Growing confidence in forestry's future Research Programme 2013-2019

Newsletter

SCION

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2017 has been a productive year for the Growing Confidence in Forestry's Future (GCFF) research programme. Here we highlight some exciting areas of research that have recently started or have produced significant results for industry. Within the team, David Pont, Grant Pearse and Marta Gallart have successfully received their PhDs – a great achievement. The Forest Growers Levy Trust has provided new funding to expand and accelerate the nursery research undertaken within the GCFF programme. The fourth annual GCFF conference was held in Dunedin. The focus was on productivity issues in southern forests and drew attention to the impact of higher stocking rates on stand productivity and profitability. Conference attendees visited the Berwick long-term site productivity trial and saw the final stages of the biomass sampling prior to the harvest of the last remaining trial in this series. Harvesting this trial is a major step towards completing an experiment that was established 30 years ago and again highlights the value of long-term trials. Field crews have been busy undertaking end-of-rotation assessments of the silvicultural breeds trials and preparing for the winter planting of the next two accelerator trials.

The next two years will be crucial as the time is nearing when significant effort needs to be given to how the programme will be re-bid. This also coincides with the process for voting for a continuation of the forest growers' levy. These processes are important and the programme team will be engaging with as many stakeholders as possible to ensure that the industry gains the most from the research currently underway, and in planning the next programme of research activities.

Peter Clinton *(Programme Leader)* and the research team.

Listening to the dawn chorus in the Douglas-fir stand at Ross Creek Reserve at the start of the GCFF field trip. Photo: Simon Papps, HFMNZ

Research updates

Staff from Yamaha and Scion celebrate the successful application of treatments to a trial area near Rolleston, Christchurch (left). *A practice application by the UAV* (right).

Will the application of plant hormones to trees improve wood quality?

The GCFF team is investigating the effects of different plant hormone concentrations on cambial growth and the formation of earlywood and latewood to see if wood quality (density) can be improved without sacrificing wood volume. Wood density is related to the duration and rate of cambial growth. If the period of cambial growth can be extended, then the average wood density could potentially be increased with the production of more high-density latewood in each annual growth ring.

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In April this year, a field trial was set up to test whether the application of the plant hormone gibberellic acid (GA) could influence the wood quality of a mid-rotation radiata pine stand in Canterbury. Gibberellic acid is naturally found in plants at very low concentrations. It generally stimulates cell divisions and elongation in the cambium and induces fiber formation.

Our trial is investigating the effectiveness of exogenous GA application for manipulating wood formation in three radiata pine clones with contrasting growth rates.

Gibberellic acid was applied at rates of between 3 and 20 g/ha using an unmanned aerial vehicle (UAV). With help from Yamaha Motor – New Zealand Sky Division, spray mixtures were applied to the crowns of 48 trees using a purpose built timer calibrated to apply a volume equivalent to current operational practices at 100 L/ha.

Micro-cores from treated and untreated trees are being collected with a Trephor tool (see below) once a month and microscopic changes in cell growth will be investigated.

For more information, please contact *Jianming.Xue@scionresearch.com* or *Graham.Coker@scionresearch.com*

Predicting the optimal post-thinning stand density for radiata pine in New Zealand forests using productivity indices

Research recently published in the *Canadian Journal of Forest Research* describes how growth and yield models have been used to predict the optimal final crop stocking rate that maximises the commercial value of radiata pine stands (Watt et al, 2017). If trees are grown too closely together they can be tall and spindly whereas excessively wide spacing encourages branch growth and underutilisation of site resources. Somewhere in between lies an optimal final crop stand density that allows forest managers to maximise the volume and value of the logs produced.

The research linked the two commonly used productivity indices (Site Index (SI) and 300 index (I_{300})) for radiata pine with environmental information such as climate and soil types to develop productivity maps, or surfaces, covering the whole country. The next step was to use the Forecaster growth and yield simulation system to predict the volume of S27 logs (logs with a small end diameter > 270 mm and diameter of the largest branch < 70 mm) that could be grown under a standard framing silvicultural regime for various combinations of SI, $I_{300}$and stand density.

From this a relatively simple model for predicting optimal stocking (S_{opt}) from I_{300}, SI and rotation length was developed for New Zealand. The average S_{opt} for growing S27 logs predicted by the model was 614 stems/ha, with S_{opt} increasing from north to south. Given that the average stand density for unpruned sawlog regimes is around 500 stems/ha, there is clearly scope for increasing the volume of high-value log products grown in New Zealand's planted forests as well as the value obtained from each hectare of forest.

While 614 stems/ha is an average optimal stand density across New Zealand, site-specific recommendations can be made by considering local variations in productivity indices, and thus taking local environments into account.

Further details can be found in Watt et al (2017) and are contained in the presentation made at the GCFF conference in Dunedin *(www.gcff.nz)*.

For more information, please contact *Michael.Watt@scionresearch.com*

Microcore sampling using a Trephor tool.

Shedding new light on wood formation in radiata pine

Wood is produced in the cambium. Fundamental knowledge on the cambium activity, and its mechanisms of action, allows us to control the wood formation process in order to try to maximise productivity without compromising wood quality.

Cambium activity is being studied within selected experiments in the GCFF programme by extracting a series of microcores comprised of cambium and developing xylem at regular time intervals (bi-weekly or monthly) throughout the growing period. A Trephor tool is being used for this.

Scion scientists have developed a novel confocal fluorescence-based method for using microcores to study cambium dynamics (Dickson et al. 2017). This method enables us to determine the timing of various stages of wood formation – division, enlargement, wall thickening and lignification. In turn, this allows researchers to determine the optimal timing for applying fertilisers or growth promoting treatments.

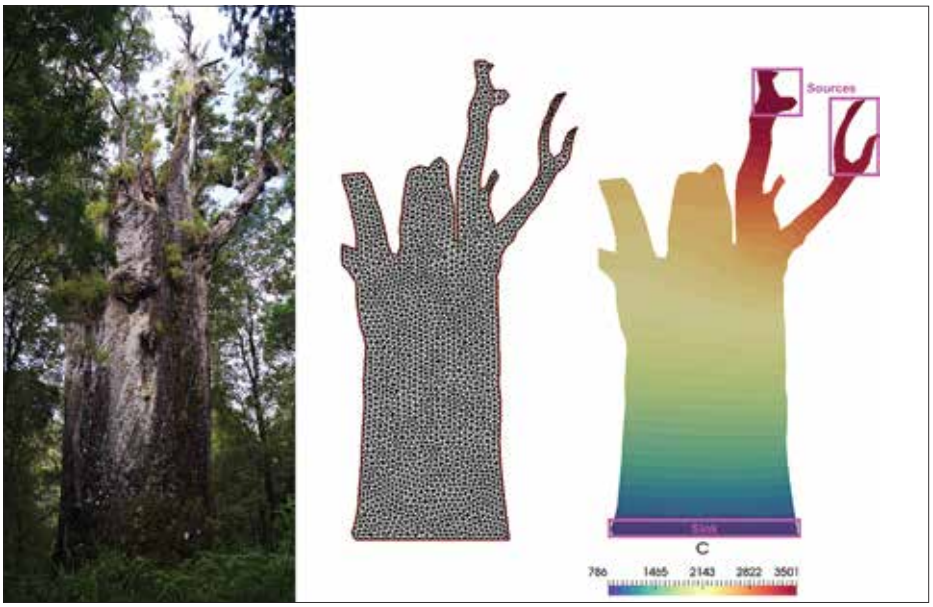
A key advantage of microcoring is that it allows us to measure the wood formation response to a particular treatment shortly after applying it. This has been demonstrated with a recent trial where different forms of urea fertilisers (foliar spray vs granular form) were applied to mid-rotation trees. The differences between the treatments were detected by microcoring several consecutive months after applying them.

Further insights into the biology of tree growth and wood formation are being obtained through the research being carried out by Damien Sellier. Damien has developed a model of sugar transport for trees in collaboration with French researcher, Youcef Mammeri from the

Laboratory for Fundamental and Applied Mathematics (LAMFA/CNRS). The model represents an important advance in the study of the dynamics of sugar translocation in real trees and will improve our understanding of trees' ability to supply sugars for tissue growth and wood formation under intensive regimes. Their work has been recently published in *Mathematical Biosciences and Engineering* (see publication list on last page) and has been supported by a Dumont d'Urville grant from the Royal Society of New Zealand.

For more information on cambium activity please contact *Bernadette.Nanayakkara@scionresearch.com*

For more information on the biology of tree growth and wood formation contact *Damien.Sellier@scionresearch.com*



Modelled sucrose concentration in Te Matua Ngahere using a mesh reconstruction from a photo.

Erosion: mapping, measuring and mitigating*

New Zealand is one of the most erodible countries in the world. Erosion is one of the major challenges that faces our primary industries and is likely to worsen as climate change brings more frequent and intense storms to our shores.

Forestry has a unique role to play in minimising erosion. Established forests are known to stabilise land for long periods and reduce erosion significantly compared to agricultural land uses. However, when the trees are harvested the risk of erosion and debris flows (associated with harvest residues left on site) increases for a period of up to six years until the next crop's canopy is fully established. This period is known as the window of vulnerability and during this time the steep, high erosion risk sites could lose valuable topsoil and incur damage from sediment and woody debris flows either in the forest or on neighbouring lands or water bodies.

Currently, there is no nationally co-ordinated approach to recording and reporting erosion and debris flow events. Without this base of information, it is difficult to gauge New Zealand's erosion problem, identify the factors that cause an erosion event (such as rainfall intensity), and to manage the risk of future events.

Scion's Growing Confidence in Forestry's Future research programme, supported by MBIE and Forest Growers Levy Trust, is addressing this gap with a three-pronged research strategy. It aims to develop methods to map erosion sites across New Zealand, measure the size of the problem and share successful mitigation techniques. Once complete, the research will assist forest managers and regulators to customise their approach to managing erosion risk.

Using citizen science to report erosion. Gathering large amounts of timely data on erosion events is a key part to developing accurate models. Dr Tim Payn, Principal Scientist, and Duncan Harrison, Geospatial Analyst, are leading a citizen science based approach to gather this data through a newly developed mobile app called 'Erode-NZ'.

Tim explains, "Anyone – forest managers, workers, neighbours, the general public – who sees a slip or debris flow can use the app to report the sighting to a national database, accompanied by photos, a description of scale and impact, and GPS co-ordinates. It's a simple tool, but the ability to report sightings as soon as they're discovered will help us build a picture of what led to the event including rainfall, slope and soil type."

The prototype app has been developed on the Thundermaps platform and is currently being user tested. At present, the data uploaded via the app can only be viewed by Scion scientists.

Measuring slips using LiDAR. The Scion team has also begun to use LiDAR to identify past erosion events. By comparing the point set data from two LiDAR flights conducted five years apart, the Scion team was able to locate slips purely from the data and without the need to visit the forest.

Tim explains, "LiDAR hasn't been used in this way before. It's enabled us to find slips that we can't necessarily see because they're covered in vegetation. It can also give forest managers a better understanding of the terrain they're dealing with, enabling them to take precise and proactive measures where they are most needed and most likely to be effective.

"For example, using LiDAR data and our improved modelling, we can provide advice to a forest manager about changing the planting regime for the site, or pinpointing the best location for a debris trap."

Mitigating erosion. The range of adaptive management techniques used to mitigate erosion is also lacking a nationally co-ordinated approach, and foresters are using what they know works for them locally. Our team is learning from their experience by surveying forest managers around New Zealand about the methods they use.

Tim says, "We have found that forest managers are using a wide variety of methods including seeding the soil early with grasses, maintaining riparian margins, using debris traps and altering planting regimes. Through these surveys, we'll match the most successful practices with the receptive land types and share

those findings with the forestry industry."

Scion is also undertaking a planting trial to see how well willow and radiata pine grow when they are planted side by side on a steep slope. This trial is taking place on the erosion prone East Coast of the North Island. The study is 18 months into a four-year programme.

Trial co-ordinator Marie Heaphy says, "We'll be measuring height, root collars and survival of the plants. If the willow can stabilise the soil faster than the radiata pine without inhibiting its growth, we could have another option to help stabilise high-risk sites and shorten the time that the soil is vulnerable".

Revealing the big picture. Combining these approaches will allow us to get an understanding of New Zealand's forestry related erosion from multiple perspectives. This work will provide evidence that will allow forest managers to better understand the erosion risk present on their land, and how they can make targeted improvements to their management practices.

For more information, please contact *Tim.Payn@scionresearch.com*

*This article recently appeared in Scion Connections and is reproduced here with permission www.scionresearch.com/erosion-article

Engagement

4th GCFF Annual Conference, Water Yield Workshop, and the LiDAR Cluster Meeting

The annual 4th GCFF conference 'Productivity Challenges and Opportunities in Southern Forests' was held from 28-30 March 2017 in Dunedin. It included two workshops (LiDAR/phenotyping and Water flows) and a field trip. The event was attended by 53 participants from across the forestry sector, MBIE, science organisations as well as two international speakers from the US and Australia. Presentations from the conference are available on the GCFF website - *www.gcff.nz/news-and-events/gcff-2017-conference-presentations/*

The workshop on 'Water Flows and Regulation from Planted Forests' included perspectives from Scion, the Our Land and Water National Science Challenge and the forest sector on issues relating to planted forests and water yield both within forests and where forests form part of the wider landscape. The discussions during the workshop will contribute towards the development of ideas for a potential new proposal to MBIE's Endeavour fund in March 2018.

For more information, about forest hydrology, including the potential new research proposal contact *Dean.Meason@scionresearch.com*

Scion contributes to the annual New Zealand Farm Forestry Association Conference

Several Scion scientist travelled to Manawatu in April to take part in the 61st Annual New Zealand Farm Forestry Association Conference. The conference brought together delegates from all parts of New Zealand, as well as number of international speakers and visitors. Presentations from Scion scientists were included in the field trip component of the conference, providing the audience with updates on GCFF research into erosion management and control, opportunities to better manage soil nitrogen in afforested ex-pastures, and the extent of the gains that can be made in forest productivity from improved nursery management.

NZFFA conference attendees listening to a presentation describing the potential benefits from reduced chemical applications and the better use of beneficial soil microbes.

This annual event is an important forum for Scion scientists to present and discuss new information with the FFA membership; the research conducted in the GCFF programme has been central to this interaction since 2014. The GCFF team is always looking for opportunities to better engage with NZFFA and provides a regular update for the NZFFA newsletter so please don't hesitate to contact us if you are interested in any of the research projects we are undertaking.

For more information, contact *Simeon.Smaill@scionresearch.com*

Testing our nursery research in the forest

Several nursery trials carried out as part of GCFF projects have shown that reductions in fungicide and fertiliser use can produce seedlings of the same or better quality when leaving the nursery gate, but how much does this matter after those seedlings are planted in the forest? Recent analysis of growth data from a 2010 outplanting trial using stock from a nursery trial has yielded exciting results, indicating that reductions in chemical use increased both survival and growth rates. At this forest site, these gains have combined to produce an 8% gain in basal area after six years.

The interim results from a larger multi-site study, established in 2015, also supports the potential to reduce chemical use in nurseries. This trial series demonstrates that, at worst, seedlings subjected to reduced chemical exposure during their time in the nursery performed exactly as well as those that received standard or increased rates of chemical treatments. While survival and growth rates across the studied sites clearly differed, the extent of chemical use had no effect on either metric at any site, adding support to the already known economic and environmental benefits of reduced chemical use in tree nurseries.

For more information, contact *Simeon.Smaill@scionresearch.com*

From science to practice with sector-led trials

The fundamental driver of the GCFF programme is using research to develop new, practical options for forest management. Taking the step from science to management practice requires a high degree of communication and coordination between Scion and forest managers, firstly to build confidence in how the results were achieved at research scales, and then to determine how to implement and test the science at operational scales. An example of this process is the research being done with a novel soil amendment with the potential to provide multiple benefits for forest performance while avoiding some of the environmental issues associated with conventional fertilisers. Inspired by the initial results from the GCFF programme, Timberlands and Rayonier/Matariki are initiating their own pilot trials with this amendment to determine the extent of any benefits to their forest estate. Scion scientists are providing support to both companies, helping to ensure the trials are sufficiently robust to accurately determine when and how the amendment should be applied. Another example of transferring science to practice is the operational nursery scale trials implemented in conjunction with ArborGen Australasia at their Tokoroa nursery. This developing partnership initially involved trials covering 2.4 ha of seed bed in 2015; one year later this area has expanded to 6.3 ha of nursery space, and has produced a number of successful outcomes.

For more information about this research and the opportunities to establish operational trials, contact *Simeon.Smaill@scionresearch.com*

Collaboration and international linkages

Understanding nitrogen cycling in forests

Brian Strahm from Virginia Tech recently completed a six-month research fellowship with Scion through the Organisation for Economic Co-operation and Development (OECD). Brian's time in New Zealand was spent working closely with GCFF scientists and stakeholders around the nexus of nutrient cycling, forest productivity, and environmental quality. Brian is evaluating the use of nitrogen stable isotopes to reveal additional information about how forests have historically cycled nitrogen. This information can help provide decision support for management decisions like fertiliser addition by indicating which forest stands are likely to show a productivity response to fertiliser addition relative to those where nitrogen leaching losses may occur. To further support this work, Brian has teamed up on direct studies of nitrogen leaching in response to fertiliser addition and is acutely interested in supporting the continued development of NuBalM's belowground component.

Brian Strahm getting more familiar with pumice soils in New Zealand.

Though he has returned to his university faculty position in the Department of Forest Resources and Environmental Conservation at Virginia Tech in the US, he looks forward to coming back to New Zealand in the near future to continue this work and contribute to the overall mission of the GCFF programme.

Bio-engineering traits of radiata pine

The European Geophysical Union has its annual conference each year in Vienna in April. Around 15,000 delegates come from all over the world to present oral papers, posters, and interactive Powerpoint talks. As part of our collaborative links with ecorisQ (a global community of professionals working on natural hazard risk management), a poster was presented (Bio-engineering traits of *Pinus radiata* D.Don) based on our joint research on radiata pine root distribution and how this data is used to calculate root reinforcement which informs slope stability models (SlideForNet and SoSlope). Our New Zealand information provides additional data with which to test and validate these

models. These collaborations enable us to connect with key researchers across Europe and have been fruitful in terms of jointly published papers and posters that are presented at conferences and other opportunities, and ensure our research is internationally benchmarked.

Filippo Giadrossich, Michael Marden, Roberto Marrosu, Massimiliano Schwarz, Chris Phillips, Denis Cohen, and Marcello Niedda (2017). *Bio-engineering traits of* Pinus radiata *D.Don. Geophysical Research Abstracts*, **19**, EGU2017-17854, 2017 EGU General Assembly.

University of Sassari (Italy) researchers conducting root pullout tests on 23-year old radiata pine trees near Gisborne.

A 23-year old radiata pine tree trenched at 1 and 2m distances from the stem to obtain lateral root distribution data.

Looking ahead

Innovation cluster meetings

- **Product Quality Improvement cluster –** on issues related to wood quality and resource characterisation. Half-day workshop on SEGMOD (techno-economic segregation model), 8 November 2017, Rotorua. For general cluster enquiries contact John Moore at *John.Moore@scionresearch.com* or phone 07 343 5425.
- **Forest productivity workshop** (Date TBC)

FOA research conference 17-19 Oct 2017, Christchurch (www.fgr.nz/event)

5th Annual GCFF conference, March 2018 (date TBC)

Selected recent publications related to the GCFF programme

Journal publications

1. Auty D, Moore J, Achim A, Lyon A, Mochan S, Gardiner B (2017) Effects of early respacing on the density and microfibril angle of Sitka spruce wood. *Forestry*, doi:10.1093/forestry/cpx004.
2. Dickson A.R., Nanayakkara B., Sellier D., Mason D., Brownlie R., Donaldson L. (2017) Fluorescence imaging of cambial zones to study wood formation in *Pinus radiata* D. Don, Trees, 31:479-490.
3. Hölbling D, Betts H, Spiekermann R, Phillips C (2016). Identifying spatio-temporal landslide hotspots by analyzing historical and recent aerial photography. *Geosciences*, **6**, 48; doi:10.3390/geosciences6040048.
4. Neary, D G, Baillie, B R. (2016, December). Cumulative Effects Analysis of the water quality risk of herbicides used for site preparation in the central North Island, New Zealand. *Water* (Switzerland) **8**(12), 573.
5. Mammeri Y., Sellier D. (2017). A surface model of nonlinear, non-steady-state phloem transport. *Mathematical Biosciences and Engineering*, **14**, 1055-1069.
6. Moore J, Cown D. (2017). Corewood (Juvenile Wood) and Its Impact on Wood Utilisation. *Curr Forestry Rep*., DOI 10.1007/s40725-017-0055-2.
7. Moore J, Dash J, Lee J, McKinley R, Dungey H. (2017). Quantifying the influence of seedlot and stand density on growth, wood properties and the economics of growing radiata pine. *Forestry*, 1–14, doi:10.1093/forestry/cpx016.
8. Telewski, F.W. and Moore, J.R. (2016). Trait selection to improve wind firmness in trees. *CAB Reviews*, **11** (50):1-10.
9. Thumm A, Riddell M. 2017. Resin defect detection in appearance lumber using 2D NIR spectroscopy. *Eur J Wood Prod*., https://link.springer.com/article/10.1007/s00107-017-1188-5.
10. Watt MS, Kimberley MO, Dash J, Harrison D. 2017. Spatial prediction of optimal final

stand density for even age plantation forests using productivity indices. *Canadian Journal of Forest Research*, **47**, 527-535.

11. Yongjun L, Suontama M, Burdon R, Dungey H. (April 2017 accepted) Genotype by environment interactions in forest tree breeding: review of methodology 1 and perspectives on research and application. *Tree Genetics and Genomes*, **13** (3).

Technical notes

1. Coker G, Evanson T, Gous S, Osorio R, Pearce S, Shailer J. (2017). *Screening trials comparing foliar treatment responses to industry genotypes – 2016/17.* Technical note of the 'Growing Confidence in Forestry's Future (GCFF) research programme, RA1.2, GCFF TN-13, 8 pp.
2. Coker G, Evanson T, Henley D, Leckie A, Manig A. Novoselov M, Osorio R, Pearce S, Scott M, Shailer S. (2017). *Response of mid-rotation applied granular fertilisers on needle mass and nutrition – early learnings from site specific treatments.* Technical note of the 'Growing Confidence in Forestry's Future (GCFF) research programme, RA1.2 ext, GCFF TN-17, 6 pp.
3. Dash J, Dungey H, Watt MS, Clinton P. (2017). *Development of a prototype phenotyping platform for plantation forests.* Technical note of the 'Growing Confidence in Forestry's Future (GCFF) research programme, RA2.1, GCFF TN-14, 8 pp.
4. Smaill S, Beets P, Garrett L, Meason D, Osorio R, Moore J, Clinton P. (2017). *The accelerator trial series – underlying concepts and progress at the first trial site.* Technical note of the 'Growing Confidence in Forestry's Future (GCFF) research programme, RA2.2, GCFF TN-15, 6 pp.
5. Smaill S. (2017). *Examining the potential uses for biuret in New Zealand forestry.* Technical note of the 'Growing Confidence in Forestry's Future (GCFF) research programme, RA 2.3, GCFF TN-16, 6 pp.

Note: Results of this programme and related work are often published in the New Zealand Journal of Forestry Science which has open access. Publications are accessible through their website *(http://www.nzjforestryscience.com/)* Summary abstracts of other subscription only journal publications are typically available online through the individual journal's websites and full information can be accessed by getting in touch with the authors directly. The GCFF website *www.gcff.nz/publications* provides the links to access the published information.

Acknowledgements and links. This research programme is jointly funded by the Ministry of Business, Innovation and Employment (MBIE (CO4X1306)) and the Forest Growers Levy Trust, with the support of the New Zealand Forest Owners Association (NZFOA) and the New Zealand Farm Forestry Association (NZFFA). In addition to this newsletter, the programme website provides links to technical reports and peer reviewed science publications *(www.gcff.nz/publications)*. Further information is also available on the Forest Grower's Research (FGR) website *(www.fgr.nz)*.

To learn more about the research projects in the programme:

Contact Dr Peter Clinton at *peter.clinton@scionresearch.com*

Visit the programme website *www.gcff.nz*

To receive our newsletter and information on upcoming GCFF events go to *www.scionresearch.com/subscribe* and sign up.

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