Measuring the Drought Tolerance of Plants

By Todd Layt

Abstract

WUCOLS (Water Use Classifications of Landscape Species) is a system used by landscape architects in California to calculate the irrigation requirements of plants. A committee from over a decade ago decided on which plants fit into which category of water use, but new plants need a method to be considered as low water use plants as well. This paper provides landscape architects with a number of new plants they can now use as proven low water use plants. For non-irrigated areas of Australia, it helps specifiers choose plants that will live through severe drought cycles. For regions in Western Australia and areas of Australia that have almost no summer rainfall, it quantifies how much irrigation is required to keep a plant looking good. Australian east coast landscape professionals can now monitor projects planted with various plants, and use real world weather data in dry times to calculate the landscape coefficient of various plants.

This paper uses real world data from many sites in Eastern Australia which receive only natural rainfall, monitoring plants over periods of drought. By using the water rates the plants survive and prosper with and plugging those rates into WUCOLS equations, it is easy to calculate the landscape coefficient for each plant. This provides specifiers with another, more accurate method to calculate the landscape coefficient needed by the WUCOLS formula.

Introduction

Claims are regularly made that plant types are drought tolerant, but evidence is rarely produced to prove these claims are true. These drought tolerant claims are mainly judgmental. Roadsides in Eastern Australia are usually planted and watered with a water truck for a few months, or planted after rain in autumn until they are established. After they are established, no irrigation is applied. Year after year these landscapes live only on natural rainfall. This paper explores a method for measuring how much water these plants received over a given period. Richmond NSW, Windsor NSW and other locations were used in this study to show how many millimetres certain types of plants can survive on.

Weather data for the Richmond and Windsor area is well recorded at two stations, namely the RAAF (Royal Australian Air Force) base, and the University of Western Sydney. This paper uses this data, data from other similar stations and the fact that many roadsides have been planted around those areas that live on natural rainfall. The information gathered from this study will help landscape architects and designers choose drought tolerant plants based on real world data and accurate measurements of how much water the plants received. This is important for not just roadside plantings, but for any planting where drought tolerant plants are required. The measurements of drought tolerance will help ensure more reliable landscape designs, and measure how much water these plants require to remain not only alive, but also healthy looking.

In some regions where plants need a little irrigation to survive such as Perth, Western Australia and dry regions of California in the USA, this data will help designers calculate how much water the plants need to survive summer. In Perth, low water use roadside plants usually are irrigated at a minimum of 80mm per month. Perth is dryer like many desert areas of California, but the real tough part for Perth is its really sandy soils. In California there is often no summer rain, however, in many dry regions plants are watered at a rate of 50mm per month or more in summer for low water use plants. Exact irrigation rates are calculated for each region by the WUCOLS formula. In California, a plant has to be categorised as a low water use plant in the WUCOLS document to be used as such. Many plants, particularly new plants from Australia, are not listed. This was the reason why this research was commenced. Many Californian landscape architects wanted proof that many Lomandra and Dianella plants fit into the low water use category. This research, however, has benefits for both Australian and Californian landscape professionals.

The idea behind categorising plants into low, medium or high water requiring plants is a good idea. Unfortunately until now, this has to be done on a subjective basis as in WUCOLS, based on horticulturists opinion, and was last done a decade ago. The WUCOLS document had a lot of conflicting data, with some plants rated as low in really dry areas, yet listed as medium in wetter regions. Now, with the methods outlined in this paper and the monitoring of landscape sites that live just on natural rainfall in slightly less dry regions that are very hot, plants can actually quantitatively be judged by whether they actually survive and are healthy at various rainfall figures over summer, rather than rated by peoples opinion. This method is more accurate than just making a well educated guess.

Many sites have been studied that had less than 50mm of rain per month on average over the hot months in Eastern Australia. This information is not only useful for Eastern Australia as to what plants will survive on natural rainfall, but also for regions like Perth and California, so they can see for certain what will survive in hot summers with less than 50mm of water per month. Some sites show many plants can survive on close to half that in summer, whilst other plants die. Pan evaporation rates were also correlated for some of these sites in Eastern Australia and parts of California, providing further evidence that these calculations are correct. Reference evapotransporation rates are available for these regions, which made calculations relatively straight forward.

Materials and Methods

Various roadside landscapes were chosen to be monitored over a two year period near Richmond and Windsor in NSW from May 2008 to May 2010. These areas were chosen due to their accurate rainfall recordings. They were also chosen due to the fact that trial gardens were being installed at a site in Clarendon, which is right next to the RAAF base weather monitoring station. Some of these trial gardens were not watered at all over parts of this trial period, and over all of the period selected for publishing in this paper.

Over the chosen period, the plantings were monitored and it was noted which plants lived and which plants died at various sites. The period chosen to report for Richmond was a particularly dry period. In fact, it was a 6 month period that was one of the driest periods on record for the region. After the dry period, rains came back and we also monitored which plants recovered better from the extreme dry. Photographic evidence was recorded for the plants in many of the trial areas. The soil types varied over the many sites, but were mainly heavy type soils. Visual inspection of the various sites was conducted to see which type of plants generally lived and which type died. As there were multiple sites, the data was confirmed on a number of occasions, making the data more reliable. Many thousands of each plants type were often planted, so this evaluation was based on large numbers of plants. The same type of study was conducted for other Eastern Australian sites. Regions that experienced drought were used in this evaluation. Generally, these regions have significantly more rainfall than dry parts of California and Western Australia. Even in the dry periods chosen, these Eastern Australia sites have more rain than the dry parts of California and Western Australia. The reason these projects are relevant for these regions as well as the East Coast of Australia, and the reason why these particular dry periods were chosen, was that they had a much dryer summer than low water use sites would have had; for example, in California and Perth under low water use irrigation, even in most periods of water restrictions. This data is very relevant for East Coast Australian landscape professionals, as it can allow them to plan for drought in their no irrigation plantings. This real world factual data was then run through the WUCOLS formula and true real world landscape coefficients were calculated for many plant varieties.

Results

Richmond

The weather data was collected from the Bureau of Meterology's (BOM) website (see Appendix A for link). For 8 months from June 2009 to January 2010 only 172.6 mm of rain fell. This period was chosen because of the lack of rainfall.

That is on average approximately 5mm per week. This was one of the driest periods in history for the sites. Most of the Lomandra including **Tanika** ® Lomandra longifolia 'LM300' ⓓ, Lomandra longifolia '**Katrinus**' ⓓ, and Lomandra longifolia '**Katrinus Deluxe**' ⓓ survived and prospered, although at the worst point they wilted slightly, but as soon as water arrived in February thanks to some good rainfall, they bounced back within 7 days to looking green again.

Tanika ® Lomandra longifolia 'LM300' ⓓ was the only Lomandra planted under large median strip plantings of Eucalyptus. Other plants were also used in these plantings including Dianella Breeze, and other plants. Only Lomandra **Tanika** ® Lomandra longifolia 'LM300' ⓓ survived the drought and the dry hydrophobic conditions created by the Eucalyptus plantings. Lomandra longifolia '**Katrinus**' ⓓ and Lomandra longifolia '**Katrinus Deluxe**' ⓓ were not used under the Eucalyptus. Other plant types that did well or died in the general areas are listed for each site later in this section of the paper. The dry was over some of the hottest months including January, which only had 22.4 mm of rainfall, and an average maximum temperature of 31.6 Celsius with 6 days or more over 37 degrees and the hottest temperature of that month being 43.3C. Remember, there is no irrigation on these sites, only recorded rainfall. It is the summer results that are important for California and Perth irrigation rate calculation. These figures are also important for East Coast no irrigation areas, or for far inland East Coast regions that are extremely dry and may need to use some irrigation.

Rainfall in mm over the period.

June 2009 - 29.6mm

July - 16.6mm

August - 6.8mm

September - 4.2mm

October - 23.8mm

November - 13.8mm

December - 55.4mm

January 2010 - 22.4mm

Total over 8 months - 172.6mm, an average of 21.6mm or 0.85 inches per month. This would equate to 258.9mm or 10.19 inches per year if the average was hypothetically equated over from the average over 12 months. The 3 warmer months had an average of 30.5mm.

The plants were monitored at various sites, and it was noted on each site which type of plants generally died and which lived. It was also monitored which plants came back after it rained. In general, all sites seem to have the same plants mainly living or mainly dying. Over the months of November, December and January the plants at Richmond received only an average of 30.53mm or 1.2 inches of water per month. These were three of the four hottest months for that year. This rainfall is less than the 50mm they would receive in California for low water plants in very dry regions using irrigation. Some of the plants had slightly dry leaves at the end of January, with so many 40 degree days, and only 30mm of water on average, but with a wetter February, the ones that performed well bounced back.

What happened to the plants in summers that got close to 50mm on average of rainfall? In December 2009, Richmond received 55.4mm, which kept the low water use plants green and healthy looking. The same thing happened in 2008 where December had 63mm. The dryer months, with only 22.4mm in January 2010, tended to dry the leaf of many of the plants. Eg; Lomandra plants in-rolled their leaf, but as soon as better rain fell the month after, many of the plants bounced back within a few days to looking green again. This is evidence that approximately 50mm in these type of conditions is enough for the maintenance of healthy plants.

Sites

Intersection of Richmond Rd, Macquarie St, and Hawkesbury Valley Way.

Plants that survived.

Tanika ® Lomandra longifolia ‘LM300’ ⓓ

Little Jess ™ Dianella caerulea ‘DCMP01’ ⓓ

Callistemon **Little John**

Lomandra longifolia ‘**Katrinus Deluxe**’ ⓓ

Plants that had more than half lost.

Breeze® Dianella caerulea ‘DCNCO’ ⓓ

Note: Many appeared to die on this site around January 2010, but by April 2010 about 50% of the ones that appeared to be dead had reshot from rhizomes under the ground. Still, compared to **Little Jess** ™ Dianella caerulea ‘DCMP01’ ⓓ, **Breeze**® Dianella caerulea ‘DCNCO’ ⓓ had much poorer results.

Windsor Rd McGraths Hill to Rouse Hill.

The rain fall at Box hill in 2009-2010 was 90mm from November to the end of January. An average of 30mm per month. So at the Rouse Hill end the rainfall was slightly more than the Richmond figures, but the plants at the Rouse Hill end had to endure similar hot days in summer, and survive with only 30mm of rain.

Plants that survived.

Tanika ® Lomandra longifolia ‘LM300’ ⓓ

Little Jess ™ Dianella caerulea ‘DCMP01’ ⓓ

Lomandra longifolia ‘Katrinus Deluxe’ ⓓ

Imperata Cylindrica

Note: This Australian native type is far more drought tough than the Rubra form from Japan.

Rivan ™ Kunzea ambigua ‘KA01’

Plants where a proportion died due to drought.

Hardenbergia violeacea

Note: About 20% of these had died due to drought. This could be due to the fact that Hardenbergia is such a variable species.

Plants that had more than half lost.

Breeze® Dianella caerulea ‘DCNCO’ ⓓ

Note: Many appeared to die on this site around January 2010, but by April 2010 about 25% of the ones that appeared to be dead had reshot from rhizomes under the ground. Still, compared to **Little Jess** ™ Dianella caerulea 'DCMP01' ⓓ, **Breeze**® Dianella caerulea 'DCNCO' ⓓ had poorer results.

Common Dianella caerulea almost all died.

Dianella longifolia all died.

Trial gardens at the corner of Ingolds lane and Cupitts lane Clarendon, opposite the RAAF base where the rainfall data was compiled.

Plants that survived.

Lomandra longifolia '**Katrinus Deluxe**' ⓓ

Meema™ Hardenbergia violacea 'HB1' ⓓ

Mundi ™ Westringia fruticosa 'WES05' ⓓ

Naringa™ Westringia 'WES01' ⓓ

Nyalla ® Lomandra longifolia 'LM400' ⓓ

Tanika ® Lomandra longifolia 'LM300' ⓓ

Anigozanthos hybrid '**Gold Velvet**' ⓓ

Little Jess ™ Dianella caerulea 'DCMP01' ⓓ

Savanna™ **Blue** Lomandra filiformis 'LMF500' ⓓ

Baby Bliss® Dianella revoluta 'DTN03' ⓓ

Little Rev ™ Dianella revoluta 'DR5000' A Did better in this dry period, than it normally does through wetter Western Sydney summers.

Cassa Blue® Dianella caerulea 'DBB03' ⓓ Did better in this dry period, than it normally does through wetter Western Sydney summers.

Lucia™ Dianella caerulea 'DC101' ⓓ

Westringia fruticosa. Well established common forms.

Xanthorrhoea spp.

Casuarina cunninghamiana. All lived, but were mature plants that were 7 years old.

Doryanthes excelsea

Callistemon **Kings Park Special**

Callistemon **Captain Cook**

Callistemon **Little John**

Callistemon Endeavor. About 10% died.

Poa labillardieri '**Eskdale**' ⓓ

Nafray ® Pennisetum alopecuroides 'PA300' ⓓ

Purple Lea ® Pennisetum alopecuroides 'PA400' ⓓ

Pennstripe™ Pennisetum alopecuroides 'PAV300' ⓓ

Plants that generally died.

Lomandra confertifolia. Most varieties died, as did the common form. The best performer from this group was WINGARRA, where about 1/3 of the plants that were less than 2 years old died, but all that were three years old or older all lived.

Breeze® Dianella caerulea 'DCNCO' ⓓ

Note: Many appeared to die on this site around January 2010, but by April 2010 about 40% of the ones that appeared to be dead had reshot from rhizomes under the ground. Still, compared to **Little Jess** ™ Dianella caerulea 'DCMP01' ⓓ, **Breeze**® Dianella caerulea 'DCNCO' A had poorer results.

Common Dianella caerulea almost all died.

Dianella longifolia all died.

Dianella revoluta common Tasmanian form all died. Interestingly a lot of seed for Dianella revoluta

comes out of Tasmania and is sold in dryer regions of Australia.

Purple Phormium types. All died except **Flamin'**® Phormiuim tenax 'PHOS3' ⓓ. But the **Flamin'**® Phormiuim tenax 'PHOS3' ⓓ survived due to 5 applications by watering can of water over the period. We knew this would die if no water was added. The other types still died with 5 waters with a watering can.

Cordyline australis; about 30% survived. Purpurea type.

Utopia ® Dianella prunina 'DP303' ⓟ

Society Garlic

Mondo Grass

Liriope muscari About 50% of these appeared to have died. They were well established. By spring next year, most had either re-shot from rhizomes, or spread from adjacent plants.

Callistemon **Hannah Ray**

Lomandra hystrix. The ones on dry slopes died, but the ones in wetter areas at the bottom of the slope lived, or those on flat ground did well.

Dianella tasmanica. **Tasred** ® Dianella tasmanica 'TR20' ⓟ, **Wyeena**® Dianella tasmanica 'TAS300' ⓟ, and **Destiny**™ Dianella tasmanica 'TAS100' ⓟ most died.

Ruby Velvet™ Anigozanthos hybrid 50% died.

Sites near Penrith

Penrith has marginally more rainfall than Richmond, but it was still very dry.

June 2009 - 28.8mm

July - 15.4mm

August - 8.0mm

September - 13.8mm

October - 52.0 mm

November - 13.6mm

December - 31.4mm

January 2010 - 43.6mm

Total - 206.6 mm; an average of 25.82mm. This would equate to 309.9mm per year if the average was hypothetically equated over from the average over 12 months.

Only one plant was monitored on this dry sloping site. It was **Cassa Blue**® Dianella caerulea 'DBB03' ⓟ. It survived well.

South Morang, Melbourne, VIC

This dry land planting went through a dry summer in 2007-2008. There were also a number of very hot days that summer.

November 2007 - 65.1mm

Dec - 79.3mm

Jan 2008 - 30.3mm

Feb - 35.7mm

March - 52.2mm

April - 17.3mm

May - 39.8mm

June - 24.5mm

July - 50.3mm

August - 53.4mm

Sept - 16.2mm

Oct - 19.0mm

Total - 483.1mm for 12 months. Average for the year of 40.25 mm per month. An average of 48.43mm in the three summer months.

Plants that survived.

Tanika ® Lomandra longifolia 'LM300' ⓟ

Nyalla ® Lomandra longifolia 'LM400' ⓟ

Cassa Blue® Dianella caerulea 'DBB03' ⓟ

Plants that partially died.

About 25% of Dianella **Silver Streak** died.

Dianella ensifolia.

Plants that generally died.

Festuca glauca

Carpobrotus spp. They actually survived this period, but died the year after. It could have been due to cold rather than dry.

Ballarat, Victoria

December 2009 - 32mm

January 2010 - 25.8mm

February 2010 - 26.0mm

An average over the three summer months of 27.93mm per month.

Plants that survived

Tanika ® Lomandra longifolia 'LM300' ⓓ

Lomandra longifolia '**Katrinus**' ⓓ

Baby Bliss® Dianella revoluta 'DTN03' ⓓ

Little Jess ™ Dianella caerulea 'DCMP01' ⓓ It does well in the dry, but the very cold Ballarat winter does send it dormant. It reshot after winter.

Little Rev ™ Dianella revoluta 'DR5000' ⓓ

Plants that died

Themeda australis '**Mingo**' ⓓ. About a third died.

Bendigo

December 2009 - 19mm

January 2010 - 13.6mm

February - 43.6mm

An average of 25.4mm per month. In January, the middle month of summer, the average

temperature was 37.77 Celsius, or 88.7 F. There were 4 days in that month over 100F or 37.77C and January only had 13.6mm of rainfall.

Plants that lived

Tanika ® Lomandra longifolia 'LM300' ⓓ

Little Rev ™ Dianella revoluta 'DR5000' ⓓ

Information for Perth, WA and California, USA

The following information may help these regions to calculate irrigation rates, and to fit plants into water use categories.

Information for Eastern Australia: The water use categories and the appropriate plants could be used to choose plants for low or no irrigation landscape plantings.

How would the WUCOLS formula work with these plants based on this research?

The WUCOLS formula is based on the Evapostranspiration (ET) rate for a particular region in California plugged into a formula with other variables. We can use the formula given, which calculates the amount of water required to keep a plant alive.

Working out the landscape coefficient of a plant type.

1) To keep a plant alive.

30.5 mm of rain per month in summer 2009/2010 Richmond. This did happen so this is fact and not an estimate.

ETL = KL ETois the equation used by WUCOLS.

From the Australian Richmond studies we know the figure for the ETL 30.5mm.

From the BOM we also know the average ETo for the same period in Richmond was 177.1mm

30.5mm = KL 177.1mm

30.5mm/177.1 = KL

0.17 = KL

From real world data we have proven that the plants that survived this drought in Richmond have a landscape coefficient of 0.17, if the aim is to just keep them alive. (Note: later the average ET rate for certain towns in California will be shown. This data is available in the USA. The same data could be made available for Australia, although this is work for another paper.)

2) To keep plants healthy.

If we choose a region that has a similar temperature to Australia, build in a margin for error of 40%, and use the recommended watering rates for Australia obtained from this real world research for the region as the ETL (water need of the planting). Based on this Richmond research, a rate of 42.7 mm or 1.85 inches builds in a higher safety margin (40%) to ensure a healthy plant. As the plants wilted slightly under a very hot dry January of 22mm of rain in Richmond but still survived well, it is reasonable to conclude that a much higher rate of 42.7 mm will keep the plants healthy. This is almost double the month of January that they actually survived well. Based on the following calculations the plants that survived fit easily into the low water use category of WUCOLS.

The ET rate of Riverside or Temecula in California is 7.9 or less. The ET rate for Richmond for this period was 177.1mm or 6.972 inches plug this into the formula, with 42.7 mm or 1.85 inches inches being the ETL rate, we can work out the KL (landscape coefficient) for the plant in question based on very conservative real world data. As this is real world data, and fact, it is a more reliable method than using a committee to estimate the landscape coefficient.

ETL = KL ETois the equation used by WUCOLS.

From the Australian studies we know a conservation figure for the ETL 42.7mm.

42.7mm = KL 177.1

42.7/177.1 = KL

0.24 = KL

Thus the landscape coefficient for the plants that survived the drought periods in Australia, with a 40% margin for error, can be conservatively stated as having a landscape coefficient of 0.24, which means that plants such as Tanika ® Lomandra longifolia ‘LM300’ ⓟ are classed as low water use plants in the south inland valley, based on real world data.

3) Super conservative figures.

Based on this research a rate of 50.8 mm or 2 inches builds in a huge safety margin than up to 70% more than it was necessary to keep a plant alive. It is probably unfair on the plants to use this rate, but it does demonstrate that even at this higher rate the plants that survived still fit into the low water use category as outlined by WUCOLS.

ETL = KL ETo is the equation used by WUCOLS.

From the Australian studies we know a conservation figure for the ETL 2 inches.

2 = KL .972

2/ 6.972= L

0.286 = KL

WUCOLS lists the categories high, moderate and low that indicate how much irrigation water is thought to be needed to maintain plant health and appearance, and are expressed as a percentage of reference evapotranspiration (ETo).

H = 70 - 90% ETo

M = 40 - 60% ETo

L = 10 - 30% ETo

Thus, based on this data, these plants easily fit into the low water use category. For a list of plants recommended for this water use category, see Table 1 in Appendix A.

This research is important for California, in that it quantifies with real world data whether the plants fit into the low water use category. If they do it will allow landscape architects new plants to use based on the WUCOLS system that were not around at the time of evaluation. It also provides a system to better calculate the landscape coefficient of other plants based on real world data, and not conjecture.

Reference ET Conditions. Reference evapotranspiration (ET_0) approximates water loss from a large field of 4 to 7 inch tall, cool season grass that is not water stressed. This is how the ET_0 is calculated for the WUCOLS calculations. Australia also has ET_0 rates calculated by the system that is recognised as the standard system by the UN. Based on the formula in WUCOLS, the evidence in this paper proves the plants that survived these droughts are low water use plants.

Pan evaporation rates for both places were also calculated. For example, in Richmond, in the 3 hottest months of the calculation period the pan evaporation average monthly rate was 11.3 inches per month, slightly higher than the 10.23 average from June and July from Riverside in California. So over the test period in Richmond, the pan evaporation rate was higher than that of Riverside, California. This shows correlation between the two regions, and as the rate is higher in Richmond for the period, it is further evidence that using these analysis is worthwhile.

Based on this and the temperature similarities of the hot dry year from Richmond and Riverside/ Temecula, this evidence supports the comparisons highlighted in this paper.

Producing a similar WUCOLS document for Australia would require additional work to achieve, but by using evaporation data in combination with this data in this paper, it could be used to calculate how much water in summer these plants need to keep growing well. Regions like Perth have additional burdens in certain regions, namely sandy soils that will increase the amount of irrigation required. Based on the information listed here, the same formula could be used with adjustments for sandy soils. These calculations could be conducted in another paper.

Discussion

Based on this study, landscape architects and designers can design landscapes that will handle long dry periods and low rainfall. But for extremely dry regions that need to irrigate to keep plants alive, this data will allow them to specify plants that have been proven a number of times in the real world to live on low summer rainfall. Often water rates of less than 30mm kept the low water use plants alive, but at this low rate of water they sometimes discoloured or went untidy. Where approximately 40mm or 50mm of water occurred, the plants stayed healthy and green looking. Based on this research, for very dry summer regions that basically get no or little summer rain and have heavy type soils, this means 40mm or 50mm of irrigation in summer will be adequate for regions that average close to 33 C or 91.4 F in summer.

In reality, most regions in this type of climate zone use 50mm of irrigation per month to keep the low water plants looking healthy. For regions that average closer to 37.77C or 100 degrees F in summer, or for regions that have very sandy soils like Perth, it would be wise to increase that irrigation to a higher rate of 80mm per month or more. Or use the WUCOLS formula instead for region 6 zones in deserts to calculate the irrigation rate, which may still allow these plants to be used as low water use plants. The Woculs formula can simply be used to work out the irrigation rate.

All the sites tested in Australia are regularly prone to multiple days higher than 40 C or 104 F, but the average was generally around or lower than 33C or 91.4 F. For example, Temecula in California has average summer temperatures that fit with the data formulated from this study in Australia. Based on this study, 50mm of water in July in Temecula will keep these low water use plants healthy with a high margin for error. In the Woculs document, irrigation rates are listed for many towns for low water use plants. See Table 2. Based on the research in this paper, using irrigation rates in the low water use plants column for 0.3 would be a conservative and sensible irrigation rate. In reality, as low water use plants listed in the Woculs document do not list which column they belong to most cautious specifiers use that column rate for irrigation.

Drought is not the only reason why plants are not suited to a region. For example, every few years in Richmond there is a very hot, humid and wet summer, so plants for that region not only need to handle the dry, but they also need to handle wetter humid conditions. That is why regions like Bendigo, Ballarat or Melbourne see plants like Cassa Blue® Dianella caerulea 'DBB03' ⓟ and Little Rev ™ Dianella revoluta 'DR5000' ⓟ do well, yet in Richmond these plants will do well some years when it is dry, but will fail when it is wet and humid. Humidity is not a problem in California or Perth. Cold is another factor that needs to be taken into account. Little Jess ™ Dianella caerulea 'DCMP01' ⓟ seems to do well in Western Sydney, but in Ballarat or Bendigo they spend much of there time brown from winter cold and suffer more in the prolonged winter. However, they do re-shoot each year.

For low water use plants in dry climates such as inland NSW and other dry areas of Australia, or for areas where landscape architects and designers want to eliminate the risk of dead plants through drought, provided they have low to moderate draining soils, the following equations can be used to work out the amount of irrigation required if no or little rainfall is expected in the summer months. This is using Richmond as guide as the calculations have been done for it. Of course doing the calculations for the region would be more accurate, but the data is not always easily available.

To keep a plant alive: 30.5 mm per month in summer 2009/2010 Richmond. This did happen so this is fact and not an estimate.

ETL = KL ETo is the equation used by WUCOLS.

From the Australian Richmond studies we know the figure for the ETL 30.5mm. (Rainfall mm)

From the BOM we also know the Average ETo the same period in Richmond was 177.1mm

30.5mm = KL 177.1mm

30.5mm/177.1 = KL

0.17 = KL (landscape coefficient) 0.24 to keep plants healthy.

How do we use this data in other areas? Let's look at Perth for example, where the ETo from the BOM website in the hottest months last summer in 2011 was approximately 277.

ETL = KL ETo

Irrigation required = 0.24 x 277mm

Minimum irrigation required to keep these extra tough drought tolerant plants looking good is 66.48mm. Based on the WUCOLS system, generally drought tolerant plants are said to have a maximum ETo of 30. So to be safe for drought tolerant plants in Perth, based on the woculs formula, the following could be said to be the case.

ETL = KL ETo

Irrigation required = 0.30x277mm

Minimum irrigation required to keep these extra tough plants looking good is 83.10.

Minimum irrigation required to keep the extra tough plants looking good is 66.48mm. If a safety margin is added for general drought tolerant plants, and to add a safety margin for these plants for an extra hot summer, a safe figure of 83.10mm of irrigation per month could be considered based on the WUCOLS equation.

Conclusion

Based on this paper, plants that survived the dry periods in Australia based on real world data can use the equation based in the Woculs document. Further based on that formula, they are low water users. This is based on fact and real world data, and is more reliable than opinion.

Further, the formula could be used for drought tolerant plants in general for Australia by simply using the equation and calculating what irrigation is required for an area assuming there is no rainfall in summer. This can be done by obtaining the data through the BOM website, and using .30 for the ETo for drought tolerant plants, and .60 for medium drought tolerant plants. A table has been added in the appendix as a guide for some areas.

Appendix

All weather Data is available from:

www.bom.gov.au/climate/data/weather-data.shtml

List of Plants that survived drought. Plants proven to be in the low water use category.
Plant variety
Tanika® Lomandra longifolia 'LM300' ⓓ
Little Jess™ Dianella caerulea 'DCMP01' ⓓ
Lomandra longifolia '**Katrinus Deluxe**' ⓓ
Callistemon Little John
Imperata Cylindrica (Note: this native Australian type is fare more drought tough than the Rubra form from Japan.)
Kunzea ambigua
Meema™ Hardenbergia violacea 'HB1' ⓓ
Mundi™ Westringia fruticosa 'WES05' ⓓ
Naringa™ Westringia 'WES01' ⓓ
Nyalla® Lomandra longifolia 'LM400' ⓓ
Anigozanthos hybrid **'Gold Velvet'** ⓓ
Savanna Blue™ Lomandra filiformis 'LMF500' ⓓ
Baby Bliss® Dianella revoluta 'DTN03' ⓓ
Westringia fruticosa (Well established common forms.)
Xanthorrhoea spp.
Casuarina cunninghamiana (All lived, but were mature 7 year old plants.)
Doryanthes excelsea
Callistemon Kings Park Special
Callistemon Captain Cook
Callistemon Little John
Callistemon Endeavor (about 10% died.)
Little Rev™ Dianella revoluta 'DR5000' ⓓ
Lucia™ Dianella caerulea 'DC101' ⓓ
Poa Eskdale
Nafray® Pennisetum alopecuroides 'PA300' ⓓ
Purple Lea® Pennisetum alopecuroides 'PA400' ⓓ
Pennstripe™ Pennisetum alopecuroides 'PAV300' ⓓ