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TREENET SHADING SA RESEARCH PROJECT

UV IRRADIANCES IN TREE SHADE

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Abstract:

The results of the Treenet Shading SA study show that street trees provide sun protection factors similar to many purpose built structures and standard personal protection strategies. It is likely that tree architecture (height, width, and shape of canopy) is more significant than individual species performance. A simple and practical methodology for collecting data is being developed so that the UV blocking performance of a wide range of trees in all locations can be readily assessed.

Aims:

This project aims to assess the performance of some common urban trees in reducing UV irradiance with a view to formulating tree selection and management strategies that will contribute to public health and safety. Treenet is collaborating with ARPANSA (Australian Radio Protection and Nuclear Safety Authority), various SA Local Government bodies, and a strong core of volunteers to conduct this study on behalf of the Cancer Council of SA.

Introduction

The UV risk

- The accepted assumption is that the ultra violet (UV) portion of the sun's electromagnetic spectrum can damage the human body with particular concern attached to the formation of skin cancers, many potentially life threatening.
- The level of risk is associated with the level of exposure.
- UV levels are measured in Joules /m2 effective UVR.
- 100 J/m2 equates to 1 Standard Erythemal Dose (SEDs)
- 2 SEDs is sufficient to cause sunburn in sensitive individuals.
- Clear sky days in summer have about 60 to 70 Standard Erythemal Doses (SEDs) as daily totals.
- Southern states get about 8000 SEDs per year while Nth Qld and Darwin get 16000 and the UK gets 4000.
- For most of the day there is more UVR effective from the sky than from the direct sun. Only at times close to solar noon (not local noon) is the direct sun UVR higher than the diffuse from the sky.
- During the hour enclosing solar noon there are about 10 to 11 SEDs on a clear sky day. This means someone would get 2 SEDs in 12 mins (if there are 10 per hour) and achieve erythema (defined as the first signs of skin reddening).
- Any barrier between the open sun and the human body (ie any shade mechanism) which partly or wholly reduces the visible impact of the sun (ie reduces light) is also considered to reduce the level of UV reaching the human body.

- Trees are one such sun barrier and people commonly shelter in the shade of trees, 1. to avoid the glare of the sun (reduction of the visible part of the electromagnetic spectrum)
  2. to lessen the heat of the sun (reduction of the infrared part of the electromagnetic spectrum)
- Previous studies have concentrated on the services trees provide in reducing the negative impacts relating to these parts of the electromagnetic spectrum. This study may be the first attempt to quantify the relative performance of a range of trees on the reduction of the UV portion of the sun's electromagnetic spectrum.
- The major outcome of the project will be the development of a resource that may be cross-referenced with associated information including species characteristics, cultural requirements, management strategies, and risk assessment. The information derived from the research will be integrated with the web-based TREENET system and freely available to the public.

Development of the Experimental Procedure

An extensive literature review and several preliminary experiments were conducted in the spring of 2004 to establish the best experimental procedure for assessing UV irradiance at near ground level beneath the canopy of different tree species. UV readings obtained using spot UV intensity measuring equipment (eg the IL1700 provided initially to the project) were inadequate as only one tree could be assessed at a time. There was a requirement to collect data from a number of trees concurrently over a specific period covering solar noon. UV sensitive polysulphone badges supplied and assessed after exposure by ARPANSA proved to be simple to deploy in large numbers, consistent in performance, accurate and easily managed by the 15 or so assistants volunteering to the project. In particular they were proven to be the most effective measure of cumulative irradiance over an extended period, thus simulating the accumulation of SED's by human targets. The badges were initially worn by the volunteers on hats and clothing, in line with the standard procedures developed at ARPANSA, but this was soon abandoned in favour of fixed targets set at standard heights and positions under the canopy. The most recently developed technique using a matt black board attached to a common orange/red traffic cone ("witch's hat") is economical, practical, and sufficiently accurate for statistical analysis. Some questions were initially raised over tilting from the completely horizontal plane but small variations appear to be tolerable.

Analysis of the initial trial experiment with these standardised targets found a statistically significant difference between the UV shading levels of 4 different tree species in the Waite Arboretum when horizontal results were plotted on a log scale and compared. By dividing the UV dose accumulated in full sun by that collected beneath the canopy a protection factor (PF) for the tree can be estimated. (summarized in table 1). This can be compared with the SPF value allocated to sun screen lotions for instance. (it should be noted that sun screen lotions with SPFs in the 30+ range barely achieve a rating of 10 in normal applications. Most users apply less than the requirement for the designated protection value.)

It was subsequently determined that 4 horizontal badges placed at the points of the compass 1 metre from the trunk provided sufficient data to adequately assess the relative UV shading effect of a tree's canopy at the centre. An experimental design using 4 replicates of 6 species at 12 sites was settled upon. It was expected that sufficient data would be collected over 3 to 4 months to statistically validate any differences between species. It was considered possible to take the results and calculate a central horizontal UV protection factor for each tree species and rank them. While providing valuable data about ambient UV levels, doses that could be measured by vertical polysulphone badges were not considered necessary for the initial assessment of canopy effects and the ranking of tree species.However for the sake of collecting some information about the scattered UV irradiance an outward facing vertical badge was deployed on each of the northern targets.

Final Experimental Design

Requirements:

- Six common local street tree species were chosen and four individual specimens representative of the species were chosen in 2 locations. (eg 2 trees per street in 2 different streets.) The species were: *Melia azedarach* (White cedar), *Jacaranda mimosifolia* (Jacaranda), *Brachychiton populneum* (Kurrajong), *Lophostemon confertus* (Brush Box), *Celtis australis* (Mediterranean nettle-tree) and *Koelreuteria paniculate (*Golden-rain tree)
- Individual trees were selected to represent typical mature examples of the species in the street environment.
- A suitable central location for measuring UV irradiance in the open.
- 100 witch’s hats.
- 75 horizontal badge holders and 25 horizontal/vertical badge holders.
- 125 polysulphone badges per month.
- 15 volunteer assistants

Procedure: Testing days

UV measurements under trees (and in the open sun for reference purposes) were conducted on one day per month until a total of 4 sets of data were collected. Measurements were only taken on days with no cloud cover over the solar disc during any part of the measuring period.. The first measurements took place in Jan 2005 and repeated on the same trees at monthly intervals until April 2005. As some deciduous species commenced leaf drop by early April, and the most critical period of UV exposure risk had passed, continuation of measurement activity ceased.

Each measurement day 2 volunteers were despatched to each group of four trees. The target placement for each tree had previously been marked with paint so that the four traffic cones could be consistently arranged around each tree one (1) metre from the trunk at the four compass points (N, S, E, W,) on each test day. One hour before solar noon a polysulphone badge was mounted horizontally to the top of each target. The badge was exposed for 2 hours then removed and protected from further UV exposure. During the exposure period the badge numbers and their locations were recorded. A parallel set of data using badges exposed for one hour while attached to a volunteer sitting in the SW sector of one specimen of each species was collected for comparison. In addition 4 witches hats were similarly placed in the full sun on each day and badges exposed for 2 hours at the same time as those under the trees. After removal the polysulphone badges were sent to ARPANSA in Melbourne for analysis. The data collected was statistically analysed and mean PF values for each species calculated (results summarized in table 2)

Results

Table 1

Tree species	UV dose Mean J/m2	% Ambient Mean	PF value Mean
Open Sun	1437		
Quercus canariensis Algerian Oak	28.4	2.00%	50
Ulmus procera English Elm	48.8	3.40%	29
Corymbia citriodora Lemon Scented Gum	473.4	32.90%	3
Lophostemon confertus Queensland Box	104.9	7.30%	14

Table 2 (Modified). UV Protection Factors of 6 different Tree Species

	11 Jan	17 Feb	8 Mar	12 Apr	Average
White Cedar	**9.5** ± 1.1	**9.3** ± 1.7	**8.3** ± 1.3	**4.7** ± 2.0	**7.95**
Jacaranda	**6.3** ± 0.9	**10.4** ± 3.9	**8.1** ± 2.5	**6.4** ± 2.1	**7.80**
Kurrajong	**5.3** ± 2.5	**5.6** ± 2.5	**4.4** ± 1.5	**3.3** ± 1.6	**4.65**
Brush Box	**7.5** ± 1.3	**8.2** ± 1.5	**6.3** ± 1.1	**4.1** ± 1.3	**6.52**
Celtis	**8.2** ± 4.9	**8.9** ± 4.5	**6.6** ± 4.7	**4.1** ± 2.0	**6.95**
Golden Rain	**8.1** ± 2.7	**7.9** ± 2.6	**6.7** ± 2.3	**4.8** ± 2.8	**6.87**

[1] Values calculated from the average of the four horizontal measurements taken around each of 4 trees.
(n = 16)

[2] Values calculated from both standard deviations of the ambient and standard deviations of the tree measurements.

Collecting UV exposure data on fixed and human targets beneath *celtis australis*

Discussion

1. The results of the Treenet Shading SA study show differences between tree species (see Table 2). These differences are significant statistically.
2. The results of the Treenet Shading SA study show that street trees provide sun protection factors similar to many purpose built structures and standard personal protection strategies.
3. The results of the Treenet Shading SA study have more details and species than any other study so far, and also deal with Australian species, which is particularly relevant.
4. An important conclusion drawn in the Treenet Shading SA study is that tree architecture (height, width, and shape of canopy) is more significant than individual species performance. In park like settings PF values approaching 50 have been obtained. (table 1) Tree management strategies to maximise UV protection are a possibility.
5. Extending the study to include validation of UVR vs light levels is a worthwhile future activity. This would enable a large amount of data to be collected simply and economically in all Local Government areas.
6. In order to draw more accurate conclusions regarding the six species studied it is desirable to carry out similar measurements in October, November and December 2005. This could be achieved economically since the methodology is proven and ARPANSA and TREENET have established a cost effective experimental regime.

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