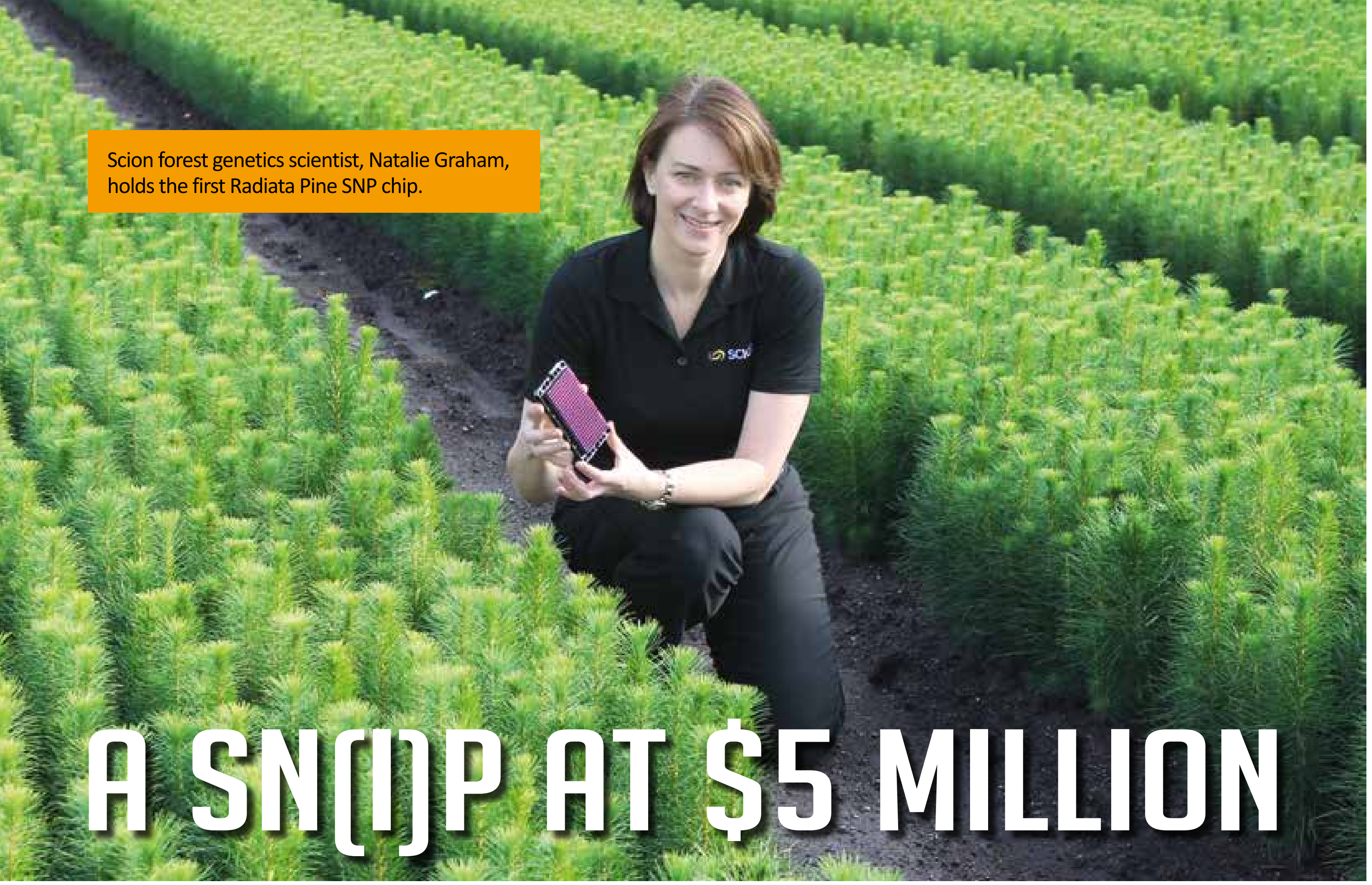

Scion forest genetics scientist, Natalie Graham, holds the first Radiata Pine SNP chip.

A SN(I)P AT $5 MILLION

THE LITTLE BLACK BOX THAT FORMER RADIATA PINE Breeding Company boss, Brent Guild, held in his hand when he spoke to a recent forestry conference in Wellington didn't look very interesting...until he mentioned that it was the result of a $5 million investment.

What could be inside? Diamonds? Rare earth minerals? No, something far more precious.

The little black box is called a SNP (single nucleotide polymorphism) chip, and it's a first for Radiata Pine.

A SNP (pronounced snip) is a type of DNA or genetic marker that represents a single base change in the DNA sequence, says Natalie Graham, a forest genetics scientist at Scion.

"The phrase 'snip chip' is, in part, a reference to the use of the semiconductor manufacturing techniques used to generate these chips, with everything done at nano scale," she says.

"Under closer inspection, a SNP chip like that which Brent held has 384 individual little pegs of about 2mm x 2mm. Each of these little pegs contains the technology to measure 36,285 DNA markers in a single sample. If we multiply 36,285 SNPs by 384 pegs, ie the number of samples you can test per chip, we now have capacity to generate nearly 14 million data points from a product that you can easily hold in your hand."

Sifting through all this data can be like trying to discover the winning numbers for next Saturday's Lotto Powerball draw, but at least this work can now be handled by powerful computers. Trying to discover and measure individual markers within the DNA of Radiata Pine the old-fashioned way was time-consuming and expensive

"We also now know that most of the traits we're interested in, like growth and wood properties, are controlled by very complex networks of genes," says Natalie.

"Using handfuls of markers across limited numbers of samples was unlikely to give us enough information to support breeding decisions.

"But this is where the SNP chip is making a difference, as we can test thousands of markers across thousands of samples at a time. It's this scale and rate of data generation which is the real breakthrough."

The first thing the Scion team is doing with the data coming from this new chip is a thorough analysis of the overall breeding programme to understand how everything is connected and related.

"We've got historical pedigree records, but we've never had the tools to verify them before," adds Natalie.

"We expect that there will be errors – they are in almost every breeding programme worldwide with most major crop species, but they have had the tools to detect those errors and fix them. We now have the ability to do this for Radiata Pine and correct our pedigrees where necessary.

"This has the added benefit of improving the trait predictions we make going forward. If we have always assumed that two trees were related but new DNA evidence contradicts this, that changes the way we interpret the phenotypes and how we breed with those trees."

When not being used, that first SNP chip sits on Natalie's desk in the Scion lab in Rotorua – an expensive office ornament! NZL

UNLEASHING THE GENOMICS GENIE

THE TERM 'DISRUPTIVE TECHNOLOGY' IS WIDELY USED these days to describe something that will be very different to what has been done in the past...and it aptly describes the difference that genomics will make to the Radiata Pine breeding programme.

We're right on the cusp of being able to develop designer trees that will be substantially better than anything grown to date.

Radiata Pine is only two-to-three generations distant from the wild population and despite the advances made in the RPBC programme, it is nowhere near to becoming the 'super tree' that will give us much better wood and more of it at a younger age. Yet.

If we just stuck to traditional tree breeding techniques, it would likely take at least 30 years before we saw a real difference, probably much longer. But when we combine tree breeding with genomics, we can speed up the process considerably, and that is what Scion is working on.

Don't confuse genomics with genetic engineering or even genetic editing. It's not like letting the gene genie out of the bottle.

Genomics involves understanding the ancestral relationships, or family relations among trees, as well as understanding the relationship between a large number of DNA markers and tree characteristics. By learning more about these marker relationships, scientists can predict the best trees to accelerate breeding, prevent the consequences of inbreeding and so on.

"Genomics is not rocket science," says Dr Heidi Dungey, head of Scion's forest genetics team, at her lab in Rotorua. "It's already applied across all animal breeding and most crop breeding, so in that sense it's not new technology, but in tree breeding we are probably one of the first to implement genomics into a conifer species operationally, so RPBC is at the forefront of this revolution.

"It's very exciting territory for New Zealand when you understand how much productivity and profitability we can deliver to the forest industry and to the country's GDP."

She explains that the major objective of the genomics programme being undertaken on behalf of RPBC is to identify SNP patterns (see A SN(i)P at $5 million, opposite) that correlate with key traits in Radiata Pine, such as growth and disease resistance. Reliable SNPs will generate accurate breeding values that will both reduce the breeding cycle and increase the amount of gain in forests. Gains of up to 50% over conventional breeding are forecast. Already, the first set of genomic breeding values for resistance to Dothistroma needle cast have been identified and released to RPBC members.

"Historically, breeding has been a bit like bucket chemistry – throw a lot of numbers in and then pick out the good stuff that floats to the top," says Heidi.

"But with the right research, we could start making designer trees for specific products. I envisage that in 20 years' time you will know exactly which trees at which site are being grown for which product.

"One of the major goals will be to understand if a tree has a particular trait that is being sought right at the start of its life, not years down the track.

"Age 8 has so far been the optimal time to assess trees for growth, but genomics will enable us to predict growth traits from the moment a tree starts to grow. With tissue culture perspective, you could test your new lines immediately after capturing your immature embryos from green cones, and only propagate the superior lines for deployment.

"We are already harvesting trees at a much younger age than a decade ago, sometimes down to 25 years'. As we continue to try and bring that age down, we also need to make sure the wood properties remain favourable, whilst also keeping the tree healthy and straight.

"We can also explore combining improved genetics with silviculture. For instance, if you plant trees close together your trees tend to have smaller areas of juvenile wood due to the effects of competition. Another option is to use cuttings that are more mature – as the starting material they are a little bit more grown up, so that juvenile wood core is usually not large.

"We also need to consider what we will be doing with wood in the future. Are we going to transition into a bio-economy, and what does that look like for trees? Then it becomes more about fibre and how fibre properties correlate with other wood properties, and whether we can make gains for both?

"We need to get this right, which means doing our research and not repeating mistakes of the past. We want to make sure that whatever we select is going to be robust."

Former RPBC CEO, Brent Guild, has moved on from working alongside Heidi and her team at the cutting edge, to becoming a user of the research as the newly appointed General Manager at Nelson Forests. Having led RPBC for three years and re-focused its work, what are his hopes for the future of our 'remarkable' tree?

"The Radiata Pine of the future is a moving feast – do we really know what it's going to look like and what it's going to do?" he muses.

"I would say it's going to be all of those things that we want today, and more; it's going to be fast growing, but even faster – the holy grail for us is a 15-to-20-year-old tree that is basically the same size as a current 45-year-old tree, with the same wood properties or better, and disease-free or at least with some sort of resilience.

"We don't find one of those every year and say 'Eureka! We've found it! We can shut the company! It's the perfect tree!' – it just doesn't work like that. Even with the advances in science, it's still going to take time."

Indeed. There's a vast network of people involved and lots of different views and agendas at play. But everyone wants a tree that is better and more profitable to grow than today. And that takes time. Even with the new scientific tools now available in their tool box. NZL