physiology of kikuyugrass that increases its fitness over indigenous turf species.

By comparing the growth and development of kikuyugrass (*Pennisetum clandestinum*) with that of two common turf species, tall fescue (*Festuca arundinacea*), a cool-season species, and St. Augustinegrass (*Stenotaphrum secundatum*), a warm-season species, UCR scientists have identified several ecophysiological mechanisms that enable kikuyugrass to become an invasive weed.

"Our results suggest that *P. clandestinum* is a successful weed in Mediterranean climates as a result of its capacity to photosynthesize over the full range of temperatures found in those climates, its rapid growth during warm weather and its apparent tolerance to moderately cool temperatures," said **Cheryl Wilen**, Extension Integrated Pest Management Advisor, and **Jodie Holt**, UCR Plant Physiologist, in their recent journal article in ***Weed Research***.

At leaf temperatures of 77 - 104°F, kikuyugrass had the highest photosynthesis rates. It increased biomass and leaf area more rapidly than St. Augustinegrass and tall fescue. Below 77°F, its photosynthesis rates were intermediate between the other two grasses.

Kikuyugrass maintains higher rates of photosynthesis at cooler temperatures than those normally associated with most C_4 (warm-season) grasses and accumulates a large amount of leaf area during warmer intervals, resulting in a plant that is more photosynthetically productive on a whole-plant basis than other C_3 (cool-season) or C_4 grasses grown under similar conditions, Wilen and Holt said.

Kikuyugrass allocates progressively more of its additional biomass to leaf production, thereby increasing phostosynthetic capacity, rather than partitioning it to non-photosynthesizing storage tissue; thus, it has a competitive edge for displacing turf species that allocate about equal portions of dry weight to roots, stems, and leaves (tall fescue) or that allocate biomass disproportionately to stems (St. Augustinegrass).

Kikuyugrass tolerates cold temperatures better than other warm-season grasses and continues to produce new shoots when other warm-season grasses have become dormant, although at a slow rate.

Despite its aggressive weediness, kikuyugrass can be beneficial as a forage crop and for erosion control. It has been introduced into many countries for these purposes, but in the past 75 years, since its introduction into California from its native African highlands, kikuyugrass has become an invasive weed in irrigated cropland, pastures, orchards, and turf, despite efforts to control it mechanically or chemically.

Grants from the Northern and Southern California Golf Associations provided financial assistance for this research.

Kikuyugrass Spreads Mainly by Clonal Propagation

Kikuyugrass spreads primarily by clonal propagation in California golf courses, say UCR scientists, who investigated the importance of seeds versus vegetative propagules in its establishment.

Kikuyugrass is a "facultative sexually spreading species," similar to other weedy species, such as johnsongrass, which has implications for kikuyugrass control, says project leader **Cheryl Wilen**, Integrated Pest Management Advisor. "Attempts to remove kikuyugrass by destroying the established plant may allow seeds in the thatch or soil to germinate and recolonize the area," she says.

Despite its reputation as one of the worst weeds worldwide, relatively little research has been done on kikuyugrass to examine its invasion and spread. An aggressive, perennial species that can reproduce clonally and rapidly via stolons and rhizomes, kikuyugrass can also spread via seeds, but typically does not flower unless mowed.

Golf courses in Palo Alto, Nipomo, and Riverside were sampled. At all three locations, the kikuyugrass showed low genetic variability, which is consistent with reproduction primarily by clonal propagation. The results showed that where open areas exist, genetic variability is higher, suggesting that the opportunity for spread initially via seeds can occur.

Sequential Herbicide Applications Provide Effective Control of Kikuyugrass

Sequential treatments of MSMA, triclopyr (Turflon), fenoxaprop (Acclaim) and quinclorac (Drive) provided effective control of kikuyugrass in cool-season turf when applied every 5 to 6 weeks over a 5-month period under experimental conditions in four Southern California locations.

Two-way herbicide combinations applied sequentially reduced kikuyugrass to less than 1% of the sward. The best single treatment reduced kikuyugrass from 80% to less than 5% of the sward.

"This control method has the advantage of reestablishing the desired species slowly, without loss of site use during the process. The competitive edge shifts from weedy kikuyugrass to the desired species, allowing it to reestablish," said **Dave Cudney**, UCR Cooperative Extension Weed Scientist.
Triclopyr or triclopyr plus MSMA is labeled for kikuyugrass control in cool-season turf. Repeat treatments of MSMA alone are currently the only registered method of reducing kikuyugrass vigor in warm-season turf, Cudney said.

Experiments were conducted over a 5-year period in Riverside, Ventura, Huntington Beach, and Costa Mesa by Cudney with UC Cooperative Extension colleagues **James Downer, Michael Henry,** and **Vic Gibeault.**

SPORTS TURF RESEARCH INSTITUTE

The Sports Turf Research Institute (STRI), of Bingley, West Yorkshire, UK, was established in 1929 by the Royal and Ancient Golf Club of St. Andrews and The Home Golf Unions to undertake research and provide an advisory service for golf clubs. In 1951 the work of the STRI expanded to encompass all turf sports and amenity grass areas. A nationwide network of advisers now visits over 2000 turf facilities a year throughout the UK, Ireland and a growing number of overseas sites. These include golf, sports turf areas, amenity grasslands and artificial turf. Specific activities of Institute staff include providing a golf advisory service as well as a general turf advisory service, research, education and publications, golf course architecture, laboratory testing, construction and drainage consultancy, and ecology. STRI is an independent organization that is managed by an executive committee which maintains close links with all major sport governing bodies. It depends for its income on subscriptions, fees for advisory services and commissioned research, donations for research, and limited financial support by the Sports Council.

Recently, STRI upgraded and expanded its International Turfgrass Bulletin. The high-quality Bulletin regularly contains articles, popularly written, on sports turf topics from spotlighting horse racing on turf tracks to the need for teamwork in construction projects. For further information about the quarterly publication, contact Anne Wilson, The Sports Turf Research Institute, St. Ives Estate, Bingley, West Yorkshire BD16 1 AU, Great Britain.

LANDSCAPE LINES

by Dennis R. Pittenger

TREES HELP COOL BUILDINGS AND COMMUNITIES

Source: Adapted from 1995 Annual, Lawrence Berkeley National Laboratory, Berkeley, CA, pp. 48-53

Cities and towns in California and other states are built with little vegetative cover and high densities of dark surfaces—roofs, highways, and parking lots—which absorb solar radiation and emit heat. This design causes significantly elevated temperatures in urban areas, creating what is known as the "urban heat island." On a clear summer afternoon, air in a typical city can be approximately 2.8°C (7°F) hotter than surrounding rural areas (see Figure 1). These higher temperatures, in turn, lead to higher electricity consumption for air conditioning (see Los Angeles case shown in Figure 2). Thus, the additional air conditioning use caused by this urban air temperature increase is responsible for 5 to 10% of urban peak electric demand at a direct cost of several billion dollars annually.

Higher temperatures also accelerate ozone formation, which is hazardous to human health. Combustion sources, such as vehicles, refineries and power plants, produce hydrocarbon and nitrogen oxide emissions that react in the presence of sunlight to form a combination of chemicals commonly known as smog. Heat catalyzes the reactions and accelerates the evaporation of organic chemicals from vehicles, paints, fuels and chemical storage tanks. Each of these effects adds to smog.

Research sponsored by Department of Energy (DOE) and conducted by the Heat Island research team from Lawrence Berkeley National Laboratory (LBNL) determined that increasing the solar reflectivity (albedo) of urban surfaces, along with extensive tree planting in urban areas, could mitigate and possibly reverse the heat island effect. The team found that the same efforts might reduce ozone concentrations by reducing chemical reactivity and evaporative emissions.

At the building scale, shade trees and solar-reflective coatings on roofs and walls can be cost-effective strategies to reduce peak electrical demand and air conditioning energy use. Solar-reflective coatings reflect more visible and infrared sunlight than common roofing and other building materials. Reflecting rather than absorbing energy lowers building cooling loads by decreasing the surface and air temperatures near the building. **Shade trees also reduce cooling loads two ways.** Trees block incoming solar energy, and water evaporating from the leaves cools nearby air—the process of evaporative cooling. *[Editor's Note: Recent field research studies have shown that in extremely hot, sunny microclimates like those common to urban centers, some tree species respond physiologically by shutting down their*

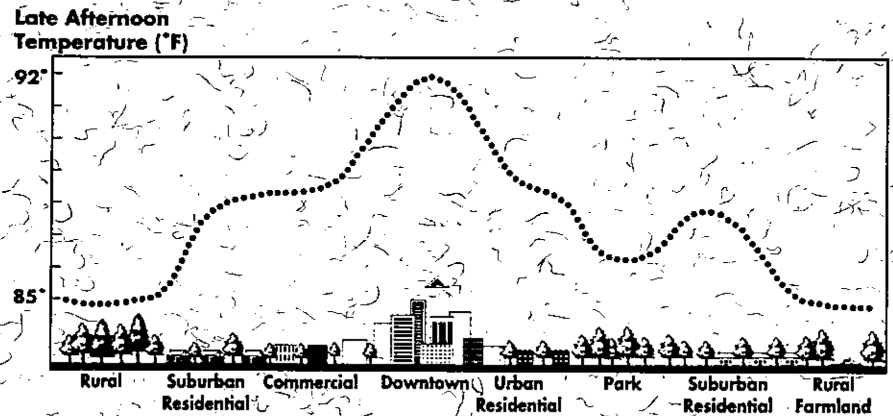

Figure 1. *Graph shows the temperature changes in degrees Fahrenheit as the density of development and trees changes.*

transpiration. Such species would not provide evaporative cooling. Thus, tree species selection is critical to maximize cooling benefits.]

The LBNL Heat Island Group investigated the direct and the indirect effects of increased urban albedo and tree cover. The Direct Effect examinations focused on the effects on building energy end-use efficiency while Indirect Effect investigators studied city-scale atmospheric cooling and reduced smog formation. The LBNL Heat Island Group cooperated with other principal investigators at UCLA and Systems Application International on the Indirect Effect component of this study. The California Institute for Energy Efficiency (CIEE) Research Board approved funding of these two complementary multiyear projects from 1990 through 1995.

Direct Effect Research

In a multiyear collaborative effort with the Sacramento Municipal Utility District (SMUD), DOE and CIEE, the LBNL Heat Island Group conducted a controlled experiment that measured and analyzed the energy-saving benefits of shade trees and light-colored surfaces on selected residences and public buildings in Sacramento.

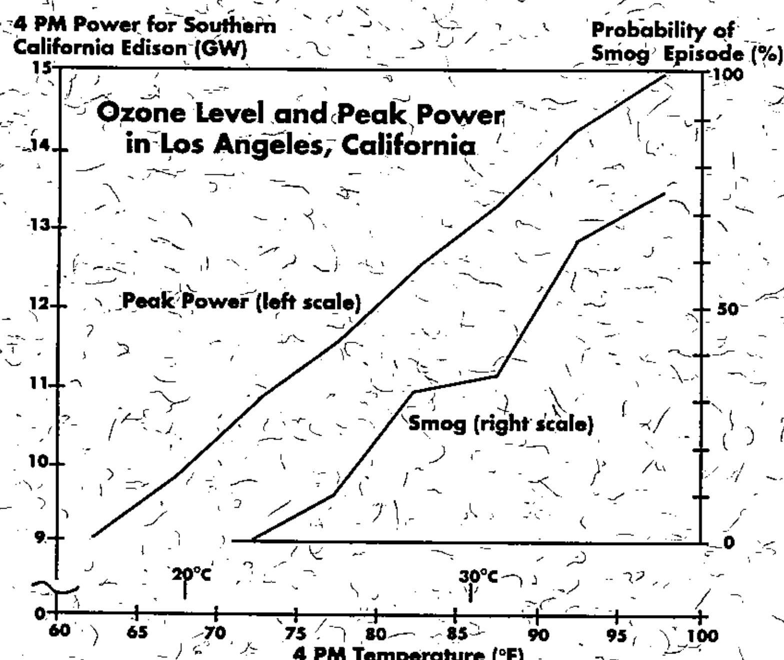

Figure 2. *Ozone levels and peak power for Southern California Edison vs. temperature in Los Angeles, CA. Peak power use rises by 3% for every 2°F rise in temperature. Probability of smog increases by 6% for every 2°F rise in temperature above 72°F. An episode occurs when the ozone concentration is above the National Ambient Air Quality Standard, 120 ppb.*

One Heat Island Group experiment showed substantial air conditioning energy savings resulting from **strategically planted shade trees** and reflective roofs, particularly in buildings with inadequately insulated roofs and walls. Investigators monitored air conditioning energy use in two identical side-by-side school buildings in Sacramento and found that the one with the more reflective roof used 35% less electricity during the cooling season. Similarly, they found that **using several trees to shade residential buildings reduced air conditioning electrical use by approximately 30%.**

The Heat Island Group also performed numerical building energy simulations. They modified a building energy computer model to analyze the energy saving benefits of high albedo and shade trees, and then validated the accuracy of this model using SMUD field data. The improved computer model can now be used to determine energy savings for different types of buildings in various climate regions that use **shade trees** and solar-reflective roofs and walls, as compared to other energy efficiency measures.

The research team also examined the feasibility of designing coatings that reflect both solar radiation and heat. Such paints would be valuable for their energy-savings and fire-retardant properties. A patent has been filed for this technology.

Indirect Effect Research

Along with measuring the building-scale impacts of albedo and vegetation increases, the Heat Island Group also quantified the potential of these measures to improve regional air quality. They were interested in whether practically achievable implementation of the measures would reduce ozone concentrations in the South Coast Air Basing (SoCAB).

The LBNL investigators made appropriate modifications to pollutant and biogenic emission inventories, and to mesoscale meteorological and air quality computer simulation models. To find out how practically achievable changes would bring population-weighted ozone concentrations below exceedance levels, they used the models to assess by how much **tree planting** and increased albedo could improve urban air quality. The improvements were benchmarked against both National and California Ambient Air Quality Standards: California requires ozone concentrations below 90 parts per billion (ppb), while the national standard is 120 ppb.

Investigators also **analyzed a variety of tree species** for their relative contributions to ozone formation. They **developed a list of trees that emit relatively low levels of ozone precursors.**

The computer simulations indicated that increasing albedo and vegetative cover in built up areas can reduce air temperature and population-weighted ozone concentrations in the SoCAB. While additional vegetation may bring the risk of increasing biogenic emissions of ozone precursors, a careful selection of species for planting should minimize any possible negative impacts.

The simulations also indicate that increased urban **vegetation lowers ozone concentrations if the additional trees are low emitters of hydrocarbons.** Adding two low-emitting trees to each house in the SoCAB would lower the exceedance exposure by as much as 14% during peak afternoon hours. Each measure studied can decrease the total daytime exceedance exposure by up to 12% with respect to the national standard.

However, the computer simulations suggest that the most powerful strategy is to increase both albedo and vegetation cover (Table 1).

The study also identified tree species that can worsen air quality. Episode-specific simulations in this study suggest that trees emitting roughly more than two µg/g/hr of isoprene (micrograms of isoprene per gram dry-leaf mass per hour) and one µg/g/hr of monoterpenes should not be introduced in large amounts in the SoCAB.

This research has also led to the development of a state of the science inventory of vegetative cover and albedo in the SoCAB as well as a detailed database of tree characteristics. Policy makers can use these tools to determine the benefits of programs aimed at reducing basin-wide temperatures through tree-planting and surface lightening.

Future Directions and Technology Transfer

The Indirect Effect project was completed in early 1995. Results have been published and shared with many interested parties, including CIEE and its Sponsors, SCAQMD, the Bay Area Air Quality Management District, The California Air Resources Board, EPA and DOE.

The SCAQMD has considered high-albedo materials and urban vegetation in its 1994 Air Quality Management Plan as potential strategies for lowering ground-level ozone concentrations. SCAQMD has expressed an interest in collaborating with the LBNL project team in performing more extensive computer analysis studies for the SoCAB and establishing new mechanisms that will permit solar-reflective surfaces and tree-planting to qualify for market incentives that exist under SCAQMD's Regional Clean Air Incentives Market program.

Table 1. Summary of scenarios and their air quality impacts.

Strategy	Cell-wide albedo increase	Maximum number of shade tress per house	Increase in air temp. change[1]	Reduction in ozone exposure[2]
1. Increase roof albedo by 0.35, pavement by 0.25	0.15	•	-1.5°C	6%
2. Increase vegetation	•	2.2	-1.5°C	6%
Both 1 and 2	0.15	2.2	-3°C	12%

Source: Haider Taha, LBNL-37316

[1]Population-weighted change in air temperature at 3PM, August 27.

[2]Reduction in population-weighted exposure exceeding California Ambient Air Quality Standards at 3PM, August 27.

THE POLITICS AND PRACTICES OF LANDSCAPE WATER CONSERVATION REGULATIONS

Dennis R. Pittenger

The California Urban Water Conservation Council (CUWCC) is the result of an effort by urban water agencies and public/environmental interest groups to implement water conservation as a demand side option on an equal basis with other supply side options. This effort was formalized in a Memorandum of Understanding (MOU) signed in 1991 by three signatory groups: urban water suppliers, public interest groups, and other interested parties. Currently there are 176 signatories, including 112 water agencies, 17 public interest groups and 43 other interested parties. The Council continues to grow with new signatories being accepted every year. Signatory water suppliers agreed to develop and implement comprehensive conservation Best Management Practices (BMPs) using sound economic criteria. An essential component of the MOU was the creation of the California Urban Water Conservation Council.

Compliance with BMPs is, and always will be, voluntary within the CUWCC as it is a selfenforcement system. The only tool for ensuring accountability of member agencies is the "Red Face" penalty enacted when non-compliance is exposed to the public.

Recently, the Council held three public workshops to solicit input on the preliminary recommendations for revising their urban water conservation BMPs. Existing BMPs related to landscape irrigation include: (a) identifying irrigators of large landscapes and providing water audits to them, (b) enacting and implementing landscape water conservation ordinances or cooperate with entities that have such authority pursuant to the Water Conservation in Landscaping Act (AB 325), (c) provide guidelines, information and incentives for new and existing single family homes that can result in more efficient landscapes and water saving practices, (d) provide incentives, such as sprinkler timers and water bill adjustments for implementing conservation measures, to the top 20% of water users in a service area, and (e) meter all new water connections and install meters to existing unmetered connections (no timetable is called for).

Within the proposed set of revised BMPs, the original landscape-related items would be largely retained and the following BMPs would be added:

(a) agencies must bill for water based on volume used and conservation pricing structures rather than block or flat rates, and agencies should recover a significant percentage of their revenue through volume charges rather than fixed charges.

(b) agencies will assign water use budgets equal to 80% and 100% of reference evapotranspiration (ET_0) per square foot of landscape area for all landscape irrigation accounts, and phase-in by the year 2000 the same budgets for mixed use and residential accounts. Water use budgets may be prepared using historical ET_0 or real-time ET_0. Customers will be notified how their actual consumption compares to their 80% and 100% ET_0 water use budgets.

Some water agencies have already assigned water budgets to their customers and imposed pricing structures that penalize over-budget water consumption. However, these draft BMP revisions clearly avoid requiring tiered-rate pricing structures or assigning a specific percentage of ET_0 for landscape water use budgets. Another revised set of recommendations, reflecting input received at the three public meetings, is scheduled to be released April 14, 1997 for written comment.

Further details on the BMPs, this process and the CUWCC can be obtained by contacting the CUWCC at 455 Capitol Mall, Suite 705, Sacramento, CA 95814, (916) 552-5883.

NEW DIAZINON FORMULATION

Source: Janet Dinsmore, Novartis Crop Protection, Tel. (910) 632-2191

A breakthrough formulation of diazinon is now available. The carrier for this new product is water, rather than petroleum solvents, so while it offers the same performance against a wide variety of home and garden pests, it has significantly less odor. According to Greg Faust, marketing manager at Novartis Crop Protection, which manufactures the product, "diazinon will be more pleasant to use, and will help reduce concerns about using an insecticide."

Diazinon controls more than 120 pests and is labeled for use on lawns, ornamentals (trees, shrubs and flowers), fruits and vegetables. Products with the new, water-based formulation should be available wherever yard and garden products are sold, according to Faust.

CALENDAR		
MONTH	EVENT AND LOCATION	CONTACT
April 22 - 23	Two-day IPM Class focuses on current techniques and research results for turfgrass, University Club at UC Davis Campus, Davis, CA	Karen Fischer (916) 757-8899
April 30 - May 5	Western Chapter International Society of Arboriculture Annual Meeting, Disney Pacific Hotel, Anaheim, CA	Western Chapter Office (916) 641-2990, FAX (916) 649-8487
July 23-26	94th ASHS Annual Conference, Salt Palace Convention Center, Salt Lake City, UT	ASHS Headquarters (703) 836-4606, FAX (703) 836-2024, e-mail: meetings@ashs.org
August 2-5	73rd International Society of Arboriculture Annual Conference and Trade Show, Salt Lake City, UT	Jerry Moorman, ISA Headquarters, (217) 355-9411, FAX (217) 355-9516, e-mail: isa@isa-arbor.com

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Co-Hort is intended to be a quarterly publication and will be distributed to Farm Advisors, Specialists, and Department Faculty working in areas related to environmental horticulture. This publication is written and edited by Victor A. Gibeault, Dennis R. Pittenger, and Ursula K. Schuch; and prepared by Susana B. Vélez, Administrative Assistant. Please address any correspondence concerning this publication to the editors.

Co-Hort is issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, W. R. Gomes, Director of Cooperative Extension, University of California.