



The area burnt by the Pigeon Valley Fire. The unburnt area around the fire illustrates just how dry the vegetation was across the region.

## Fire danger

Wildfire is devastating. The Pigeon Valley fire that burned in the Nelson/Tasman region was one of the largest forest fires (2400 ha) New Zealand has seen in some time. It caused the evacuation of more than 3000 people and 700 livestock, featured nightly on the news and took over five days to be contained. These kinds of large, extreme fires are likely to increase with climate change.

Our Rural Fire Research Team is amid a five-year programme funded by the Ministry for Business, Innovation and Employment (MBIE) called 'Preparing NZ for Extreme Fire'. The goal of this research is to prepare New Zealand for a climate change-affected future, where fire danger is an increasingly large threat. The MBIE programme forms part of our wider rural fire research, which includes assisting rural fire managers to assess risk, predict the spread of fires, and manage the safety of firefighters and the public.

### Highest fire danger levels in 20 years

On average, the Nelson/Tasman region experiences 9-10 days/year of very high and extreme forest fire danger. However, this year, the region had already experienced seven days of very high, and eight days of extreme forest fire danger during the first 35 days of the year, helped along by a heatwave and significant soil moisture deficits throughout the region.

The very hot, dry and windy weather had a major effect on forest fuels, drying slash and prunings, understory vegetation, pine needle litter and organic material in the soil, all of which contribute to the amount of fuel available to burn. Dry and high fuel loads contribute to easy fire ignition, spread, and to high fire intensities.

The Buildup Index (BUI) component, which describes the overall fuel dryness

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# Moving to the new economy



Scion has had a long history of supporting New Zealand's planted forest industry. Our cutting-edge research has played an undeniable role for 70-plus years growing the forestry industry into what is now the third highest primary export earner for our nation.

We continue to meet our responsibility as a CRI to work with industry, government and Māori to achieve four national outcomes for New Zealand:

- Increase the value and productivity of New Zealand forestry, wood products, wood derived and other biomaterial sectors.
- Protect and enhance market access and manage risk.
- Increase renewable energy production and energy security from forest biomass.
- Enhance benefits from forestry-based ecosystem services.

We are active and world class in the areas that you would expect. Our biosecurity team's discovery of the pitch canker pathogen avoided a disease becoming established that was predicted to cause over \$400 million in damage to the forest industry.

Through our work to improve radiata pine genes we have already increased the value of New Zealand's planted forests by more than \$3.5 billion. If our existing genetic improvements from selected

breeding were applied to the whole planted forest estate, we'd increase the value to around \$8.5 billion.

Yet our role has been changing. As New Zealand adapts to a world living with the effects of climate change, Scion is helping to solve the new challenges that arise, and to support the transition into a new economy focused on sustainable design and renewable resources.

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The principles of the circular bioeconomy are fundamental to many of the Government's goals and an environmental and economically sustainable future New Zealand. As a country, we are moving from an oil-based to a 'new' plant-based economy.

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In 2005, we adopted the name Scion to reflect the growth of research programmes that included the development of new materials and energy from renewable resources and waste streams. Fourteen years later our work covers many of the Government's environmental and economic development goals, supporting the transition needed to address climate change and other challenges. Working with advanced technology, industry, Māori, international science networks and a diverse group of stakeholders we are using science, deep learning and 'outside the box' thinking to create solutions to nationwide problems such as how to reduce greenhouse gas emissions from energy.

Energy was responsible for 40.5 per cent of New Zealand's GHG emissions in 2015, the second largest contributor after agriculture. Scion's research shows that if we swap just 30 per cent of our petroleum-based liquid fuel for cleaner, greener biofuel, we'd reduce greenhouse gas emissions to the equivalent of taking half the cars off the road. On the East Coast

alone this would involve planting one and a half times more trees, investing \$1 billion into infrastructure and creating 1000 new jobs.

The principles of the circular bioeconomy are fundamental to many of the Government's goals and an environmental and economically sustainable future New Zealand. As a country, we are moving from an oil-based to a 'new' plant-based economy. This new economy is business as usual for Scion. We have years of research and experience in bioproducts that may go on to replace fossil fuel-based products.

Scion has developed bioplastics that are made with renewable bio-resources which naturally degrade. In our bioplastic composites, primary industry byproducts are used as resources rather than treated as waste.

Working with Zespri, we have used waste from the kiwifruit industry to make a bioplastic spoon-knife (the biospife), to replace Zespri's polystyrene spife made with fossil fuels. By adding another use to this resource, its carbon is stored longer before regenerating back into the environment.

We've also used waste from the winemaking industry to make bioplastic vineyard net clips, which replace the 16.8 million polystyrene clips that fall to the ground and become microplastics.

Scion's contribution to forestry and the new economy is evident and we recognise that we must continue to build not only our scientific strengths but also our key capability in creating solutions and partnering. We look to grow these aspects through the development of the innovation hub of the Scion campus in Rotorua to support this.

I welcome your thoughts on this topic and any other matter raised in *Scion Connections*.



Dr Julian Elder  
Chief Executive

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Nursery Technician Colin Faulds has been working in the Scion Nursery for 35 years. The new facilities will significantly improve many of the existing nursery processes for him and his colleagues.

# Scion Nursery upgrade

Forestry in New Zealand can trace its beginnings back to the tree nurseries of Whakarewarewa (near Rotorua) established after the Mount Tarawera eruption in the late 1800s. In the years that followed, the nursery was home to the first experiments of New Zealand's young forestry industry. That work went on to set the New Zealand nursery standard for commercial nursery practices and was established as world class.

Our proud history of nursery-based science continues today. Our research, development and expertise in nursery operations, propagation and mass production of a diverse range of species supports sustainable forestry that delivers economic and environmental benefits to all New Zealand. To ensure we are up to the challenges ahead in forestry and tissue culture science, this year Scion will build the first 'pilot' stage of a new nursery, specifically aimed at meeting novel science and commercial challenges in exotic and indigenous forestry.

## Opportunity knocking

Changes are afoot in forestry. As we face significant challenges within the existing forestry nursery industry, such as labour shortages, changing chemical and waste

management legislation, shifts in weather patterns and more, it is time to re-invent our nursery and how we grow trees. The future is in high spec, hygienic, mechanised nurseries with high throughput of seedlings and clonal material. The opportunity for indigenous propagation is also significant. Indigenous forestry is now in its infancy, not dissimilar to radiata pine 70 years ago, and Scion is ready to lead the way once more.

Scion's Nursery Research Scientist Craig Ford says, "Our aspiration is that the New Zealand forest nursery industry becomes a leaner and more sustainable industry which provides more attractive, skilled work opportunities. Ultimately, we aim to facilitate integrated tissue culture and highly automated nursery propagation for exotic forestry into mainstream practice and to carry out more novel science in indigenous forestry."

## Our pilot nursery

The first phase of the Scion Nursery redevelopment will cost around \$1 million. It will be a small scale, modular, automated, lean-flow, environmentally sustainable propagation facility.

New facilities will allow Scion to pioneer and showcase more environmentally and economically sustainable production

systems through improved ergonomics, hygiene, water, frost and heat management options, and improved growing media and growing container options. Such facilities will help industry move away from chemicals, plastics, non-sustainable growing media and a reliance on non-renewable energy for heating and lighting. It will use several new-to-New Zealand forest nursery machines and techniques, such as automated paper pot sowing lines and containerised mini-hedge tunnels (mother stock for rooted cutting production of high-value genetic material).

With these facilities, the team will be able to perform climate-controlled seedling and cutting production trials for indigenous and exotic species, and tissue culture hardening, growing and ex-vitro rooting trials. Construction began in March 2019, and the new facilities will be ready in spring 2019 for the growing season.

## Long-term vision

This is a first step. The longer-term vision for the Scion Nursery includes an integrated propagation research facility that incorporates generative, classical vegetative and tissue culture propagation with a high level of automation and mechanisation.

Our investment will continue to advance exotic and indigenous forestry and provide spill-over educational benefits by allowing for training through student internships and course lecturing.

Craig sums it up, "Our vision is to develop, demonstrate and deploy technologies within New Zealand to grow improved trees more quickly, sustainably and do so without compromising on health, survival, and growth in the field for both native and exotic species.

"We're not interested in competing with commercial scale nurseries. We want to adopt and demonstrate the latest technologies and help New Zealand nurseries reach their full potential, while also serving our science needs to advance tissue culture, propagation and pathogen management. We obviously also still retain our role as a 'boutique' nursery for those internal and external clients who require help producing niche crops for testing."

**FOR FURTHER INFORMATION** on the nursery upgrade contact Craig Ford at [craig.ford@scionresearch.com](mailto:craig.ford@scionresearch.com)



Energy Systems Engineer Dr Muthasim Fahmy is part of the team working on the prototype. Muthasim specialises in engineering thermodynamics and microwave technology development.

# Reinventing the toilet – from proof of concept to prototype

Tucked away on the Scion campus is a toilet attached to a microwave reactor. This is no ordinary toilet; this toilet could save lives.

The toilet has been designed by Scion and is one of many projects in the Reinvent the Toilet Challenge, supported by the Bill & Melinda Gates Foundation. The toilet looks like your standard toilet bowl, but when you hit flush, a vacuum pump akin to an aeroplane facility sucks the waste away. From there the waste goes through a process that uses wet oxidation (high heat and pressure with the addition of oxygen) to break down solids and kill bacteria and pathogens.

## The challenge

Scion entered the Reinvent the Toilet Challenge in 2015 based on our wet

A particular challenge was to find materials for construction that are compatible with microwaves.

oxidation technology developed for the pulp and paper industry. By 2016 the team had created a proof of concept showing that wet oxidation could be an effective way to treat human waste. Since then, they have gone on to design and create an entirely new way of treating the business.

Their journey hasn't been without challenges. The initial proof of concept

device used heating coils located on the outside of the wet oxidation reactor. Although it worked, the process wasted energy as it heated up the exterior of the reaction chamber before that heat passed to the material inside. The prototype needed a more efficient way to provide the heat for wet oxidation. Microwaves were identified as a suitable option.

## Why microwaves?

Microwaves are good at quickly and directly heating the waste material, rather than the reactor body itself. The microwave reactor can heat the waste material to 260°C with speed, yet the technology has not been adopted by any of the other parties in the Reinvent the Toilet Challenge so far.

“Using a different and unique technology allows us to add something new to the

collective knowledge of the toilet challenge parties. We could potentially provide a solution that might benefit another one of the parties,” explains Dr John Andrews, who leads Scion’s toilet team. “We work collaboratively, because we’re all working on the same problem.”

### **Engineering to the limits of the design code**

However, novelty can be a double-edged sword. The engineering team discovered that microwaves need a lot of fine tuning to be efficient. “Microwaves interact in complex ways depending on geometry and the reactor materials used,” explains Dr Muthasim Fahmy, an Energy Systems Engineer at Scion. “Using them with success requires multi-disciplinary engineering skills.”

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“Our work on the reactor pushed up against the limits of the code. It was a potential future stumbling block – because you could create a reactor design that no one would sign off as being safe to use.”

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The high pressure and extreme heat created operating conditions not easily catered for. The team had no choice but to design a lot of their own equipment. They created various versions of reactors, designed holding tanks with stirrers, made mixing mechanisms, and put it together within a tight time frame. All the while ensuring the system was robust enough to cope with any proverbial goldfish that could get flushed down a toilet.

A particular challenge was to find materials for construction that are compatible with microwaves. Initial tests melted a seal in one of the first stage microwave reactors, and that was just the beginning according to Mechanical Design Engineer Gary Campbell, “We’ve had to specifically consider the material of every component that made up the reactor. Even the sensors had to be specially designed to sit in a port on the outside of the main reactor cavity to protect them from microwaves.”

Mixing also had to be incorporated into the reactor using an oscillating platform. Mixing is essential for mass transfer between oxygen and liquid, but the sloshing moves the liquid all over the void in the reactor and some microwave energy then reflects out of the reactor.

With all the specific requirements in mind, the design of process and equipment also needed to fit within the American Society of Mechanical Engineers, Boiler and Pressure Vessel Code VIII specifications. After all, what good is a new high-tech toilet if no one can safely use it?

Mechanical Design Engineer Rob Whitton explains, “Our work on the reactor pushed up against the limits of the code. It was a potential future stumbling block – because you could create a reactor design that no one would sign off as being safe to use.”

In late 2018, the reactor was officially certified as compliant with the design code, and the project took another significant step forward.

### **Support from all ends**

Some of the other challenges the team had to overcome were slightly less technical in nature. Sourcing enough human waste to test their treatment was a team effort aided by a few Scion staff, but not without some persuasion.

The team recount some funny moments to balance out less pleasant tasks such as daily emptying of the waste tank to store in the biohazard freezer for later use in testing. A dramatic seal failure once caused a jet of brown steam to leave the reactor, and finding the flushing mechanism

was switched off when the toilet needed to be flushed has left more than one team member red faced with embarrassment or laughter. But it has all been part of a wider team effort that has been supported by several local service providers.

Rob says, “This is an unusual project – there’s no doubt about that. But the support we’ve had has been incredible. Local providers have given us great service in time to meet our fast approaching deadlines.”

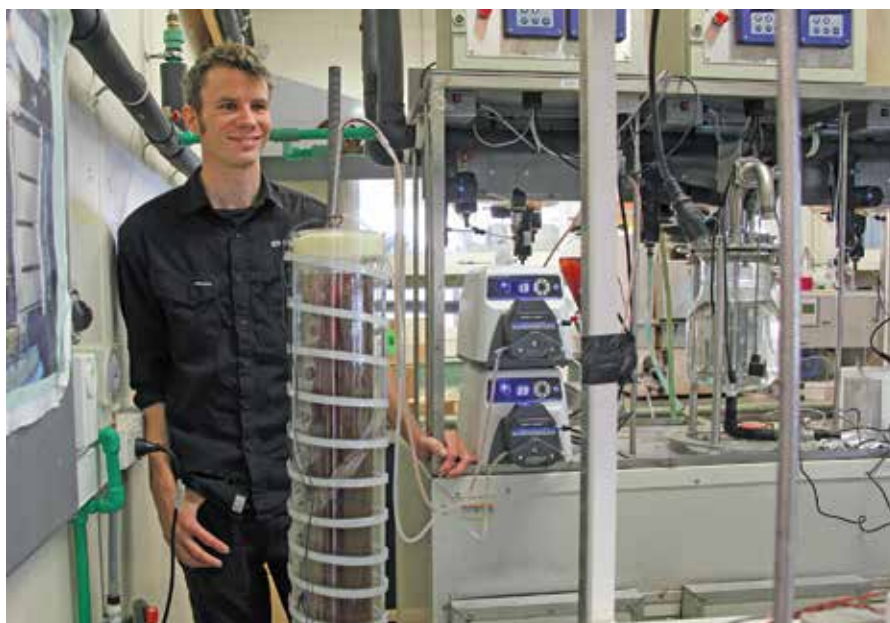
Some special services that need to be acknowledged for going above and beyond include Tailored Controls, Metalform, Stewart and Cavalier Engineers, Lyle Engineering, Microwave New Zealand and Applied Industrial.

### **The world needs a new toilet**

The end goal is to build a sustainable, cheap to use (less than US\$0.05 per user per day) and ‘off the grid’ toilet that is safe for humans and the environment. This technology has shown great promise for treating human waste, whether it be in developing countries around the world, New Zealand’s cities, back country, or in global disaster zones. The team is now in the process of commissioning and testing the toilet and reporting its findings back to the Bill & Melinda Gates Foundation.

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**FOR FURTHER INFORMATION** on our work in the Reinvent the Toilet Challenge contact Dr John Andrews at [john.andrews@scionresearch.com](mailto:john.andrews@scionresearch.com)



*Mechanical Design Engineer Rob Whitton leads the engineering of the prototype.*



IMAGE: ROSS YOUNGER, WWW.FLICKR.COM/PHOTOS/CRAZYSCOT/33795624452

# Urban residents are a new audience for wildfire messages

The 2017 Port Hills fire brought the country to the town in a frightening way. Nine houses were destroyed and five more damaged, and over 1400 residents, most of whom were living on small urban fringe or suburban properties on the margin of Christchurch, were evacuated. Though New Zealand has experienced fires on the fringes of cities before, none had threatened such densely populated urban areas to this extent.

To gauge how people reacted to this fire on their literal doorsteps, Dr Lisa Langer and Simon Wegner examined how the fire was reported in the media, and the opinions of people commenting online to gain an indication of how urban residents perceived the fire risk, the social norms that shaped discussion, underlying conflicts and their understanding of where the responsibility for action lies.

Lisa acknowledges that online commenters may not represent the entire community. “Nevertheless, they can give us clues about how city dwellers perceive the risk of wildfire, prepare, respond and make sense of it. This helps us identify issues that previous research largely focusing on rural communities has not explored.”

## Gauging the mood

Generally, the mood of the public was one of surprise that a wildfire could threaten

city neighbourhoods, and there was an expectation that authorities could, and would, control the fire. Rural residents were assumed to have more fire knowledge.

Largely missing from mainstream media were actions that individuals could take to mitigate fire danger and loss. For example, properties generally were described as saved due to firefighters’ efforts and elements of luck, not property characteristics or mitigation efforts such as keeping grass mown or planting fire resistant plants. And any suggestion that some responsibility for loss lay with property owners was quickly shut down as victim blaming.

## Mainstream media

In the mainstream media narrative, responsibility for action was laid largely on officials; far less emphasis was placed on the roles and responsibilities of individuals or communities. But interestingly, complaints about the way evacuations were communicated and handled were met with strong counter responses on social media emphasising the need for accepting personal responsibility.

Overall, mainstream media followed a relatively uniform narrative, while public comments reflected the differences and divisions that make our society complex. “We don’t know if this experience has

changed urban fringe dwellers’ awareness of wildfire, or if it has influenced them to do more now to mitigate the risk of, or prepare for fire, at home or in their community. This initial research has led to plans to undertake a more thorough study of residents’ reactions,” says Lisa. “The Port Hills fire has shown that urban fringe residents are a new audience that needs to be aware of wildfire risks and be prepared for fire disasters that are likely to occur in the future.

“The recent significant Pigeon Valley wildfire affected lifestyle properties in rural valleys in the Nelson and Tasman districts. Parallels exist as about 3000 residents were evacuated, many from suburban areas of Wakefield and Wai-iti, along with lifestyle block residents.”

## Fire research

Wildfire social research has been an integral part of Scion’s Rural Fire Research Group for 15 years. It has contributed a wealth of knowledge to the fire sector within New Zealand. Lisa and Simon’s research was supported by the Resilience to Nature’s Challenges National Science Challenge.

**FOR FURTHER INFORMATION**  
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# What good is wood in streams?

Freshwater ecologist Dr Brenda Baillie has completed a two-year study of naturally forming, small debris dams that have an important positive role as habitat for aquatic invertebrates in forested headwater streams.

## Debris dam habitat

Debris dams are accumulations of wood, sediment and organic matter. In small forested streams, they generally cover a small percentage of the streambed and often contain a high proportion of the total organic material in a stream system.

Debris dams form structurally diverse habitats that provide shelter and trap leaf litter that goes on to become a major source of food for aquatic invertebrates in small forested stream ecosystems. As such, aquatic invertebrate density and diversity are typically higher in debris dams than in the surrounding stream bed.



## Findings

A study in three headwater forested streams found that densities of *Ephemeroptera* (mayfly), *Plecoptera* (stonefly) and *Trichoptera* (caddisfly) taxa were significantly higher in debris dams compared to the habitat in riffles (a rocky or shallow part of a stream or river where

the water flows brokenly). Debris dams also contained a higher number of less common taxa and significantly higher densities of shredders (invertebrates that shred larger leaves into smaller particles of organic matter).

Brenda's work suggests that in forested streams, debris dams are important storage sites for organic matter and create areas of biodiversity hotspots for aquatic invertebrates.

## Management

Retention of forested riparian margins along stream edges are important for maintaining the natural processes of wood and leaf litter inputs into small forested streams. These sources of organic matter contribute to in-stream sources of food, habitat and aquatic invertebrate biodiversity in forested stream ecosystems.

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**FOR FURTHER INFORMATION** on the debris dams as habitat contact Dr Brenda Baillie at [brenda.baillie@scionresearch.com](mailto:brenda.baillie@scionresearch.com)

# Fire danger

(Continued from page 1)

and amount of fuel available for consumption, shows the January 2019 levels of extreme dryness/risk at the Nelson Aero weather station. A BUI of 60 is very high, and 80 is extreme. This year the BUI reached 100 by the end of January, and continued to increase through February, reaching values over 140, levels which have not been seen since 2001.

## Severe fire days are likely to increase

Fire dangers in the Nelson/Tasman region are predicted to increase with climate change. They could experience 12-13 days of very high and extreme forest fire danger on average each year. However, Nelson/Tasman is not the only area with increasing fire risk. Modelling of potential future changes in fire danger with hotter, drier and windier conditions caused by climate change shows that the number of severe fire weather days is likely to increase around the country by an average of 70 per cent by 2040. The most marked relative

changes are for Wellington and coastal Otago, where the number of severe fire weather days is likely to double to around 30, and triple to 20, per year respectively.

"Areas like coastal Otago, which doesn't often have to cope with wildfires, could be much more likely to face one in the future than Nelson/Tasman," says Fire Scientist Grant Pearce.

## Scion smoke forecasts

During the Pigeon Valley fire, Scion atmospheric scientists and smoke dispersion experts provided up-to-date forecasts on the likely path of smoke produced by the fire.

Predicting the path of the smoke plume is important for health reasons as fine particulate matter less than 2.5 microns can penetrate deep into people's lungs and affect those with asthma or other breathing conditions and, under high concentrations, cause poor health effects for everyone.

Smoke forecasting also allows air traffic controllers to minimise disruption to air traffic; helps local councils to make decisions on road closures; Civil Defence authorities to make best decisions about evacuations; and schools or other organisations (e.g.

sport or music events) to make decisions about closures or change of venue.

The forecasts were produced using a real-time smoke and fire spread prediction tool undergoing development by Scion's Rural Fire Research Team as part of its MBIE-funded research programme.

## Scion's Rural Fire Research Team

This team is New Zealand's only provider of specialist fire research expertise in rural and forest landscapes. The research programme focuses on understanding how fires and their smoke are likely to behave in different weather conditions, terrain and fuel types, and factors affecting public and firefighter safety to protect life and property and to manage fire in the landscape.

To follow the team's research, you can visit their website [ruralfireresearch.co.nz](http://ruralfireresearch.co.nz) or follow their blog [www.ruralfireresearch.wordpress.com](http://www.ruralfireresearch.wordpress.com)

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**FOR FURTHER INFORMATION** on rural fire research contact Dr Tara Strand at [tara.strand@scionresearch.com](mailto:tara.strand@scionresearch.com)



CEO Dr Julian Elder and General Manager Māori Forestry Futures Hēmi Rolleston.

## Welcoming Hēmi

Scion has a new General Manager Māori Forestry Futures in Hēmi Rolleston (Ngāti Whakaue, Ngāi Te Rangī, Ngāti Ranginui) as of late February.

Hēmi's experience in the primary industries as CEO of Māori kiwifruit business Te Awanui Huka Pak and the research and development sector as General Manager Māori Economy and General Manager Sectors at Callaghan Innovation makes him an ideal fit for Scion's own primary industry based research and development.

*Scion Connections* met with Hēmi to kōrero about what brought him to Scion and back to Rotorua.

### **What attracted you to the role at Scion?**

I am really passionate about making a positive difference for Māori by using my skills, connections and experience in the Māori economic and innovation space. Scion's work is in an exciting area of innovation, in a field that is also special to Māori.

Māori are becoming a significant economic entity and forestry is one of our key resources.

Our people are no longer satisfied being a landlord. We want to innovate through research and development. I see Scion playing a significant role in partnering with Māori to achieve their aspirations, through Scion's capability and experience in forestry science and innovation.

Alongside that is a great opportunity to take advantage of the focus on government priorities around forestry and sustainability. Collectively, Māori and Scion can partner to make an exciting difference for Aotearoa and the world.

### **Where do you think is Scion's biggest area for potential growth?**

The biggest potential is through creating collaborations with Māori looking at innovative opportunities throughout the value chain.

There is also potential to identify land use options for Māori in forestry and ensure that returns are maximised through use of innovation while balancing Māori values.

Bringing the Māori world view into mainstream thinking and weaving in the Māori story will provide a unique point of difference. We also need to take the tamariki of today on the journey, and equip them with the skills and knowledge to provide an exciting future using this resource.

### **What do you think the biggest challenges will be?**

The biggest challenge is in changing the mindset and attitude from both Māori and in Scion. It begins with developing authentic relationships and the rest will follow with each party understanding the respective values and opportunities they can bring to the table. This is where the magic happens, there is so much opportunity in this space.

Another key challenge will be to prioritise workstreams. We can't do everything, we need to focus on the areas that will make the biggest difference and that will help to show the way.

First, we must get everyone on the waka before we paddle off.

### **FOR FURTHER INFORMATION**

about Hēmi's new role email  
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