ROUNDTABLE

Urban Forestry in the Drought Zone

I have been involved with trees and urban landscape management for over 30 years now and have a few thoughts about drought in the southeastern U.S. It seems that our summers are getting hotter and drier. Weather events are getting more extreme. Just last year, for example, we had killer tornadoes in April, a severe drought in August combined with temps in the mid- to upper-90s every day, followed by 10 inches (254 mm) of rain and floods on Labor Day. Other locales around the Southeast have experienced similar conditions in recent years. Although my experiences are only one tile in a larger mosaic, I suspect that when you fit all of the tiles together, it creates a picture of climate change with which all of us are now trying to cope.

So what's a poor city forester to do? I have elected to plant those trees that are both drought tolerant and heat resistant. In my area that includes 'Princeton' American elm (*Ulmus*), and some of the sweetgum (*Liquidambar*) cultivars. But it also includes some of the non-native trees that do particularly well here, including Chinese pistache (*Pistachia chinensis*), ginkgo (*Ginkgo biloba*), crape myrtle (*Lagerstroemia indica*), and lacebark elm (*Ulmus parvifolia*). As part of an effort to counter the impacts of climate change, I have adopted a policy of planting trees that will develop the largest canopy possible for a given site. In this way our trees can provide the maximum benefits for their ecological services of reducing the heat island effect, absorbing air pollutants, and intercepting rainfall for stormwater detention. If your City is in the process of developing a climate adaption plan, this type of action would fit in very well.

In Chattanooga, we typically use a 20-gallon (76-liter) irrigation bag for watering. We chose this item for practical reasons because it allows us to quickly fill the bags with a watering truck. It also offers a broad flat side onto which we paint the logo for our tree planting initiative, "Take Root." I instructed the employees to always face the logo toward oncoming traffic so that drivers can see the logo hundreds of times as they drive down the street. This is our form of guerilla marketing, and it works well.

—Gene Hyde, City Forester, Chattanooga, Tennessee

A tree irrigation bag in Chattanooga, Tennessee publicizes the City's Take Root program to passersby. Photo by Preston Roberts

Last year, the Great State of Texas suffered the most severe drought ever recorded. The hottest June, July, and August on record seared Texas to a crisp. In August 2011, Texas was brutalized with the hottest month recorded for any state ever in U.S. history.

Parts of Texas experienced 20 inches (510 mm) less-than-normal rainfall from October 2010 to September 2011. Many Texas cities set new records for number of 100-degree days and consecutive 100-degree days. Fort Worth recorded 71 days over 100 degrees F (32 C) during the summer of 2011. Texas Forest Service estimated that 5.6 million urban shade trees were killed by drought across the state, as much as 10% of the total Texas urban forest. Estimated cost of removal statewide is $560 million. Estimated loss in environmental benefits provided by drought stricken trees is roughly $280 million per year. High temperatures and low humidity caused wildfires to rage across Texas, burning 3,993,716 acres (1,616,199 ha).

Severe drought can have a long-lasting effect on trees. As wood tissues dry, they separate, creating internal checks and shanks. Trees lack the ability to close internal wounds. These hidden faults become points where limbs will break under load-bearing stress such as wind, rain, ice, snow, or flush of growth. Fort Worth saw a 13% increase of Priority 1 work orders to mitigate tree risk last summer over the previous summer, but we believe this is only a preview of things to come. Our records indicate that after a prolonged dry, hot period, the volume of emergency response work orders spikes with the next load-bearing event. Statistically this most often occurs during spring winds and/or storms in April or May. The volume of broken limbs hanging and in the street could increase dramatically this year.

Total tree failure can occur when trees already structurally compromised by trunk cavities, dry rot, or leans are further weakened by internal drying and cracking. In some instances, extremely dry soil lacked the cohesive strength to hold a leaning or unbalanced tree upright. Midsummer, an otherwise healthy 42-inch- (107-cm) diameter pecan (*Carya illinoinensis*) tree fell on parkland in Fort Worth because of soil failure.

Last year's drought caused decreased vigor and death to many trees throughout the state. Some species are more susceptible to drought than others. One of the species hardest hit in Fort Worth was the American elm. By the end of summer, forestry staff reported that all American elms had shown signs of drought stress. We conservatively estimate that 25% of the 3,863 American elms growing on the parkway will need removal or pruning due to drought stress within the next one to three years. Early estimates predict that 66,000 City trees will need some form of hazard mitigation within the next one to three years due to drought stress. Forestry crew's current work capacity is 19,000 trees annually.

The Texas Forest Service was quick to respond by producing a flyer and video on proper watering of urban trees. The City of Fort Worth added the video to their home page and forestry staff added a link on their email signature line. Over a thousand trees planted within the past three to ten years were given emergency water during the scorching summer by forestry and park employees as well as volunteers. Despite supplemental water, thin-barked trees could not withstand the prolonged high temperatures. Red oaks (*Quercus rubra*) and magnolias (*Magnolia* sp.) across the City of Fort Worth were cooked to death.

In Fort Worth, we treated the 2011 drought as any other debris-generating event with the luxury of an extended reaction time. By late summer we had park employees counting and marking dead and severely stressed trees on park property. Forestry staff was in the middle of a street tree inventory and modified data collection to include drought-stressed trees. With these numbers we were able to project a cost to the City for removal. Forestry worked feverishly over the winter to mitigate hazards before spring storms. Because of our projections, we were spared this fiscal year's hiring freeze.

The City tree farm lost over 1,500 trees to high temperatures and water stress. One employee spent 80% of his time last summer repairing irrigation lines damaged by water-starved rodents and other wildlife. With water shortages across the state and a prediction by meteorologists that the drought would extend into 2012, we made the decision to concentrate transplanting efforts on container stock which required more water to maintain than field grown stock. Once the container grown tree was in the ground, it would require less water than in the nursery. In this way, we were conserving water by transplanting trees. Unfortunately, our tree-planting partners, intimidated by water rationing, were pulling out of projects. A campaign was initiated to generate public interest in planting trees on City property. On average we plant 1,600 trees each year on public land; we are projecting 1,000 this year.

Mitigation is two-part: remove risk, and reforest. Without benefit of spreading limbs and cooling transpiration, our cities in Texas will suffer hotter temperatures, more stormwater runoff, and greater number of ozone days. Our role as urban foresters is more important than ever.

—Melinda Adams, City Forester, City of Fort Worth, Texas

Conditions in south-eastern Australia have always been challenging, but climate change is making things more unpredictable. Years of drought have been followed by widespread flood events and destructive tropical cyclones (hurricanes) in the northern tropics. Australia is definitely a country of 'droughts and flooding rains'.

In Adelaide, South Australia, we have a Mediterranean climate with an annual rainfall of 550mm (21.7 inches). We have recently come out of a seven-year drought, coupled with water restrictions, which saw many large, mature trees give up and die. Some of these trees were over a hundred years old. We had to come up with strategies to try to save the remaining urban forest.

This included planting species that are drought-resistant, like yellow gum (*Eucalyptus leucoxylon* 'Goolwa Gem'), wilga (*Geijera parvifolia*) and tuckeroo (*Cupaniopsis anacardiodes*). These species are hardy, adaptable to poor soils, can handle salt and wind, and appear to be pest and disease resistant. Mulching of established and newly planted trees has played an important part by retaining soil moisture and providing favourable conditions for beneficial organisms that help to improve soil health and condition.

When planting new stock, we use soil conditioning additives including hydro-absorbent granules which swell quickly on contact with water to help retain moisture in the root zone. Combining this with a slow-release

Green wells are a key part of the drought management strategy in Campbelltown, Adelaide, Australia. Photo by Henry Haavisto

fertiliser also helps to buffer the plants from stress. Green wells placed around the base at planting time assists with watering of the trees, as they can hold up to 50 litres (13.2 US gallons) and maintain efficient bowl integrity around the base of the tree. They also help to reduce mechanical damage from grass trimmers and lawn mowers.

These measures are only a small sample of what we are using to reduce the impacts of climate change. Perhaps it is also time to remember an old Chinese proverb, "The best time to plant a tree was twenty years ago. The second best time is today."

—Henry Haavisto, Manager of Urban Trees, Campbelltown City Council, Adelaide, Australia

Like most of the southeast U.S., South Carolina has experienced a number of drought years since the late 1990s. Since 2009, most of the state has seen drought conditions ranging from moderate to exceptional. The effects of this dry weather have varied, but much of it has been beneficial to urban forestry.

Any arborist knows that stress factors in trees are cumulative. Newly planted trees, over-mature trees, and damaged trees predictably fared poorly in the hot, dry weather unless supplemental watering was provided. The positive benefit to this was to reinforce the need for purchasing quality planting stock, selecting the best tree species/cultivars for the site, and installing them properly.

An ARRA (American Recovery and Reinvestment Act—the President's stimulus program) grant to the South Carolina Forestry Commission was passed through to dozens of communities to pay to remove hazardous trees and replace them with appropriate, high quality, properly installed trees. Specs provided to the communities helped to educate both municipal tree managers and contractors with regard to tree quality, proper installation, and hazard tree assessment. Statewide, this resulted in over 900 hazardous trees removed and over 1300 new trees planted. This grant program came about from the effect of the drought on our city trees.

We will continue to see the effects of drought on our city trees for some time to come. If normal weather patterns resume, it will still take a number of years for established trees to replenish their carbohydrate reserves. Meanwhile, insect outbreaks or further drought will challenge municipal forestry programs but will also encourage quality urban tree management.

— Jimmy Walters, Urban Forester, South Carolina Forestry Commission

Throughout the southern tier of the United States we have experienced a severe drought. Some cities are harder hit than others; Savannah, Georgia is no exception. One of our methods in dealing with the drought is utilizing the right tree for the right site. Here we plant trees that can handle drought conditions and the high reflective heat we have in our southern city.

Some species, once established, handle the drought better than others. For example, crapemyrtle (*Lagerstroemia* sp.) is a top performer for us; other species that perform well are trident maple (*Acer buergerianum* 'Aeryn'), lacebark elm (*Ulmus parvifolia*), and nuttall oak (*Quercus nuttallii*).

How do we establish trees during a drought? We use tree watering bags to help the tree grow a viable new root system. The slow release of water over a period of time is a textbook way to establish a good root system. We also like to use a wetting agent in the water that goes into the bags. Savannah, like many other cities,

has compacted soils, and the wetting agent allows water to penetrate Savannah's compacted sandy soils.

The delivery of water to the trees is key in dealing with the drought. About 90% of the trees that are planted within a given year on the City's right-of-way do not have any irrigation. For those trees, we use three water trucks with 250-gallon (946-liter) tanks in the bed to deliver water. In addition to the three watering trucks, we have an additional 250-gallon tank on a trailer and we have a 750-gallon (2839-liter) tank that can be installed quickly in back of a large dump truck. We use these two other tanks during the hottest part of summer for any trees showing signs of drought stress. We purchased these items over the years while the economy was going well; plan and budget now for the worst-case scenario!

We can also manage with the drought by varying the number of trees we plant in a year. We know how many trees a crew can water in a day; with that information, we plan how many trees we should plant for the year in order to have a good survival rate. We arborists have many tools at our disposal and in my opinion, planning is the greatest tool you can use in battling the drought.

—Michael W. Pavlis, Tree Maintenance Supervisor, City of Savannah, Georgia

The City of Santa Clarita, California is located in the Santa Clarita Valley, 30 miles (48 km) from the Pacific Coast, and nestled in the north end of Southern California's Los Angeles County. Sitting at 1,200 feet (366 m) above sea level, the region historically experiences a dry climate with an average rainfall of 17 inches (432 mm) per year. Currently, the drought in California is less extreme than that of Texas. Santa Clarita's water sources consist of near equal amounts of ground water and imported water from the statewide aqueduct system. As a result, the impact to the community is lessened; however, residents conserve water to avoid the possibility of rationing.

Santa Clarita is home to many large native trees, including the valley oak (*Quercus lobata*), coast live oak (*Q. agrifolia*), California sycamore (*Platanus racemosa*), and the cottonwood (*Populus fremontii*). Many of the native trees prefer alluvial soil and do best near riparian areas, or where ground water is available. Some of the drought-resistant non-native tree species selected for use in Santa Clarita include the African sumac (*Rhus lancea*), Chinese pistache (*Pistachia chinensis*), crapemyrtle (*Lagerstroemia* sp.), mesquite (*Prosopis* sp.), paloverde (*Parkinsonia aculeata*), and *Eucalyptus* species.

Property owners are responsible for watering trees growing in residential parkways and rights-of-way, while the City maintains those growing in parks and along major roadways. Trees growing in non-irrigated parkways are closely monitored, and mulch is continually added to tree wells to ensure a higher volume of moisture retention in the soil. Of the estimated 45,000 trees maintained by the Santa Clarita's Urban Forestry Division, approximately 1,200 trees require supplemental watering by a water truck for establishment and ongoing survival.

As water is a precious commodity in the City of Santa Clarita, its use is not treated lightly. The City's Urban Forestry Division is mindful of this concern each time a tree is planted. Tree selection is based on drought and temperature tolerance, as well as tree site locations. These considerations are critically important, but water is the living factor that will determine if the tree succeeds or fails for the resident and for our community.

—Robert Sartain, Urban Forestry Supervisor, Public Works Department, Santa Clarita, California

Texas is one long drought broken by an occasional flood. 2011 was the hottest and driest year in recorded history. We saw a bit of reprieve over the winter, but the drought for much of the state is forecast to persist or intensify. Our communities are dealing with a widespread natural disaster; it is estimated that 5.6 million trees have perished in Texas communities.

The Houston area was hit particularly hard last year. So far, we have documented over 50,000 public trees that have been removed at a cost of approximately $10,500,000. This alone represents $1,000,000 a year in lost environmental services. It would cost over $10,000,000 to replace these trees with 3-inch- (76-mm) caliper trees. There are parks in Houston where 90% of the trees have died.

San Antonio completed a major tree planting initiative during 2011—and keeping those trees watered was tough. The combination of Treegators, many water trucks, and a dedicated staff have made the difference for these new trees but have reduced the number of additional trees that we have been able to plant and care for. We are also seeing an increase in stress-related diseases such as hypoxylon canker. There will be many public and private trees removed this year.

Gazing deep into the crystal ball, we need to plan for hotter and drier years. Adjusting our recommended plant palette, planting season, and maintenance specifications are just a few changes we will have to enact. We tree people have been pushing fall planting, but not effectively. I think the drought gives a good solid reason to concentrate on fall planting because most tree root growth occurs when the leaves are dropping in the fall and right before they grow in the spring. Following that logic, the best time to plant is between Halloween and St. Patrick's Day. Not planting trees isn't the answer. More Trees, Please!

—Paul Johnson, Regional Urban Forester, Texas Forest Service

The City of Melbourne, Victoria, Australia has recently emerged from an extended decade-long drought period where the average rainfall was nearly half that of long-term averages. The low rainfall combined with severe water restriction has resulted in a steep increase in tree mortality due to stress and die-back from lack of water. Our tree population of 70,000 park and street trees has many trees well over 100 years old, vulnerable to change, that are now in rapid decline. A Useful Life Expectancy assessment indicates that over the next twenty years we could lose over 40% of our existing trees.

The tree population of Melbourne includes an important population of approximately 6,500 elms (many species, but predominantly *Ulmus procera* and *U. hollandica*) that have never been affected by Dutch Elm Disease. The oldest of these trees date back to the period 1850-1860. These elms, along with London plane tree (*Platanus* x *acerifolia*) account for many of the large street trees in Melbourne and contribute character to many parks. London plane trees account for more than 75% of the trees in the Melbourne central business district.

Our response to these immediate challenges and loss of trees has been, in the short term, to maintain the health of existing trees and, in the long term, to plan for the future forest. The short-term response has seen a significant effort to source and supply non-potable water to trees and green spaces by means of such thing as water-efficient drip lines, water barriers, deep soil water injection, tanker watering, and stormwater harvesting. This has been combined with extensive mulching of existing trees in parklands to remove competition for soil moisture by turf. Water Sensitive Urban Design plays a significant role in how we plant new trees to ensure that storm water naturally irrigates vegetation and cleans pollutants before it enters waterways.

The development of an Urban Forest Strategy sets a clear vision to create a future forest that will be resilient, healthy, and diverse and will contribute to the health and wellbeing of our community and to the creation of a livable city. The strategy recognizes the key role that trees and green infrastructure play in underpinning the health of the community and the health of the city.

In its Urban Forest Strategy, Melbourne makes provisions for significant tree planting efforts to offset the massive losses due to drought.

Stormwater harvesting is a key part of Water Sensitive Urban Design in Melbourne.

Melbourne has recently emerged from a decade-long drought that resulted in a steep increase in tree mortality. Melbourne Photos Courtesy Ian Shears

Key elements of the strategy are to increase canopy cover and diversity of species, increase soil moisture, enhance biodiversity, and engage with the community. Research includes quantifying thermal benefits of trees in Melbourne and physiological indicators to climatic stress, identifying which species we should use in the future, and attributing economic values to urban trees. Advocacy and networking is also critical in ensuring trees and green infrastructure is integral to city planning.

Corporate website:
www.melbourne.vic.gov.au/urbanforest
Consultation site:
www.melbourneurbanforest.com.au
YouTube: *www.youtube.com/watch?v=BplUmxFCE8A*

—Ian Shears, Manager Urban Landscapes, City of Melbourne, Victoria, Australia

Darwin, Northern Territory, Australia, is a tough place to be a tree, and a tougher place to be an urban forester! The two typical seasons, the dry season, April-September, and the wet season, October-March, can display extensive rainfall variation. The 2010 dry season provided a rainfall total of just 10.4mm (.4 inches) during a 113 day period, with a mean average temperature of 32 degrees Celsius (100 F). In stark contrast, the 2010-2011 wet season dumped 2959.4mm (116 inches) of rainfall at Darwin Airport weather station, for which Tropical Cyclone Carlos was mostly responsible. What's known as the Dry Tropics can be certainly both dry, and tropical.

Amenity tree selection becomes difficult when trying to compromise between drought tolerance, an ability to sustain periods of flooded/anaerobic conditions, be resistant to wind throw, and meet the site constraints and amenity expectations of the community. As I state regularly, there is no perfect tree ... but there are plenty that are close!

In the past, the city has favoured species such as yellow flame tree (*Peltophorum pterocarpum*), river red gum (*Eucalyptus camaldulensis*), weeping rosewood (*Pterocarpus indicus* var. *pendula*), African mahogany (*Khaya senegalensis*), and red condoo (*Mimusops elengi*). Tropical Cyclone Tracey in 1974 left Darwin denuded of vegetation. The mass planting effort following the cyclone saw many of the above species, and more, installed throughout the city's suburban streets and parks. Some have proven to be highly valuable assets; others have proven to be problematic.

Many local indigenous tree species are now being cultivated in nurseries for their genetic ability to withstand the rigors of the local environmental variability. The trialed use of various underutilized local tree species helps to achieve species diversity goals, limit potential effects of catastrophic pest/disease outbreak, and provide multiple ecosystem functions. Species such as white bush apple (*Syzygium forte*), allosyncarpia (*Allosyncarpia ternata*), Herbert's gum (*Eucalyptus herbertiana*), white cloud tree (*Maranthes corymbosa*), bush currant (*Carallia brachiata*), and Hill's salmon gum (*E. tintinnans*) are all very useful Northern Territory Tree Species for various function, form and amenity purposes. Many introduced species are also used for their drought tolerance and heat resistance values.

Challenges for many of Australia's urban foresters may include climate change, urban heat island effect, water scarcity, population increase and urban intensification, and simply finding the resources to achieve the future vision of the urban forest. All this whilst battling increased drought effects!

In my position as Darwin Technical Officer Parks and Reserves, I am currently reviewing operational process-

es to meet the City's Strategic Direction Towards 2020 and beyond. A key strategy to create and maintain an environmentally sustainable city has produced a Climate Change Action Plan, including a key action to develop a strategy to maintain and enhance the urban forest.

Recently, I have been setting the foundations for the development of an Urban Forest Strategy for the City of Darwin. My focus has included evaluation and quantification of the city's urban forest, tree inventory completion, and i-Tree Eco environmental and economic data reporting to Council. With sound strategic direction and clear targets, not only will I have the ability to improve the forests' drought tolerance, but improve and extend many other of its essential functions to the community.

In a practical sense, I utilize an integrated approach for limiting drought stress on Darwin's tree population, including:

- Species selection for drought tolerance
- Adding organic compost and organic mulch to soil surface throughout the dripline for soil moisture retention, soil temperature remediation, and soil carbon addition/ increase
- Soil amendment with water crystals pretreated with humic/fulvic acids and various beneficial microbes to aid beneficial microbe population and to take advantage of the potential soil improvements created
- Development and implementation of diverse irrigation provisions—routine water truck, water bags, tree tanks, tree wells, centralized digital irrigation systems
- Water Sensitive Urban Design WSUD, modification of storm water systems to irrigate root zones, and permeable pavement design
- Experimentation with micorrhizal and other beneficial microbe inoculants to increase a tree's feeding ability and improving localized soil properties
- Research/experimentation with other untried dryland/drought-tolerant tree species for utilization in Darwin's future urban forest

The effects of climate change will have huge implications for staff that are responsible for urban tree populations. The challenge for us is to effectively combat the negative effects, and promote the urban forest as having an ability to do so. Our tree populations form part of the solution, and I am excited to be a leaf on the solution tree...

—Edan Fisher, Technical Officer Parks and Reserves, City of Darwin, Northern Territory, Australia