Final Report

Project title:

Evaluation of Nursery Tree Stock Balance Parameters

Project leader:

Prof. Mark G. Tjoelker

Delivery partner:

Western Sydney University

Project code:

NY15001

Date:

29 March 2019

Confidentiality:

Is this report confidential?

☒ No

☐ Yes (whole report)

☐ Yes (sections of report are confidential)

If sections of the report are confidential, list them here:

Disclaimer:

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Content

Summary

Quality assessment of nursery-grown trees for landscape use has gained increased attention in the industry with the recent adoption of a national standard; yet questions remain regarding specification criteria and their broad applicability in the Australian nursery context. In particular, the criteria for assessing tree stock root to shoot balance remains poorly understood. This knowledge gap was the subject of a recent nation-wide research project on tree stock balance (NY15001) undertaken by researchers at Western Sydney University.

This study of 23 production nurseries throughout Australia revealed wide natural variation in the metrics used to quantify root to shoot balance under the national standard AS 2303:2015 *Tree Stock for Landscape Use*. Research findings were used to provide recommendations to Australia Standards for a revision of the standard. Following wide consultation and public comment, the national standard for tree stock quality assessment was revised and updated. AS 2303:2018 "*Tree Stock for Landscape Use*" was published on 21 December 2018. The objective of this final project phase was to communicate research findings back to growers and stakeholders and facilitate wide uptake and adoption of the newly revised quality assessment standard for nursery-grown trees for landscape use.

This objective was achieved through the development and delivery of a nation-wide roadshow. The branded roadshow included a research presentation and discussion, live demonstrations in nurseries and supporting educational materials (tool kit, how-to-guide, videos) and an online tree stock balance calculator. Roadshow events were held in Melbourne, Adelaide, Perth, Brisbane, Darwin and Sydney. The six events attracted 518 registered participants, including growers, councils, arborists, landscapers, landscape architects and other "green life" professionals.

Keywords

AS 2303:2018 *Tree Stock for Landscape Use,* Container-grown Trees; Nursery;

Introduction

Under project NY15001, a team of investigators from Western Sydney University travelled to each mainland state and territory, visiting 23 wholesale nurseries and collecting biometric data on nearly 14,000 container-grown trees, sampling 159 tree varieties. One of the key research findings was that specifications for root to shoot balance in AS2303:2015 did not adequately capture existing natural variation across the large diversity of trees ready for dispatch in Australian nurseries. Of otherwise standard-conforming trees, only 32% fell within the specified range for root to shoot balance.

These research findings were used to revise the tree stock balance provisions of national standard AS 2303:2015 *Tree Stock for Landscape Use.* Project leader, Prof. Mark Tjoelker, was nominated to the Australia Standards Committee EV-018, Arboriculture, representing Western Sydney University as research provider and independent expert on the tree stock balance provisions.

Following consultation and public comment, the new standard (AS 2303:2018) was adopted and published on 21 December 2018. The revised standard provides new criteria and a wider range of acceptable root shoot balance. The new preferred range encompasses the 25th to 75th percentile of size index values for a given container volume across the full range of container sizes (20 to 3000L) typically used in Australia. The new standard ensures that quality assessments adequately encompasses the natural variation of tree stock produced in Australia.

The purpose of this engagement project was to communicate research findings to growers, horticulture, landscape industry stakeholders and facilitate uptake and adoption of the new nation-wide quality assessment standard for nursery-grown trees for landscape use.

Methodology

Research findings and promotion of the new standard were delivered through a nation-wide roadshow to industry stakeholders. The research and communications team at Western Sydney University developed a coordinated, branded roadshow. The team produced supporting educational materials, including a roadshow tool kit, a "how-to- guide" for quality assessment, and online tree stock balance calculator based on the revised Australian Standard AS 2303:2018. Accompanied by a targeted promotions campaign via press releases and social media, the roadshow events were successfully delivered to stakeholder audiences in six capital cities.

Outputs

1. Trade conference engagement (two national conferences)

Presentation to TREENET 2017 national symposium (Adelaide, South Australia)

Tjoelker, MG, CE Campany, RA Duursma, S Pfautsch, MJ Aspinwall, D Thompson. 2017. Insights into standards for nursery-grown tree stock. TREENET Proceedings of the 18th National Street Tree Symposium. 7-8 September 2017, Adelaide, South Australia (invited symposium presentation).

High-definition video recording of the presentation (24 minutes, publicly available): https://www.treenet.org/resources/insights-standards-nursery-grown-tree-stock/

Presentation to the 2018 biennial national conference of the Nursery and Garden Industry (Hobart, Tasmania)

Tjoelker, MG, CE Campany, RA Duursma, S Pfautsch, MJ Aspinwall, D Thompson. 2018. Insights into standards for nursery-grown tree stock. Nursery and Garden Industry National Conference "*The Growing Edge*." 19–21 February 2018, Hobart, Tasmania (invited presentation).

2. Trade journal articles (two total)

Nursery Papers July 2017: Testing the tree stock standard. *Hort Journal Australia* **10(1)**, 21–24.

Summary. The Australian standard for producing quality landscape trees ensures a nationally consistent benchmark for quality tree stock for landscape use. A component of the current standard focusing on root to shoot balance criteria can be influenced by the climate trees are grown in, the species of tree, the treatment they receive in the nursery, and regional differences in their performance. In 2016-2017, researchers assessed 13,820 trees in 23 wholesale nurseries to see how well Australian Standard 2303:2015 Tree Stock for Landscape Use applies to trees of different species and climates in nurseries across the country, with specific emphasis on tree stock balance and size index equations. This Nursery Paper looks at the findings of their research and their recommendation that the current standard is modified.

Nursery Papers April 2019: Roadshow unveils new tree stock standard. *Hort Journal Australia* **11(9)**, *4 pages* (in press).

Summary. A new benchmark to assess the quality of Australian trees has been unveiled by Western Sydney University's Hawkesbury Institute for the Environment (HIE) at a series of capital city workshops last month. The new standard, AS 2303:2018 *Tree Stock for Landscape Use*, follows two years of research funded by Hort Innovation using nursery industry levies and funds from the Australian Government. In this Nursery Paper, we revisit the research findings that led to a broader, more applicable tree standard, as well as the national roadshow, which brought together 450 growers and landscape professionals to learn about the updated criteria.

3. Roadshow events (six events)

The roadshow was launched in Melbourne at the "*Three Days of Trees*" event (31 October to 2 November 2018). This roadshow project was a key event sponsor, helping underwrite the costs of hosting Dr. Ed Gilman from the University of Florida (USA) as lead speaker for the three-day event that included workshops and a tree stock quality assessment demonstration. Each of the remaining five roadshow events were designed around a half-day schedule (typically 9:00 am to 1:00 pm) that included a slide presentation/discussion, morning tea, live demonstration of the application of the standard by Western Sydney and nursery hosts and lunch.

City	Event/Venue	Date	Registered Attendees
Melbourne	"*Three days of Trees*", University of Melbourne, Burnley Campus	1 November 2018	175
Adelaide	Salisbury United Football Club & Heyne's Nursery	5 March 2019	34
Perth	Ellenby Tree Farm	7 March 2019	73
Brisbane	Caboolture RSL & Rothpark Nursery	12 March 2019	94
Darwin	Darwin Central Rydges Hotel	14 March 2019	22
Sydney	Alpine Nurseries	19 March 2019	120
		Total	518

4. Education and outreach products

Project website with project description, educational materials and explainer videos: http://bit.ly/TreeStocks

Online assessment tool to calculate size index and assess compliance with the tree stock balance provisions of the new standard: http://treestocker.westernsydney.edu.au

Roadshow presentation providing a research summary and introduction to the new standard AS 2303: 2018 "*Nursery Tree Stock for Landscape Use.*"

Roadshow "tool kit" consisting of branded promotional materials, including calipers, tape measure, pen, thumb drive.

Project brochure describing the key research findings, the new standard and a "how-to-guide" for assessing tree stock quality.

Tree standard summary card describing the testing process and new tree stock balance provisions in the standard.

Outcomes

This project provided research-based information that led to revision of the national standard for assessing and specifying nursery tree stock quality, AS 2303:2018 *Tree Stock for Landscape Use*. The nation-wide roadshow delivered research-based information and promoted use of the standard to over 500 participants from across the nursery, landscape and green life industry, councils, and general public. A project website with educational materials and accompanying online tool provide on-going resources to inform growers and buyers on the principles of tree stock quality assessment. In the intermediate to longer term, increased focus on tree stock quality and its specification will help drive product quality and consumer confidence in the tree nursery industry and, in turn, facilitate market growth and public support for local, state and national urban greening initiatives.

Refereed scientific publications

Chapter in a book or Paper in conference proceedings

Tjoelker, M.G., Campany, C.E. Duursma, R.A, Pfautsch, S., Aspinwall, M.J. Thompson, D., 2017. Insights into standards for nursery-grown tree stock. In Williams, G. (Ed.), TREENET Proceedings of the 18th National Street Tree Symposium 7 – 8 September 2017, pp. 55-60. (This document is publicly available as a free download).

Intellectual property, commercialisation and confidentiality

No project IP, project outputs, commercialisation or confidentiality issues to report.

Acknowledgements

I acknowledge David Thompson and Laura Castaneda Gomez of Western Sydney University for their efforts in creating and developing the roadshow promotional and educational materials and program. I acknowledge Dr. Sebastian Pfautsch of Western Sydney University, who along with David Thompson attended and presented at a number of roadshow events. I thank the nurseries who participated in hosting the roadshow. These include Damien Choate of Mt. William Advanced Tree Nursery, Carl Heyne and staff of Heyne's Nursery, Craig Woodroffe and staff of Ellenby Tree Farm, Robert Percy and staff of Rothpark Nursery, Kym Zammit and staff of Paradise Nursery and Ken Bevan and Nick Holdsworth and staff of Alpine Nursery. Finally, I thank Sophie Keatinge and Meg Pearce of Cox Inall Communications for superb event logistics coordination and communications support.

Appendices

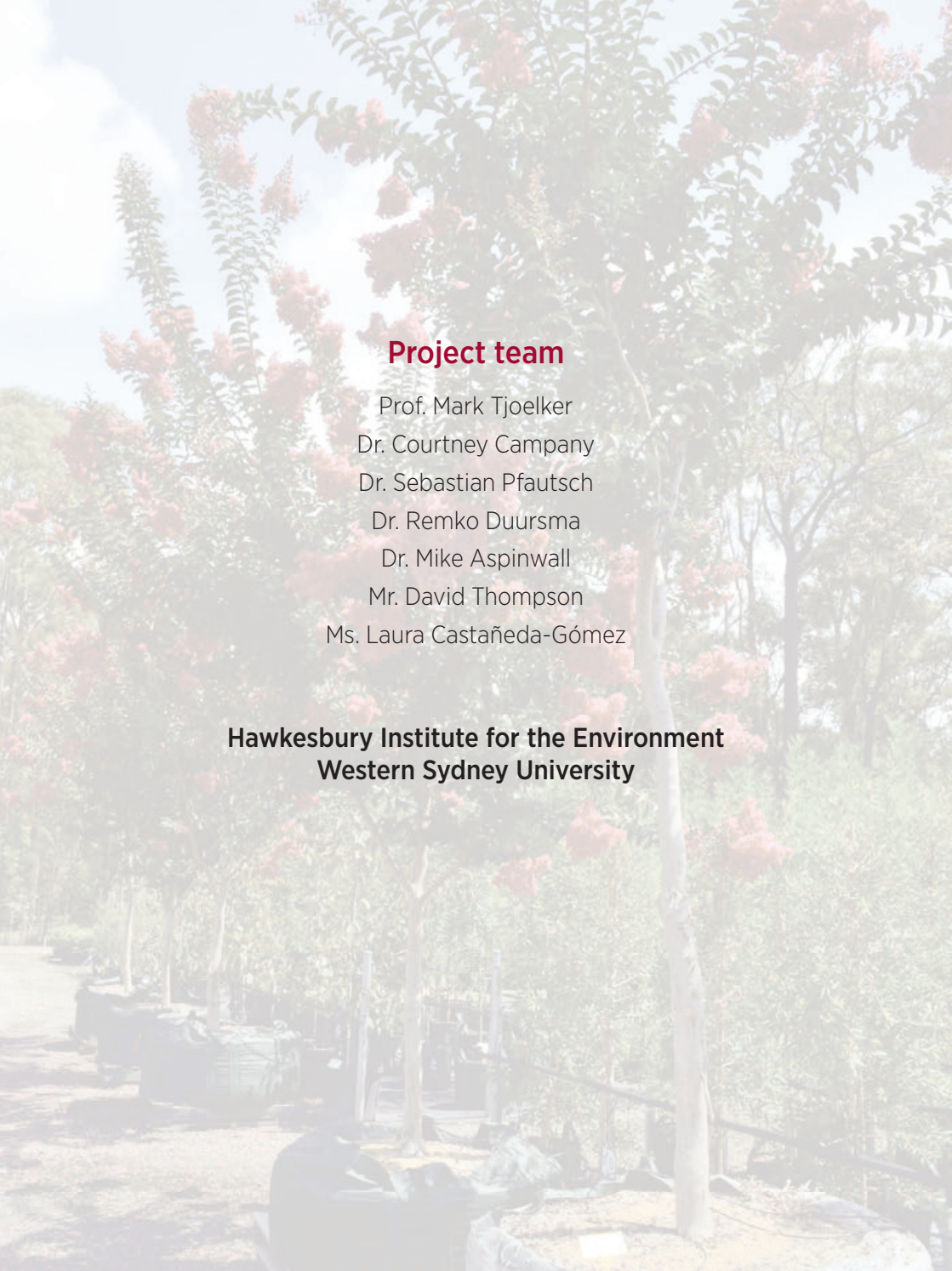
Project brochure describing the key research findings, the new standard and a "how-to-guide" for assessing tree stock quality.

Tree standard summary card describing the testing process and new tree stock balance provisions in the standard.

TREE STOCK STANDARD PROJECT: A BETTER WAY TO ASSESS THE QUALITY OF AUSTRALIAN TREES

Outreach tour 2018

Testing the Australian Standard AS 2303:2015



Project team

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The relevance of trees in urban landscapes

Healthy trees are integral to sustainable urban landscapes now and in the future. Never before have trees received the current level of attention as key component of sustainable urban design, delivering substantial benefits to ever growing cities. These services include cooling, stormwater mitigation, carbon sequestration, improving air quality, biodiversity and property value, as well as making our cities more liveable and sustainable.

Major national initiatives such as the 202020Vision are on their way to increase urban green cover by 20% by the year 2020. Also, Western Sydney University, in collaboration with Hort Innovation and its "Hort Frontiers Green Cities Fund", have embarked upon a 5-year plan to develop planning tools, engaging the public and stakeholders in a new conversation about urban greening and the role that trees play in urban ecosystems.

hort frontiers
Strategic partnership initiative

GREEN CITIES FUND

Container-grown trees are the building blocks of greener and more sustainable city landscapes

Nurseries and consumers play a crucial role in the development and success of such initiatives. Industries and markets involved in urban greening depend on high quality tree stock. High quality container-grown trees increase planting success with enhanced rates of survival and growth in the urban landscape.

Nationally-recognised Standards help in assessing the quality of container-grown trees. Improved tree stock quality generates profits for growers and raises confidence in consumers. Following the guidelines for qualitative and quantitative metrics specified in such Standards to assess tree stock, helps ensure the successful establishment of container-grown trees in landscape plantings.

Tree Stock Standard Project: from the Australian Standard 2303:2015 to the revised AS 2303:2018, Tree Stock For Landscape Use

Adopted in April 2015, the AS 2303:2015 Standard is currently used to assess the quality of trees within three main categories: aboveground, belowground and the root to shoot balance. The industry called for **new research to validate the Standard**, particularly the root to shoot balance metrics, through field surveys of trees produced in nurseries throughout Australia.

Specifying root to shoot balance criteria in Standards has been problematic owing to a lack of information on potential influences of biological variation among species, nursery production practices and the role of climatic influences on root to shoot balance.

The importance of root shoot ratios and the balance concept

Functional and structural plant traits are important in ensuring a healthy tree. These functional traits are reflected in structural balance between root and shoot in container-grown trees. Thus, how a tree is grown and whether the root ball is of sufficient structural integrity to support a self-standing shoot is key to enhancing positive legacy effects of container-grown trees following dispatch and planting.

The **Tree Stock Standard Project** was initiated to better understand how the shoot to root balance varies with species and climatic regions. This information was later used to support the development of the new **AS 2303:2018, Tree Stock Standard for Landscape Use.**

A nation-wide field survey of 14,000 trees in production nurseries assessed tree stock characteristics. Researchers visited 23 wholesale nurseries where they assessed 650 production batches that ranged in container size from 18L to 3000L. Only stock deemed ready for sale and that had passed the above-ground and below-ground quality criteria set out by AS 2303:2015 were measured.

Research Methodology

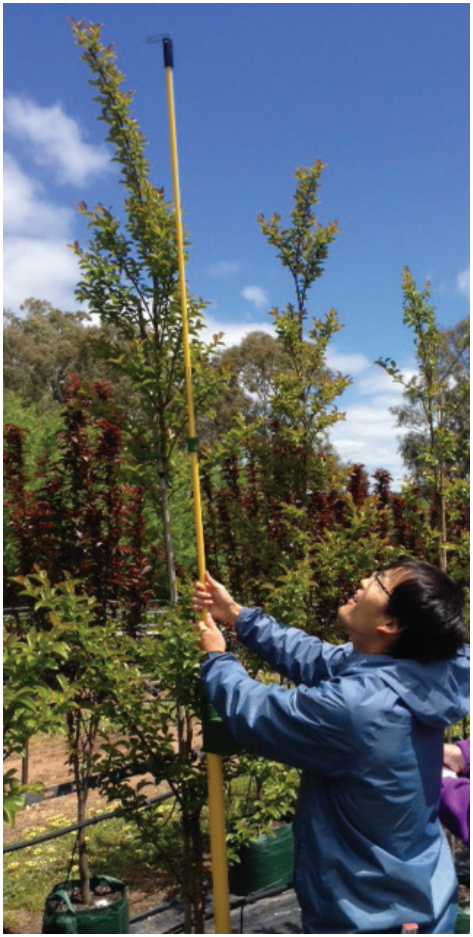
1. Identify batches of trees ready for sale by consultation with nursery.
2. Complete visual assessments of above and below-ground morphological quality.
3. Measure the tree's height and calliper on a large selection of trees that have passed step 2.
4. Measure additional factors such as canopy width and leaf sizes.
5. Collect climate, production information from each nursery.

Why? *This methodology ensures that the trees being measured possess the quality morphological attributes required at dispatch. From this database we can assess variation in above-ground tree size in relation to container size, species, climate and nursery.*

Introducing the new AS 2303:2018, Tree Stock for Landscape Use

The research output from the Tree Stock Standard Project was used to modify and develop new criteria to assess the root to shoot balance in tree stocks. These new criteria better reflect the variability of the Australian tree stock and the climate regions and species available in nurseries.

With the research completed, a wider range of preferred sizes (size index values) for a given container volume is now included in this Standard.



TESTING PROCESS FOR THE AS 2303:2018 STANDARD

Before starting

Containerized and ex-ground tree stock?

- Place tree stock on a firm surface
- Do not remove the container
- Remove any stakes or support system if present

1

Above ground testing

- Is tree stock labelled correctly? (True to type).
- Have you measured and recorded height and calliper?
- Does tree stock exhibit good health? Check crown density, cover and form. Leaf colour and size. Absence of epicormic shoots and dieback.
- Is the crown symmetric?
- Is the stock free of significant injury? (no wounds, bleeding areas, cracks, fungal bodies).
- Does the stem taper? Calliper at any point on the stem should be less than calliper at any lower point on the stem.
- Is the tree self-supporting? Does it exhibit a good stem and branch structure?
- Does the formative pruning follow AS 4373?
- Are branch and stem unions free of inwardly turned concave bark?
- Is the trunk position within 10% of the centre of the rootball diameter?
- If grafted tree stock, is the graft union sound and compatible?
- Is the tree stock free of active pests and diseases?

This information has been extracted from AS 2303:2018 Tree Stock for Landscape Use as a broad guide. Refer to the original text of the Standard for a more detailed explanation of the measurements necessary to assess your tree stock.

Bare-rooted tree stock?

2 Balance and rootball assessment

- Have you calculated the size index? Size index is the product of the stem height from the root crown to the top of the trunk (m) multiplied by the calliper (mm).
- Does the size index fall within the 25th to 75th percentile for a given container size? (Appendix D)
- Have you assessed the rootball diameter, depth, height of root crown?
- Is your tree stock free of suckering rootstock and active pests or diseases?

3 Below-ground testing

- Is the rootball fully occupied? (at least 90% of the growing media remains intact upon removal of container)
- Are the roots growing in an outwards (radial) or downwards direction?
- Is the rootball free of j-roots, girdled, kinked and circling roots?

4 Bare-rooted tree stock testing

- Is rootball diameter ≥ 10x the calliper?
- Are the roots growing in an outwards (radial) or downwards direction?
- Is the rootball free of j-roots, woody circling roots, kinked roots or girdled roots?

Key Findings from the Tree Stock Project

A large proportion of otherwise conforming trees ready for sale do not fall within the size index range set by AS 2303:2015

- Size index at a given container volume exhibits large natural variation among trees surveyed across Australia
- Only 32% of measured trees fell within the specified range across all container sizes (18 to 3000L)
- 23% of measured trees exceeded maximum limits
- 45% of measured trees fell below minimum limits

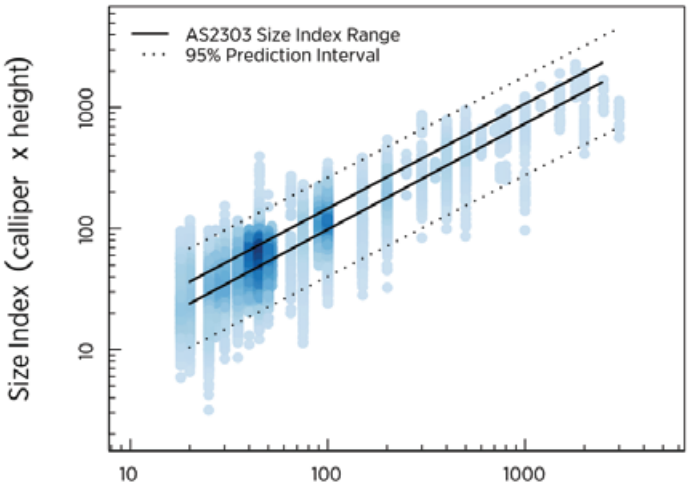


Figure 1. Above-ground size index across a range of container sizes for trees measured across 23 production nurseries in Australia. The specified size index range in the AS 2303:2015 Standard is shown with solid lines. The 95% prediction interval shown with dotted lines was obtained from the Tree Stock Research Project. A large proportion of the measured trees, ready for sale, do not fall within the set range by this Standard.

Table 1. Top 10 genera by numbers of species surveyed

Genus	Species
Eucalyptus	18
Ficus	6
Acer	5
Corymbia	5
Syzygium	4
Callistemon	3
Fraxinus	3
Melaleuca	3
Quercus	3
Araucaria	2

The variation against the AS 2303:2015 Standard differed with container size

Trees in smaller container sizes tended to be larger than specified by the Standard, compared to trees in larger container sizes which tended to be smaller than specified by the Standard.

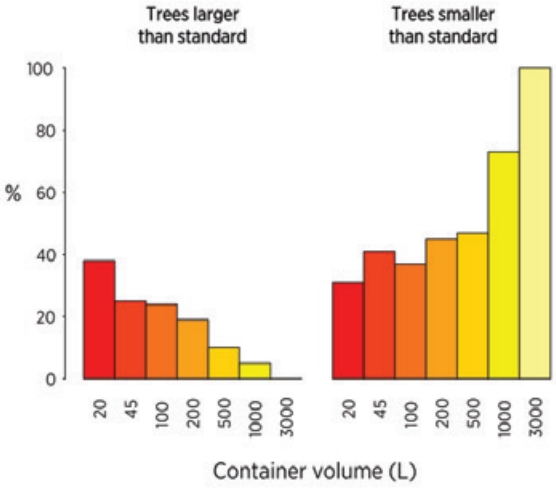


Figure 2. Percentage of trees by container volume that deviated from AS 2303:2015. More plants in small containers (20-100L) were larger than specified by the Standard. Tree stock in large containers (500-3000L) were smaller than specified in the Standard.

Size index variation is influenced by broad species differences

Non-native deciduous trees tended to have greater size index values than native evergreens in smaller (<50 L) container sizes, contributing to the observed natural variation among tree stock.

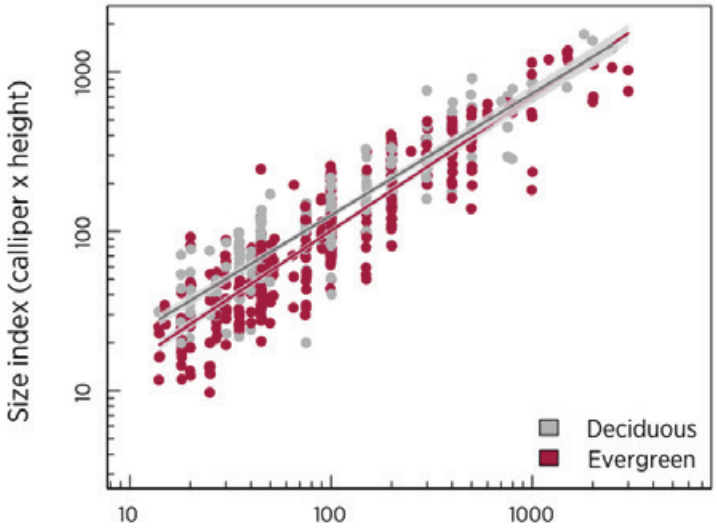


Figure 3. Size index variation of deciduous and evergreen trees. Deciduous trees in containers with a volume less than 50 L, on average, tended to have higher size index values than evergreen trees.

Origin	Leaf habit	Species (varieties)
Native	Deciduous	10
Native	Evergreen	75
Non-native	Deciduous	58
Non-native	Evergreen	16

Table 2. Native and non-native trees.

Ranking	Species (variety)	Sites	Regions
1	Corymbia maculata	10	NSW, SA, VIC, WA
2	Angophora costata	12	NSW, QLD, SA, VIC, WA
3	Magnolia grandiflora Little Gem	10	NSW, QLD, SA, VIC, WA
4	Callistemon viminalis Kings Park Special	7	NSW, SA, VIC, WA
5	Jacaranda mimosifolia	12	NSW, NT, QLD, VIC, WA
6	Lagerstroemia indica Natchez	9	NSW, QLD, SA, VIC, WA
7	Lophostemon confertus	9	NSW, QLD, VIC
8	Araucaria heterophylla	12	NSW, NT, QLD, SA, VIC, WA
9	Waterhousea floribunda	9	NSW, QLD, VIC, WA
10	Ficus microcarpa Hilli Flash	7	NSW, QLD, VIC, WA

Table 3. Top 10 species by numbers of trees surveyed

To sum up

- The specified range of size index in AS 2303:2015 captures only about one third of otherwise conforming trees ready for dispatch at Australian nurseries nation wide.
- Trees in smaller containers tended to exceed the upper limits of size index more so than trees in larger containers.
- Landscape tree stock have a much greater natural variation in size index than the AS2303:2015 Standard specifies. This could mean that buyers are rejecting trees based on a Standard that is **OVER-LIMITING** compared to real-world tree production.
- A modified generalised specification of root to shoot balance with revised upper and lower limits is now included in the Standard. These new criteria were adopted to better reflect the variability of Australian tree stock across climate regions and the species available in nurseries (Table 4).

Table 4. New and wider range of preferred sizes (size index values) for a given container volume included in the revised AS 2303:2018.

Nominal container volume (L)	5th percentile	Preferred range			95th percentile
		25th percentile	50th percentile	75th percentile	
18	10	17	25	36	57
20	II	19	27	39	62
25	14	23	33	47	73
27	15	25	35	50	77
30	16	27	38	54	84
35	18	31	44	61	94
40	20	35	49	68	104
45	23	38	54	75	114
50	25	42	59	82	124
52	26	44	61	84	127
65	31	53	74	100	151
75	35	60	84	113	168
90	42	71	98	130	193
100	46	77	107	142	209
150	65	111	151	196	284
200	84	142	193	247	354
250	102	173	233	295	419
300	119	203	272	341	481
350	136	233	310	385	541
400	153	262	347	429	598
500	186	318	420	512	709
600	218	373	490	593	814
700	250	428	559	670	915
750	265	454	592	708	964
800	281	481	626	746	1012
1000	341	585	756	891	1199
1200	400	686	883	1031	1377
1500	487	835	1067	1232	1631
1800	571	980	1246	1425	1872
2000	626	1075	1363	1550	2028
2500	761	1308	1647	1852	2402
3000	892	1535	1923	2142	2758

Advisory board members

Dr Anthony Kachenko	*Hort Innovation*
Mr Ken Bevan	*Alpine Nurseries*
Mr Tim Carroll	*Andreasens Green*
Ms Carole Fudge	*Benara Nurseries*
Ms Leanne Gillies	*Fleming's Nurseries*
Mr Hamish Mitchell	*Specialty trees*
Mr Chris O'Connor	*Nursery and Garden Industry Australia*

Nursery and staff

Adelaide Advanced Trees
Adelaide Tree Farm
Alpine Nurseries
Andreasens Green-Kemps Creek
Andreasens Green-Mangrove Mountain
Arborwest Tree Farm
Benara Nurseries
Cleveland Nursery
Darwin Plant Wholesalers
Ellenby Tree Farm
Established Tree Transplanters
Fleming's Nurseries
Freshford Nurseries
Greenstock Nurseries
Heynes's Nursery
Ibrox Park Nursery
Logans Nursery
Manor Nurseries
Mt William Advanced Tree Nursery
Pallara Trees
Plants Direct
Speciality Trees
Trees Impact

This project "Evaluation of Nursery Tree Stock Balance Parameters" (NY15001) has been funded by Hort Innovation, using the nursery research and development levies and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture.

TREE STOCK STANDARD OUTREACH

A better way to assess the quality of Australian trees

Nursery & Garden Industry Australia

Hort Innovation

WESTERN SYDNEY UNIVERSITY

Hawkesbury Institute for the Environment

TESTING PROCESS FOR THE AS 2303:2018 STANDARD

Before starting

- Place tree stock on a firm surface
- Do not remove the container
- Remove any stakes or support system if present

1 Above ground testing

Includes assessment of tree height, calliper, crown density, cover and form as well as stem dimensions and trunk position. Moreover, observations of the health of the tree stock, absence of injuries, active pests and diseases, adequate formative prunning and compatible graft unions must also be assessed.

Bare-rooted tree stock?

Containerized and ex-ground tree stock?

2 Balance and rootball assessment

- Requires calculation of the **size index (si)** = stem height (m) x calliper (mm) and checking that this value falls within the 25th to 75th percentile for a given container size.
- Assess the rootball diameter, depth, height of root crown and absence of suckering rootstock and active pests or diseases.

3 Below-ground testing

Involves checking that the rootball is fully occupied, roots growing in correct direction and free of girdled, kinked and circling roots.

4 Bare-rooted tree stock testing

Includes measurements of rootball diameter and making sure that the roots are growing in the correct direction and free of j-roots, woody circling roots, kinked roots or girdled roots.

This information has been extracted from AS 2303:2018 Tree Stock for Landscape Use as a broad guide. Refer to the original text of the Standard for a more detailed explanation of the measurements necessary to assess your tree stock.

TREE STOCK STANDARD OUTREACH

WHAT'S NEW?

Thanks to the **Tree Stock Standard project**, the shoot to root balance assessment was revised and new criteria were adopted to better reflect the variability of Australian tree stock across climate regions and the species available in nurseries. The research has provided a new and wider range of preferred sizes (size index values, see Table) for a given container volume, now included in the revised **AS 2303:2018**.

Nominal container volume (L)	5th percentile	Preferred range			95th percentile
		25th percentile	50th percentile	75th percentile	
18	10	17	25	36	57
20	II	19	27	39	62
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65	31	53	74	100	151
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1200	400	686	883	1031	1377
1500	487	835	1067	1232	1631
1800	571	980	1246	1425	1872
2000	626	1075	1363	1550	2028
2500	761	1308	1647	1852	2402
3000	892	1535	1923	2142	2758

Visit our TreeStocker App **(treestocker.westernsydney.edu.au)** to check if the size index of your stock falls within the specified range.

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