

In the last few months we have achieved several highlights for the Growing Confidence in Forestry's Future (GCFF) programme. The research team have worked to realise the benefits from several long-term research trials established between 1987 and 1991 that examine the interaction between silviculture, site and tree breeds. They have also finished installing six large trials designed to test the next generation of trees and management techniques. These trials will create a resource for future researchers to study over time, generating more knowledge about the future management of radiata pine in New Zealand.

Other highlights include the publication of a scientific paper about the forest phenotyping platform in one of the leading international plant science journals, *Trends in Plant Science*. This has been one of the focus areas of the GCFF programme and as a result of the work to date, Scion has been asked to develop and lead the forest phenotyping theme of the International Plant Phenotyping Network.

Finally, our ability to monitor forest health has been progressed by research undertaken in the GCFF programme and is described in one of the articles featured in this newsletter.

The research outputs from the GCFF programme are well placed to support the successful delivery of the government's One Billion Trees programme. Our diverse work covers improvement in seedling quality, through to quantification of the benefits of forests planted in the right place for the right reason. And indeed, more and more of the programme researchers are working with companies to implement research in their operational programmes. Recent workshops on the use of soil and foliage information are good examples of the ways forest managers have engaged with GCFF researchers. Watch this space for future opportunities to get involved and benefit from the use of new information.

The GCFF programme has also facilitated international collaboration through the recent hosting of the International Union of Forest Research Organisations (IUFRO) Extension and Knowledge Exchange

conference in Christchurch. Many of the presentations addressed questions relevant to the uptake and use of information by diverse groups, and highlighted the need to know and target the correct audience.

Early in 2018, GCFF researchers made a large contribution to one of the most prestigious forest soils conferences, held once every five years. The conference focussed on the important role that this event has had over the years in creating and maintaining collaborations and networks for young and emerging researchers. Many aspects of the GCFF programme were featured during the conference and it attracted a lot of interest.

Looking ahead, the current GCFF programme is drawing to a close in September 2019. The focus is now on the big questions facing the forestry sector and what research science and technology can contribute in terms of a new research programme.

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

Research updates

Investing in soil modification to improve future tree rotations

The research team is currently installing the sixth and final site in the Accelerator Trial series at Tokoiti, Otago. This 10 ha trial site is being established on fertile soil that produced a highly productive first rotation of trees, but the productivity of the second rotation is expected to be increasingly limited by moisture availability. To address this, the GCFF team is attempting to modify



Loretta Garrett standing amongst the first rotation of radiata pine at the site. Scion scientists made several visits to the site prior to the harvest of the first rotation, during which the soil properties at the site have been examined and future plot locations identified for the trial.

the capacity of the site to store moisture. Research is focussing on treatments to increase the organic matter content in the soil by retaining more harvest debris from the first rotation and incorporating this material into the soil profile to a depth of 500 mm. The land preparation treatments at the sites are nearly complete, and the second rotation at the site will be established with a range of improved radiata pine genotypes in late August.

Cultivation on this scale is outside the bounds of conventional forest practice, but has been strongly supported by the forestry company that provided the land. They recognised the potential for this intervention to increase the value of the next rotation, and that of subsequent rotations.

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Examination of the root plates from fallen trees indicated a very shallow rooting depth in some areas of the trial. In this case tree roots did not extend more than about 350 mm into the soil, forming a dense mat above an impermeable layer of rock. This greatly reduces moisture storage and availability, and has informed the cultivation treatments designed to modify physical soil properties at the site.

Monitoring forest health from afar

UAV multispectral imagery and satellite data can be used to monitor physiological stress in trees.

Researchers from Crown research institute Scion treated selected *Pinus radiata* with herbicide to stress the trees. The colour of the pine needles changed as the herbicide took effect. The changes were monitored over time using a UAV-mounted multispectral camera, and using data collected from the Rapid Eye satellite.

Lead researcher Jonathan Dash says both data sources were sensitive enough to detect the changes in needle colour. “However, the UAV data were more sensitive at a finer spatial resolution and could detect stress down to the level of individual trees. The satellite data we tested could only detect stress in clusters of four or more trees.” Resampling the UAV imagery to the same spatial resolution as the satellite imagery showed the differences in sensitivity were not just the result of spatial resolution. Vegetation indices suited to the sensor characteristics of each platform were needed to optimise the detection of physiological stress from each data source.

“Detecting physiological stress in forest trees is vital for ensuring productive forest systems,” says Jonathan.

“We have shown that remote sensing can be used to detect conditions that cause changes in foliage colour before they can be observed

from the ground. UAV imagery was more sensitive, but satellite data remains a very valuable and cost-effective way to observe trends in forest health over larger areas. Research like this provides a useful range of complimentary tools for forest growers and researchers to monitor forests”. Forest owners and managers can now use remotely-sensed data opportunities to augment traditional monitoring practices. This will be especially useful in distant and difficult to access terrain. As well as physiological stress caused by disease, the effects of drought, lack of soil nutrients and attacks by pests will be able to be detected and responded to early, leading to healthier and

more productive forests.

Dash, J P, Pearse, G D & Watt, MS (2018). UAV multispectral imagery can complement satellite data for monitoring forest health. *Remote Sensing*, **10**(8), 1216. <https://doi.org/10.3390/rs10081216>

Thanks to Heidi Dungey, Toby Stovold, Rod Brownlie, Kane Fleet, Mark Millar, Dave Pont and Marie Heaphy, who also contributed to the work.

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Linking multispectral satellite imagery to UAV data provides a valuable tool for monitoring forest health.

Engagement

Site specific management - soil and foliage workshop

In July 2018, Scion held a workshop series on the use of soil and foliage information for site-specific forest management. The purpose of the workshops, which were held in Rotorua and Christchurch, was to give forest managers greater confidence in managing planted forest productivity using soil and foliage information together with their current practices.

The workshops focused on providing practical approaches to soil or foliar analytical results, and learning how forests respond to management practices like fertiliser inputs. Workshop content also took a holistic perspective, considering climate, terrain, disease spread and genetics ensuring the right tree is in the right place, and for the right purpose.

Scion staff provided information on (1) nutrient movement in planted forests (storage, uptake and nutrient cycling), (2) foliar and soil test interpretation (including micronutrients), (3) how to design and install Permanent Sampling Plots (PSP) to represent the forest, and when to sample PSPs for foliar and soil, (4) how to improve site productivity through nutrient management (e.g. keeping organics onsite or the addition of nutrients

through fertilisers), (5) examples of fertiliser responses from trial data, (6) the implementation of forest nutrition management plans, (7) developments using a “balanced nutritional approach”, and (8) possible future forest nutrient management paradigms.

Both workshops were warmly welcomed by the forestry industry participants, who found the events to be very useful. The following discussion sessions implied that

the learnings from the workshops were very useful and would be taken up and applied by industry. In addition, there was consensus that this type of content should be undertaken more often, and incorporate recent research to support forest industry needs and identify practical applications of the latest science.

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Loretta Garrett leading the site-specific management workshop in Christchurch.

International Union of Forest Research Organisations (IUFRO) Extension and Knowledge Exchange Conference, 9-13 September, Christchurch



A visit of the Rolleston forestry field sites to learn about the effects of genetic and environmental factors on radiata pine.

Scion hosted 51 attendees for the 2018 IUFRO Extension and Knowledge Exchange (EKE) conference ‘*The Importance of Engaging Local Communities and Stakeholders to Increase Successful Adoption of New Technologies*’.

Warwick Foran from MPI opened the proceedings with an overview of the One Billion Trees Programme, and how extension practices will ensure New Zealand can meet its ambitious goal.

Other presentations covered a wide range of topics including teaching Chilean forest nursery workers new strategies for more efficient use of water and nutrients, adopting new technologies for leader control in Oregon Christmas tree production, fire management and working with local communities in fire preparedness. Content also included educational programmes

that facilitate forest establishment and management for small woodlot owners and family forest owners in North America, including some useful checklists for field-based learning programmes.

On the last day, Auburn University ran a half day workshop on the use of UAVs in forest management and planning, that was

followed by a demonstration flight in Hagley Park. Participants were treated to a visit of the Rolleston forestry field sites to learn about the effects of genetic and environmental factors on radiata pine (*Pinus radiata*) clones. The working party also helped to establish more trees in a local Rongoā Garden and Kahikatea grove restoration project, where each attendee

got to plant a few trees as part of the effort to restore native trees and plants.

Janean Creighton, US EKE working group organiser, reported: "Here's to another successful and informative EKE meeting - in one of the most beautiful and diverse countries I have ever seen!"

Collaboration and international linkages

Scion scientists at the 13th North American Forest Soils Conference

Five soil scientists from Scion attended the Forest Soils Conference, from June 10-14 in Quebec City. Session themes addressed the role of forests and forest soils in climate change adaptation and mitigation, the effects of fire on soil properties, technological advances in forest soil research and monitoring networks, the linkages between management, land use change and forest productivity, as well as a session exploring the role of forest soils in society.

From the Scion contingent, Peter Beets presented information regarding research into the soil factors that have the greatest consistent effect on forest productivity in New Zealand conditions. Amanda Matson took the stage to present preliminary results from a nitrogen leaching trial, and Loretta Garrett discussed results from end-of-rotation assessments of long term organic matter removal and fertiliser trials. Simeon Smaill also presented information on trials exploring soil-plant-microbe interactions in New Zealand planted forest systems and their impact on productivity. Simeon and Loretta then combined to introduce the large scale Accelerator Trial network to the attendees and provided some early results from these new trials.

Peter Clinton had the honour of bringing the conference to an end, presenting a closing keynote address. He explored the importance of preserving the value that forests and forest soils provide to society, and the need for forest scientists to keep ahead of the pressures that climate change will bring.

The team engaged with various attendees during the conference, advancing existing collaborations and identifying new opportunities for joint projects. After the conference Loretta, Amanda, Peter Beets



Peter Beets, Peter Clinton, Loretta Garrett, Simeon Smaill and Amanda Matson amongst a group other soil scientists during the conference field trip. The forest is dominated by sugar maple, which is the source of that great Canadian invention, maple syrup.



and Peter Clinton visited the world famous Hubbard Brook Experimental Forest in New Hampshire (8,000-acre area). The long-term experimental forest has been running for over six decades and studies the response of ecosystem (air, water, soils, plants and animals) structure, composition and function to disturbances, both natural and anthropogenic.

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Looking ahead Upcoming GCFE events:

1. 16-18 October 2018, Annual FGR conference.
2. Forest productivity workshop - TBC.
3. Forest phenotyping workshop - TBC.

Selected recent publications related to the GCFF programme

Journal publications

1. Clinton PW. 2018. Future expectations of forest soils: increasing productivity within environmental limits using new knowledge. *New Zealand Journal of Agricultural Research*. <https://doi.org/10.1080/00288233.2018.1446992>.
2. Burdon RD, Moore JR (2018) Adverse genetic correlations and impacts of silviculture involving wood properties: analysis of issues for radiata pine. *Forests*, 9 (6). doi:10.3390/f9060308
3. Gallart, M., Adair, K. L., Love, J., Meason, D. F., Clinton, P. W., Xue, J., & Turnbull, M. H. (2018). Genotypic variation in *Pinus radiata* responses to nitrogen source are related to changes in the root microbiome. *FEMS Microbiology Ecology*. Published online April 2018: <https://doi.org/10.1093/femsec/fiy071>
4. Giadrossich F, Schwarz M, Cohen D, Cislighi A, Vergani C, Hubble T, Phillips C, Stokes A (2017). Methods to measure the mechanical behaviour of tree roots: A review. *Ecological Engineering*, 109: 256-271.
5. Dungey, H.S.; Dash, J.P.; Pont, D.; Clinton, P.W.; Watt, M.S.; Telfer, E.J. (2018) Phenotyping whole forests will help track genetic performance. *Trends in Plant Science*. Available on line <https://doi.org/10.1016/j.tplants.2018.08.005>
6. Hubble T, Clarke S, Stokes A, Phillips C (2017). 4th International Conference on soil bio- and eco-engineering (SBEE2016) 'The Use of Vegetation to Improve Slope Stability'. Special issue editorial. *Ecological Engineering*, 109: 141-144.
7. Marden M, Lambie S, Phillips C (2018). Biomass and root attributes of eight of New Zealand's most common indigenous evergreen conifer and broadleaved forest species during the first 5 years of establishment. *New Zealand Journal of Forestry Science*, 48(1): 9. DOI: 10.1186/s40490-018-0113-y
8. Marden M, Lambie S, Rowan D (2018). Root system attributes of 12 juvenile indigenous early colonising shrub and tree species with potential for mitigating erosion in New Zealand. *New Zealand Journal of Forestry Science*, 48:11 <https://doi.org/10.1186/s40490-018-0115-9>
9. Phillips C, Marden M, Basher LR 2017. Geomorphology and forest management in New Zealand's erodible steeplands: An overview. *Geomorphology*, 307: 109-121.
10. Schimleck L, Antony F, Dahlen J, Moore J (2018). Wood and Fiber Quality of Plantation-Grown Conifers: A Summary of Research with an Emphasis on Loblolly and Radiata Pine. *Forests*, 9 (6). doi:10.3390/f9060298.
11. Zhou XQ, Xu CY, Bai SH, Xu ZH, Smail SJ, Clinton PW, Chen CR (2018). Manipulating interactions between plant stress responses and soil methane oxidation rates. *Biogeosciences*. Published online June 2018. <https://doi.org/10.5194/bg-2018-102>

Note: Results of this programme and related work are often published in the *New Zealand Journal of Forestry Science* which has open access, and publications are easily accessible through their website <http://www.nzforestryscience.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 <https://gcff.nz/publications> provides the appropriate links to access the published information.

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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

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