ScionConnections

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Cunonia capensis *(Butterspoon Tree) has sentimental value for herbarium curator Dr Matt Buys, who fondly recalls collecting specimens in the Afromontane forests of southern Africa.*

National Forestry Herbarium turns 75

2020 marks the 75th anniversary of the National Forestry Herbarium, a specialist collection of permanently preserved plant specimens focusing on cultivated tree species associated with forestry and amenity planting.

The herbarium is managed by Scion as one of New Zealand's Nationally Significant Collections and houses the country's largest collection of planted and indigenous forest tree species. Established in 1945, it is home to about 31,000 fully catalogued, geo-referenced and securely quarantined specimens in tailor-made storage held at Scion's Rotorua campus. Each specimen in the collection holds a wealth of information along with where, when and who collected the specimen.

Over the years, the herbarium's collection has contributed to a huge range of important research. This has included the National Forest Surveys, and identifying host species for biosecurity responses such as painted apple moth, Dutch elm disease and myrtle rust.

A brief history

The herbarium predates Scion and its predecessor the Forest Research Institute. It was founded in 1945 as part of the Forest Experiment Station when the National Forest Survey began (the decade-long survey of indigenous forest for timber). The plant samples from this time contributed to the fledgling herbarium, and the records now form a dataset held by Manaaki Whenua – Landcare Research. By 1952 the herbarium had secured over 4,100 specimens, which were mostly indigenous species.

The second large wave of collections occurred in conjunction with another decade-long survey from 1956. The New Zealand Forest Service carried out the Ecological Survey to map and describe forest types based on their ecological characteristics. When the survey was completed, the plant reference information was added to the herbarium.

The 1950s and 60s also saw New Zealand's indigenous timber supply begin to decrease. Research interest surged in exotic conifers as a fast-growing replacement for indigenous tree species. Eucalypts were also studied and collected in Australia in large numbers during this time.

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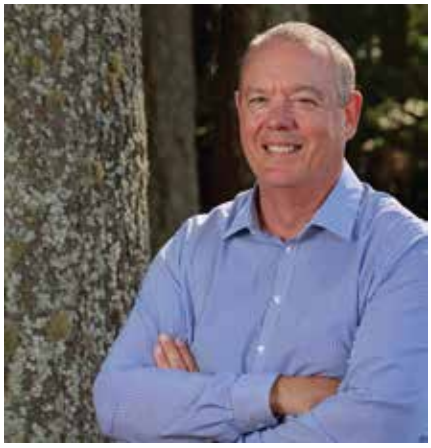
Missing the biopilot bridge between science and commercialisation



We know how crucial science is to informing New Zealand's COVID-19 response and recovery phases. The next phase – rebuild – needs to look long-term and have bold aspirations that address the global challenges we face, such as climate change, non-sustainable production processes and environmental degradation.

In my last editorial I talked about the future opportunities for New Zealand if we purposefully shape the post-COVID-19 rebuild to bring about better social, environmental and economic outcomes for our people and the place we call home. A key aspect of delivering on these opportunities is the link between research – in this case Scion research – and its adoption.

The rebuild Scion is championing is one that will transform our industries. By 2030, we want to see new biobased industries that use materials derived from tree- and wood-waste up and running, replacing those relying on imported chemicals and fuels.

Can we realise this in a decade? I believe we can. With the will and the means, our innovative, agile country should be able to move from the linear 'take, make, waste' model of production and consumption to a model based on circular bioeconomy principles.

The 'will' is there. Consumers are increasingly wanting sustainable and environmentally friendly production practices, and policy and regulatory frameworks are reflecting public expectations. However, the 'means' to enable emergence of bioindustries is a barrier. There's a key gap in the New Zealand innovation system that is constraining new bioproduct development. We can carry-out promising lab-scale development, but lack of pilot-scale facilities that allow the scale-up of technologies using new biomaterials makes it hard to prove commercial viability and attract investors.

Around the world, pilot facilities are key infrastructure in the step up to establishing commercial operations. They operate as open-access research and demonstration facilities enabling new and existing businesses to de-risk, advance, prove and scale-up innovative products.

If New Zealand is to embrace the transition to a circular bioeconomy, and join the rapidly developing global trend, we must recognise the need to invest in specific technologies required for reprocessing and substitution of petrochemical materials with biobased alternatives.

A national cluster of scale-up facilities (a biopilot centre) attached to the Scion research facility here in Rotorua will unlock new manufacturing opportunities for high-value products made in regions with abundant biomass (such as forestry and other primary industries).

Nowhere in the world have such new industry opportunities been substantially realised without an enabling innovation ecosystem that includes open-access pilot plant facilities. And in the global landscape numerous pilot plant facilities are almost exclusively funded by governments in the national interest.

Critical to the establishment of and supporting ecosystem for such a nationally significant asset is secure funding from a partner, or partners, with the capacity and breadth of interest to make it happen and commitment from industry to utilise pilot-scale facilities.

A national cluster of scale-up facilities (a biopilot centre) attached to the Scion research facility here in Rotorua will unlock new manufacturing opportunities for high-value products made in regions with abundant biomass (such as forestry and other primary industries). Opportunities are significant for waste reprocessing, bioproduct development and maximising value from primary industry feedstocks. An independent report indicates the creation of thousands of jobs through establishing new manufacturing operations and industries[1].

Te Papa Tipu Innovation Park in Rotorua is an ideal location for a national biopilot centre. The park is the home of Scion and 30 other linked business partners, is close to forestry, other primary sector resources and waste streams, has Toi Ohomai Institute of Technology nearby and is emerging as the hub for forestry and high-tech materials companies.

Scion has received wide support for a biopilot centre, and we are now looking to bring in partners, whether they be partners to use the facility, equipment suppliers to have their equipment used or funding partners.

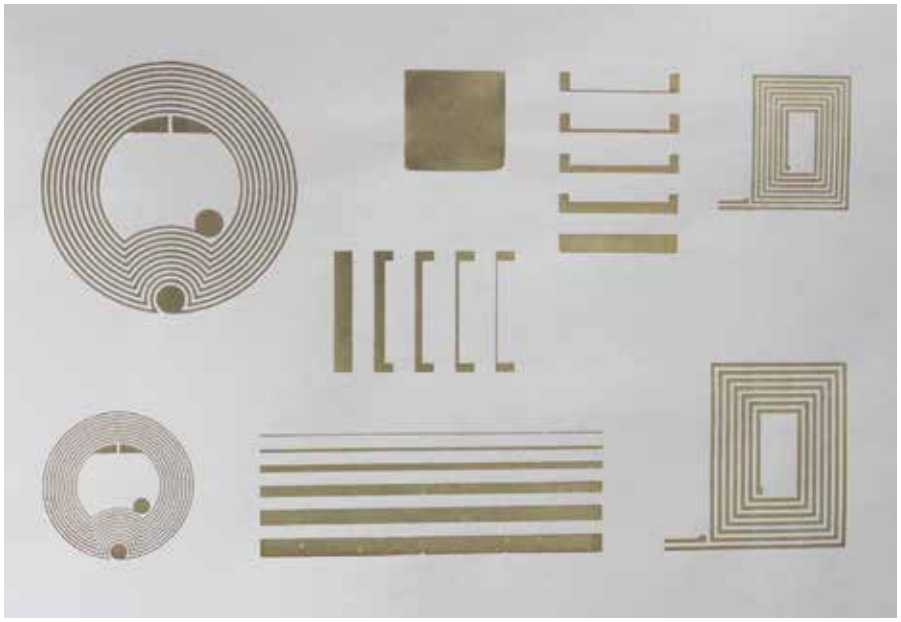
Successful implementation of this key piece of national infrastructure will provide a legacy impact for New Zealand supporting significant new business opportunities and employment throughout the country.

If you want to be part of creating a national asset to grow a whole new primary industry for New Zealand please let me know of your interest at any level.

Dr Julian Elder
Chief Executive

FOR FURTHER INFORMATION
contact Dr Julian Elder at julian.elder@scionresearch.com

[1] https://www.mpi.govt.nz/dmsdocument/34011-strategic-rationale-for-a-bio-pilot-plant-hub-for-new-zealand



Printed sensors with wood-based ink could play an important role in developing biosensor technology.

Green sensors a step closer to reality

Real time information about the conditions being experienced by New Zealand export products may soon be provided by biobased sensors being developed by Scion.

The majority of New Zealand's primary produce is shipped internationally. To ensure goods like kiwifruit, apples and meat arrive in the best possible condition, they need to be stored and shipped at appropriate temperatures and humidity and not subject to physical shocks, for example.

In an ideal situation, it would be possible to monitor the whole supply chain and provide real time data to remote users to alert them of significant events in time to prevent potential product loss. Current sensor systems, however, have trouble meeting these requirements. They may be big and bulky, require a lot of energy, data may not be able to be transmitted long distances, or only be accessible at the end of a journey and often do not meet green credentials.

Prototype biosensors

An essential first step in developing biobased sensors has been showing that we can overcome these issues by using commercially available, metal-based technology. A prototype that uses a combination of GPS, cellular technologies and a short-range mesh network that can be installed on pallets has demonstrated this is possible.

> Biobased products that can decompose at end of life to replace metal and plastic sensors are a great example of circular bioeconomy thinking.

Scion technologists and engineers are now exploring the possibilities for replacing components of the monitoring system with biobased alternatives. The potential for these has been demonstrated by the development of a fully biobased, flexible, strain sensor.

The prototype sensor uses a conductive ink containing lignin carbon fibres combined with a biobased binder and is printed onto a flexible wood film. Biobased, wood-derived flexible electronic devices have potential for use in a wide range of applications.

Circular, biobased solutions

The use of biobased products that can decompose at end of life to replace sensors currently made from a variety of metals and plastics is a great example of circular bioeconomy thinking. Swapping non-renewable resources with renewable replacements will lead to reduced environmental footprints and help minimise waste.

Better monitoring of goods as they move through the supply chain will also provide a full picture of the demands on packaging used to ensure the goods reach their markets in sound condition. This data will help packaging technologists develop materials and design new, lighter, stronger packaging that better protects the goods within.

International produce shipping is big business. The combination of better sensors, biobased materials and improved packaging will reduce spoilage and waste and ensure that the primary products that are essential to New Zealand's post COVID-19 recovery reach our global markets in the best possible condition.

Scion has been working with Plant and Food Research Limited (PFR) and Massey University on this project. PFR has carried out trials to compare the advantages and disadvantages of different existing sensor technologies. Engineers from Massey University's Department of Mechanical and Electrical Engineering have assisted in the development of the prototype's remote, real time monitoring system.

FOR FURTHER INFORMATION on our prototype biosensors, contact Dr Kate Parker at kate.parker@scionresearch.com

Forest microbiomes: Small actors play a big part

The bacteria, fungi and other organisms that make up the soil microbiome affect the way trees and other plants respond to their environment, influencing forest health and function.

What is a microbiome?

A plant microbiome includes all the bacteria, fungi and other microbes that interact with a plant. The whole microbiome includes organisms in the soil around the roots, on the plant above ground and even inside a plant's tissues.

The intimate relationship between plant and soil microbiome is generally mutually beneficial. Plants release carbon molecules that attract microbes by providing them with energy. In return, the microbes help the plant by improving uptake of nutrients and water, fixing nitrogen, producing chemicals that affect plant growth, or protecting against pathogens.

An important function of the plant microbiome is reducing plant stress. Pathogen damage, drought, salt, and organic and inorganic contaminants accelerate the production of plant stress hormones like ethylene. These can have negative effects on the growth of the plant. Some bacteria produce an enzyme that can break down the immediate precursor to ethylene. When these bacteria are present, they can help improve a plant's resistance to environmental stress.

> Trees that received low fungicide treatments had a significantly higher survival rate after six years and had a significantly greater plot basal area, compared to the standard treatment.

This interaction is one of many that indicate the potential to improve plant health and productivity and even to increase their resistance to environmental and other stresses through understanding and optimising microbiome/plant relationships.

A key research question Scion is exploring is how we can utilise the microbiome to protect plants from the impacts of climate change. Trees, as long-lived and sessile organisms, are highly exposed to impacts of climate change. If we can protect our trees and forests through managing the microbiome, we can future-proof all the benefits of forestry to New Zealand, from wood and fibre production, to carbon storage and supporting biodiversity.

Better microbiomes for seedlings

In seedling nurseries, fungicides are applied to control potential fungal diseases, and fertilisers are used to promote growth. Scion researchers have looked at the effect of fungicides and fertilisers on seedling microbiomes, tree health and how the seedlings later fare in the forest.

Initial research with pine seedlings found that the abundance of fungi that provided the greatest benefits to the tree was reduced with increased fungicide doses. Increasing exposure to fungicide was also associated with smaller seedlings (decreased root collar diameter).

Curious as to the long-term effects of manipulating seedling fungal communities, the researchers followed the survival and growth of nearly 2,600 seedlings that had been exposed to different fungicide treatments and then planted in the Kaingaroa Forest.

Trees that received low fungicide treatments had a significantly higher survival rate after six years and had a significantly greater plot basal area, compared to the standard treatment. Although the differences in fungal community structure associated with the trees disappeared after two years in the forest, the researchers concluded that the "better" fungal community on the seedlings that had received less fungicide in the nursery provided them with a head start that was still evident relative to the other fungicide treatments.

The effect of fertiliser application in seedling nurseries was also investigated. Seedlings that received standard or increased amounts of fertiliser were also larger at planting, however, after six years, no difference between fertiliser treatments could be seen.

The researchers caution that the stock for this field trial was obtained from a single cohort of seedlings from one nursery and the field results were derived from a single forest site. However, a range of other planting trials are now underway across New Zealand and interim results from those trials are aligning with those discussed here.

The work has provided an opportunity to explore the potential gains associated with precision use of chemical inputs and microbial community structure in the nursery. It may be possible to give seedlings a head start while also reducing the negative environmental effects from chemical use and strengthening the social licence of nurseries to operate.

Optimising the microbiome/plant relationship

The possibilities for understanding and exploiting the microbiome and its role in tree health in New Zealand's plantation forests are intriguing but challenging. One factor is that the number of different microbial species involved can run into tens of thousands. In fact, soils are the most complex and species rich ecosystem known, with far greater diversity than tropical rainforests and coral reefs! Another aspect is the complex dynamic nature of the relationship and a multiplicity of factors such as plant genetics, soil pH, salinity, moisture and organic matter interacting with each other and changing with time.

For example, fertilisers are known to cause short- and long-term responses in soil microbial communities. Optimising fertilisation strategies, such as regulating

A trial on the effect of fungicides on the fungi communities associated with pine seedling roots, found that numbers of the most beneficial fungus were strongly reduced.

doses, application timing, or choosing alternative chemical forms, have the potential to alter soil microbe community structure and function, creating direct effects on tree health and productivity.

Scion researchers have looked at what happened when fertiliser was added to plots of second rotation radiata pine planted in the Woodhill and Tarawera Forests. The two sites had differing soil physicochemical properties and, unsurprisingly, these were associated with site-specific differences in bacterial and fungal communities. Fertiliser addition affected the bacterial and fungal microbiomes differently at each site and the effects were long lasting.

Other work has looked at the effect of adding fertilisers containing different forms of nitrogen. Adding nitrogen in either organic or inorganic forms was found to affect tree growth as well as soil properties. These responses were also associated with variation in the microbial communities in and around tree roots.

The research team suggested that different nitrogen forms influence nitrogen and carbon dynamics where the plant meets the soil by causing responses in the roots that in turn cause changes in the root microbiome.

Future

Working with forest microbiomes is inherently challenging, but the potential rewards are substantial. This research is already creating new opportunities to increase forest productivity, optimise chemical inputs, improve soil properties and enhance the resilience of our forests to threats like climate change.

Scion researchers are actively developing plans to take this work further by attempting to capture the full depth and scale of the radiata pine microbiome, focussing on how it has allowed this species to survive and thrive despite the climatic changes and other major disruptions it has faced over the last 15 million years. This knowledge will uncover new pathways to work with the microbiome of this species, and also provide a blueprint for other tree species that are important to New Zealand.

FOR FURTHER INFORMATION on Scion's forest microbiome research contact Dr Simeon Smaill at simeon.smaill@scionresearch.com or Dr Steve A Wakelin at steve.a.wakelin@scionresearch.com

Photo: Rangiora Nursery.

Microbial communities in and around tree roots form part of the microbiome.

Leading our shift to a circular bioeconomy

Scion's vision for New Zealand is clear. We believe that through the power of forestry we can create a future that is sustainable, biobased and circular.

The COVID-19 pandemic has offered New Zealand a rare chance to reset our economy and shift our momentum towards a greener future where we value nature more for the benefits it offers us, and what we can learn and make from renewable natural resources.

Scion's newly updated strategic plan through to 2030 sets out our long-term direction and programmes of work to deliver our purpose and achieve great outcomes for New Zealand, nationally and regionally.

Drs Tara Strand, Roger Hellens and Florian Graichen have each taken up new leadership roles with a determined focus on how our research can help to deliver our vision. Here are their aspirations for New Zealand's future.

Dr Tara Strand, General Manager Forests and Landscapes

Imagine a place where Aotearoa forests, indigenous forests, are helping to solve New Zealand's complex issues. They were planted decades earlier and have helped to ensure clean freshwater; they mitigate against erosion; they counter our carbon release; they have improved our mental and physical well-being. Standing forests have a recognised value based on their purpose. Te Ao Māori has helped to design and meet this purpose.

In 2050 New Zealand is a globally treasured place, leading the world in methods for counter-balancing our industrial needs with carbon-based solutions provided by standing forests and the circular bioeconomy.

Dr Roger Hellens, General Manager Forests to Timber Products

What role will trees play in our society in 2050? I want to see the New Zealand domestic and export economy thriving from wood and timber products that have trusted and tailored applications thanks to the digitisation of the timber supply chain.

Exotic and native tree crops will be designed, through the application of new breeding technologies, to meet consumer and industry demand for quality, and the New Zealand domestic market demonstrates the global opportunity for tree-based products.

New Zealand's 1,000,000,000 tree planting initiative will have sparked an appreciation of the environmental benefits from growing trees and put trees and the forestry industry at the centre of climate change remediation policy.

Communities will be empowered through better connection to their local culture and urban environment. Trees and urban green spaces will be central to improvements in the well-being of all their citizens.

Dr Florian Graichen, General Manager Forests to Biobased Products

By 2050 New Zealand could be one of the big winners of a global transition to circular bioeconomies. By weaving the Māori world view and stories into our science and innovation we have an additional, globally unique point of difference.

We can create value chains from gene to product that meet increasing sustainability demands. In 2050 we would have a high tech, resource-efficient and competitive economy. In the research focused on biobased products and manufacturing we would see:

- Biorefinery solutions and infrastructure – for energy as well as renewable high-value materials and products.
- De-centralised manufacturing close to renewable resources – boosting our regions.
- Additive and other advanced manufacturing technologies using biobased resources.
- Symbiotic designer forests – customised feedstock for the circular bioeconomy.

FOR FURTHER INFORMATION about our new general managers, contact Dr Tara Strand at tara.strand@scionresearch.com Dr Roger Hellens at roger.hellens@scionresearch.com and Dr Florian Graichen at florian.graichen@scionresearch.com

An artist's impression of the finished Ecogas Reporoa site.

Your food waste to bioenergy

Ecogas has broken ground at Reporoa on the site of its new bioenergy plant that will turn food waste into resources including renewable heat, power, carbon dioxide and biofertiliser.

The plant will process 75,000 tonnes of food waste collected from households and businesses around the North Island. The process, anaerobic digestion, uses microorganisms to breakdown the food waste.

Scion scientists have proudly been involved in de-risking the key technologies since 2016. Anaerobic digestion plants are common internationally but the varying composition, particle size and possible non-biodegradable contaminants are long-term challenges that the Scion team will continue to finesse.

Ecogas' new plant will be a commercial showcase, sitting on two hectares of farmland beside T&G Global's five hectares of tomato-growing greenhouses. Heat generated by burning the biogas will warm the greenhouses; and CO_2 will be pumped in to enhance plant growth. Biofertiliser will also be produced and applied onto more than 1,500 hectares of productive farmland, reducing imported and manufactured synthetic fertilisers.

This system will see food waste from households, production, logistics and manufacturing used to enhance the growth of more food, creation of local clean energy and showcase what is possible in other parts of New Zealand.

There are opportunities to reduce climate change emissions by diverting food waste from landfill (where it releases methane and CO_2 into the atmosphere); using heat and CO_2 generated from biogas will reduce the fossil fuel use from the glasshouse operation, and finally, biofertilisers will replace synthetic fertilisers, made from fossil-fuel sources.

A blessing and ground-breaking ceremony took place in Reporoa on 4 August, and the plant is expected to be up and running in 2022.

FOR FURTHER INFORMATION about anaerobic digestion, contact Dr Suren Wijeyekoon at suren.wijeyekoon@scionresearch.com or Dr Daniel Gapes at daniel.gapes@scionresearch.com

National Forestry Herbarium turns 75

(Continued from page 1)

During the 1970s and 80s, an ecological focus led to many herbarium records from regional vegetation surveys being vouchered (certified as a reference material for taxonomic purposes). This included samples from a buried forest in Pureora, dating back 1800 years to the time of the last Taupō volcanic eruption.

Databasing of herbarium specimens commenced in 1991 and took seven years to complete. The National Forestry Herbarium is the only fully databased herbarium in Australasia. Specimen images are being added to the database and to date about 45 per cent have been completed. The database is available online at nzfri.scionresearch.com and provides a resource for researchers worldwide.

What's in the collection?

Today, the herbarium contains a wide range of mainly New Zealand native, naturalised and cultivated plant specimens. Plantation tree species from Australia, Fiji, Samoa, Vanuatu and Mexico are all well represented. Eucalypts and pines make up approximately 23 per cent of the collection. More than 2,800 specimens of cultivated eucalypts have been collected, representing 395 species.

What's next?

All biological sciences are underpinned by taxonomy, biodiversity infrastructure such as the herbaria, and the expert knowledge of staff who manage and curate these collections. Reproduceable biological research would not be possible without taxonomic knowledge and resource.

Herbarium curator Dr Matt Buys says, "The herbarium has been privileged to have had some dedicated curators in its 75 years, and it's a great honour to be counted among them. We will continue to ensure that this collection serves science and New Zealand well into the future".

Scion's management of the herbarium is supported by the Ministry of Business, Innovation and Employment.

FOR FURTHER INFORMATION about the National Forestry Herbarium, contact Dr Matt Buys at matt.buys@scionresearch.com

Adapting to changing consumer behaviour in China

Packaging is everywhere; it protects much of the food we buy, and it is nearly impossible to avoid. Rather than trying to eschew packaging we can make it better - stronger, lighter and made from novel biomaterials. Packaging researchers around the world, including those at Scion, aim to do just that.

Scion's packaging research is exploring new sustainable (renewable or more recyclable) materials for packaging that also meet technical needs such as strength. Part of this work is to ensure these materials comply with the complex world of food contact material regulations.

Is your packaging material transferring substances into your food?

Food safety is a major concern worldwide. More than ever consumers are seeking assurance that their food has been packaged in materials that are safe and don't transfer any unintentional substances into food products.

Different countries have different standards for the materials that come into contact with food (known as food contact compliance). These rules are important for New Zealand because our export economy relies on shipping food.

Much of New Zealand's export food is destined for China where consumers are very conscious of food safety issues.

Consumer preferences through COVID-19

The COVID-19 pandemic has had an undeniable effect on consumer perceptions about food safety. It has altered consumers' purchasing behaviours and increased consciousness of food safety issues.

Research by the University of Otago has observed changes to the way Chinese consumers are thinking about and interacting with food. Changes include more in-home cooking and eating, increased consumption of health/immune-enhancing foods, and increased concern for food safety and sustainability especially in relation to products of animal origin. These changes could shift the market environment long-term, and New Zealand producers need to take steps to meet consumer expectations and seize new opportunities.

Researchers from Scion will be part of a new project with the University of Otago, AgResearch, Xi'an Jiaotong-Liverpool University (China), and China Agricultural University (Beijing, China) to explore how COVID-19 has affected Chinese consumer preferences (including their choice of packaging). Scion's packaging research leader Dr Kate Parker says that the project will take a three-step approach, beginning with a look at changes in Chinese consumers' attitudes post-COVID-19. Next, the team will seek to understand what New Zealand exporters need to know about the Chinese market; and then gauge Chinese consumers' food and food packaging safety-related attitudes, practices and expectations in this new landscape.

Kate says, "We want to help New Zealand exporters develop new strategies on how to operate in the post-COVID-19 Chinese market". This project will be completed late 2021.

FOR FURTHER INFORMATION on our post-COVID-19 packaging preference project, contact Dr Kate Parker at kate.parker@scionresearch.com

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