A digital future for New Zealand forestry

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Figure 1: Photo depicting future concept of digital forests providing real-time data and insight from sensor networks and remote sensing

Abstract

This paper brings together perspectives on the future of forestry from academia, research and industry. A diverse group of people have been interviewed from the University of Canterbury, Toi Ohomai, Forest Growers Research (FGR), Scion, Port Blakely Ltd, Forest Protection Services Ltd and Forest Management Ltd. The results highlight the unprecedented potential of data and the power of a collective approach for shared learning and digital democratisation. The paper touches on what a forestry tech sector platform and service opportunity could look like for New Zealand. Finally, it explores what future work may look like due to mechanisation and automation and considers how support can be provided to the next generation of foresters joining the forestry sector.

Impact of digitalisation on forestry in NZ by 2030

Imagine if we knew every tree by name and could treat it personally. A network of trees providing health, growth and market data sensed in real-time. We could view our forest inventory, see our wood flows to different markets, spot secondary markets and waste streams, and create smart supply chains to trace and protect this natural resource to market. With digitalisation as the bonding force, by 2030 we have the potential to create a new value web for our forest-based industries in New Zealand.

Connecting to global megatrends by 2030, we will see more forests in urban environments and increased use of wood in these urban settings to reduce carbon emissions and enhance the overall wellbeing of communities. The full potential of trees will be realised through their role as a critical tool for climate change mitigation and as a natural regenerative solution to break society away from its reliance on fossil fuels. New Zealand will shift focus from logs as an export commodity to wood products with engineered and embedded value and bio-based products that are more sustainable and command higher worth in the hands of consumers. This will deliver new employment pathways at regional levels through distributed manufacturing and a demand for more digital-led skills.

Digitalisation will provide the ability to virtually see, hear, understand and manage our forests in ways that have not been possible before. The multiple dimensions that boundaryless data can provide to our forestry sector and nation will impact all levels and generate new jobs, new platforms and services, new ways of working, and new insights to drive and enhance productivity.

Forests rich in data will provide new value and insights

The forestry sector is collecting more data than ever before. The democratisation of technology, illustrated through the now widespread use of

unmanned aerial vehicles (UAVs), has highlighted the power of technology and data to the industry. Five years ago, forestry companies commonly had a spatial division comprising a single spatial analyst, for whom a key role was the production of maps. Today, UAVs are empowering a more diverse range of people to take part in remote sensing and mapping. With the additional influx of data from platforms, including UAVs, data science is the new skill in demand.

University of Canterbury lecturer in Geospatial Technologies, Dr Vega Xu, says that we cannot separate data from the technology, which means there is an increased need for data science. She notes that we have moved from megabytes of data to terabytes and working with new technologies creates a huge amount of data. There will be an increased need to develop methods for storing and maintaining this data in the future. Enhanced storage and cloud-based processing services will become more available and more cost-efficient.

Dr Xu says that large forestry companies will tend to adopt new geospatial technology first, as the cost for smaller forest owners is very high. However, those who can take advantage of the technology have the potential to unlock new value. Smaller forest owners are better off acquiring spatial data collectively.

Forest Management Group forest manager, Matt Cotterrell, believes that understanding forest growth as early in the rotation as you can enables much better decisions on the ground. He says that the sector will continue to become much more data-driven, and the longevity of data will span the forest's lifecycle. Trees will be monitored from the moment they are put in the ground, compared with today, where spatial data (such as LiDAR) is captured primarily for mature stands and currently provides limited use for early rotation stands.

Data will also drive greater accuracy and efficiency of common tasks. Alfred Duval, regional forester at Port Blakey Ltd, has described performing tasks using a lot more detail but with a lot less human input. He says that they are already performing what would have been

Figure 2: Scion unmanned UAV collecting LiDAR data over a pine forest

Figure 3: Mitchell Cooke and Alfred Duval from Port Blakely carrying out post-thinning quality control assessments with their UAV

a four-week task to manually review plots of young planted areas in a fraction of the time. They fly a UAV for two or three days, do two days of data processing and two to three days of 'ground truthing'. The output is highly accurate and stored for life. Port Blakey has seen huge value in the use of technology in the last three years, and Alfred Duval anticipates that this use will be perceptible in the crop and that the further value of using technology to assess stands at an age of 10 years, after thinning, or in 20–30 years at harvest time will be significant.

As well as utilising data such as visual imagery and point clouds for specific operations, digital data will also improve automation. With the increase in computing power in the past decade, the fields of machine learning and deep learning have made quantum leaps. Algorithms from these sub-fields of artificial intelligence (AI) require vast amounts of data, which can be used to train highly accurate models for solving many problems.

In forestry, deep learning and machine learning are being applied through operations such as seedling detection, land cover classification and phenotyping. These methods require vast amounts of training data to fulfil their potential. The challenges of working with such large bodies of data meaningfully, and compiling training datasets to deliver insight, need a collective industry approach.

Alfred Duval says there is an opportunity for data collaboration, especially for smaller forest owners, where participators' data could collectively flow into auto-detection models while keeping privacy paramount. This would provide a huge benefit for the industry, helping to democratise data and provide insights to foresters regardless of the size of their organisations.

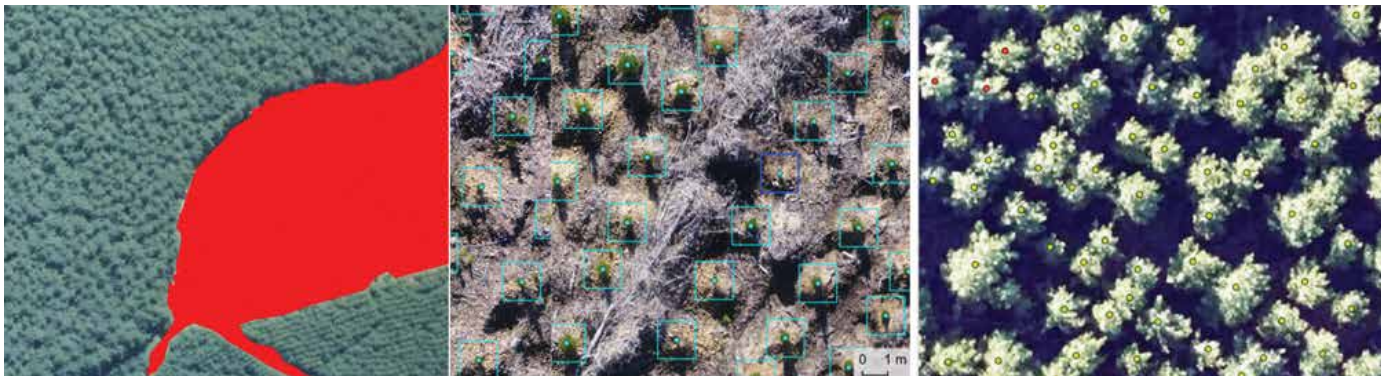

Figure 4: Deep learning (AI) models have been shown to work well for tasks such as mapping cutover (left), detecting seedlings (centre) and counting individual trees after thinning (right)

Scion remote sensing scientist, Dr Grant Pearse, believes that forestry companies will have data science teams as opposed to a data science person in the future.

University of Canterbury Associate Professor Dr Justin Morgenroth has highlighted the impact that technologies have in the hands of students. He says that they are creating LiDAR-based models using the iPhone 13. He notes that if developing LiDAR-based models can be made as easy as Apple has made everything else, then young people around the planet will know how to work with this technology in the future.

He also describes the intersection between LiDAR and drones, with photogrammetry as another potentially more accessible and cost-effective approach for foresters. There is potential to extract 3D structural data from our forest using something as familiar as photos. This provides information on forest structure without needing advanced data science or processing capability.

Supply chain connectivity will unlock new value chains

Data will continue to flow not just out of the forest but up and down the whole supply chain. This will support enhanced efficiency for existing commodity timber markets and shift into specialist, niche timber and bio-based product opportunities that could command new and higher values.

Dr Craig Morley, Associate Professor of Resource Management at Toi Ohomai Institute of Technology, believes this is an opportunity for Māori. From a Te Ao Māori perspective, forests, forestry and the management of the forest are seen in different ways. Embracing this difference has the potential to offer new value for Māori, which could then lead to higher value products to market or value protection.

Forest Growers Research Harvesting and Logistics programme manager, Keith Raymond, says the Wood First Policy will become more of a reality over the next decade. He notes that by 2030 the Wood First Policy will be more like law rather than lip service. Architects, engineers and specifiers will prioritise wood unless supply dictates other materials. He describes a future with smarter supply chains, smarter modelling and smarter buildings.

A smart supply chain also provides an opportunity to trace timber, with its associated unique characteristics (origin, genetics, treatment and management) through to market. There are now many tools available to the industry to enable the detailed tracking of silvicultural treatments and their impacts on the quality of the end product.

Forest Protection Services director, Kevin Ihaka, describes the value of digitalisation in validating and authenticating their work as forestry contractors. He points out that a contract management company usually sits between the contractor and the landowner to audit the work, representing 10%–15% of the contract value. If a contractor can advance to producing accurate, validated data to provide evidence for work done, that would take a step out of the supply chain and put more money back in the contractor's pocket.

Kevin Ihaka has also described this as a more transparent, data-led, 'warts and all approach', but he says there need to be industry protocols to ensure the approach is validated and authenticated. There is an

Figure 5: Digitalisation could offer greater value and protection to beautiful native podocarp forests through the ability to trace value through the supply chain

opportunity to standardise the methodology and for forestry contractors to become more technical and lift their game. In this approach, data-enabled contractors will move up the supply chain and take a greater share of the management role.

Indufor team leader of resource monitoring, Dr Pete Watt, describes the potential to take the data collected and transform it into useful information that drives new insight. Such information provides a real opportunity to re-think and improve workflows. It could enable better targeting of field resources, focusing on areas that may require intervention, and further enhance understanding of a site's growth potential. It could link tree locations with height information to give an immediate understanding of tree performance – even at the early establishment stage the data can provide a glimpse into the future.

Dr Watt says the detection model's scalability, transferability and accuracy are equally important. Forests are often widely dispersed, making it challenging to achieve timely coverage across large areas, and the industry is on the cusp of a real paradigm shift as innovation allows a move towards precision forestry.

Rise of data-driven companies, platforms and services

With this influx of data, we can also expect data companies to emerge to take advantage of the opportunity. These companies will look different from today's traditional forestry or forest management companies.

Dr Pearse says we could even see 'data-first' forestry companies, backed by large private equity that will bring a different perspective driven by algorithms to buy, sell and manage forests. Kevin Ihaka can also see the benefit of data service providers supporting forest management

Figure 6: UAV LiDAR point cloud colourised by individually segmented trees

with new platforms and services where data service providers might provide a valuable new service in the supply chain. They could deliver platforms where managers could upload data that would then return a count of the trees, plus any derived insight into health, pests and weeds. This could be done through an online portal with standardised outputs and services.

The forestry workforce of the future will be digital-led

Jobs and ways of working in forestry will look different, but people and the transition of the existing workforce will be paramount. The practicality of mechanising or automating tasks in the forest is a leap that not all foresters see the value in yet. In contrast, others can envisage a future that includes robot swarms and complete job transformation.

Keith Raymond says we will see multi-dimensional job roles, with a transition to becoming a supervisor of multiple automated machines. He notes that this will require a large effort in training and re-training and that we do not want to lose the skilled people we have in this expansion phase. However, we need these people to transition from the old roles into these new roles.

Figure 7: AI-derived tree locations and heights from fixed-wing aerial imagery (5 cm)

Figure 8: M-Planter in Kinleith Forest, Tokoroa. Multiple companies in NZ are currently using mechanised planting machines

Scion Human Factors scientists, Dr Richard Parker and Brionny Hooper, have outlined the importance of taking people out of the danger zone but keeping them in the loop. Dr Parker says the future is likely to look more mechanised than fully automated. He thinks we will see people controlling simplified machines, but emphasises it is good to have people in the forest. In this way, you have a workforce that knows the forest, is fit, can fight fires, keep an eye on security, and has a connection to the land and the local community that is part of the forest and environment.

Dr Parker also says we should consider a future where technology will enable much smaller, quieter devices instead of having large, expensive machines. For example, silviculture provides a good opportunity for smaller machines to solve smaller and more contained problems. There hasn't been a lot of technological advancement in tree pruning, but in the future there could be small, lightweight pruning machines with a novel power supply (battery pack on the ground beaming up to the device). The approach of taking a low-tech problem and applying an advanced technical solution could carry through to all tasks in nursery operations, planting and thinning.

Brionny Hooper says smaller machines will also change the structure of the workforce. She notes that currently contractors spend millions of dollars on machinery and must be very experienced to operate it. New technologies, smaller in size, will achieve the same or better output for less money with safety at the forefront.

Dr Parker believes this change to smaller machines could deliver a big impact on the reputation of the forest industry. He says that several simple machines

Figure 9: An example of a smaller machine – a robot capable of moving from tree-to-tree to carry out forest thinning operations developed in collaboration with Scion scientists, FP Innovations and inFact Ltd

could be involved in an operation with less reliance on one big machine. It used to be like this with chainsaws – one person operated a lightweight personal machine, and if they were unavailable (due, for example, to illness) another operator could easily step in to replace them. Now harvesting gangs are often based on one big harvesting machine, and this machine needs to harvest one tree a minute to justify the capital cost.

Dr Morley can also envisage a future with more miniaturised terrestrial robots. He envisages swarm technology, multiple data sources and drones working as a team. The big challenge is sifting through the data to find value, but he believes we will advance through deep learning and AI to ask the right questions. There is a big role for academia to offer wider specialisations to set people up for the future directions of forestry.

Kevin Ihaka challenges the need to mechanise or automate certain tasks at all. He asks, 'Why mechanise planting?' He explains that emissions produced through this are a lot more than two planters on the hill. A machine has one person in it and is burning a lot of fuel. He challenges that if we start to think hard about carbon, there are some things we really shouldn't mechanise. The best option is always the one that supports people doing the job and we need to understand the supply chain and social costs of change better.

While Alfred Duval is open to trialling new approaches, he concedes it is hard to visualise how new technology will roll out. For him, the biggest issue is the practicality of mechanising some of the tasks. Port Blakey will trial mechanised planting systems next year, but have concerns about speed and quality. He says that a boot can get a lot closer to firm a seedling in the ground than a chunk of steel.

Keith Raymond believes that the rise of machines will open opportunities for New Zealand-based high-tech manufacturing industries – winch-assisted harvesting is a good example. This technology has now enabled four viable manufacturers in New Zealand alone. Over the next decade, technology will stimulate a New Zealand-based high-tech industry with a thriving export base. Adopting technologies from overseas is often not possible in the New Zealand market because of our steep terrain and large tree size.

Dr Pearse believes that we are more likely to be technology takers, not setters. He says that it takes an enormous investment to come up with something from scratch and that we need to look at places where there is the most value to be gained first. Determining which tree to thin and how to buck logs should not necessarily be a job for people. There is a lot of value to be gained from automation at those points and these are the most obvious places to begin.

Training our foresters of the future

Toi Ohomai Forest management tutor, James Broadley, outlines the need for more cloud-based learning platforms connected to experiential learning. He says that we need to consider on-the-job work experience as part of the qualification. Work experience and cloud-based training platforms go hand-in-hand. Students in the forest or processing facility could have a range of tasks to fulfil, and they could be sharing the videos, imagery and data back to the tutor to assess. This means less time spent in the classroom and more time spent in the forest, learning and practising skills (such as flying drones and gathering and analysing data). Increased digitalisation will be key to this improved learning pedagogy.

Figure 10: ClimbMAX Steep Slope Harvester manufactured by Trinder Engineers Ltd, Nelson (the first commercial NZ-made winch-assisted harvester)

Dr Morley says COVID-19 has progressed the use of digital education solutions. However, there is still a lot of room for improvement in the design of education in a digital world, improving training and better supporting people into work.

Dr Xu believes that many students still see advanced algorithms used in analysing geospatial data, such as deep learning and machine learning, as a black box. She says that we need to teach students a wide range of topics, but the current curriculum for undergraduate study is reasonably fixed. To be more specialised for jobs, such as working with geospatial data, a student may consider further study for certain forestry specialisations.

The future of forestry for NZ

When considering the future of forestry for the country and combining this with the new value that data will offer, there is an untapped opportunity to look at our national forest estate as one.

Dr Pearse says there is an opportunity to have one digital view of our total forest. He says that this will answer a much broader range of questions. It will offer the potential for more insightful research that can happen faster and will drive decision-making. It will deliver immediate value for wood flows, wood supply and wood pricing. It would also help quantify the forest estate's aggregate value to the entire country.

He says this will become more important as the industry becomes more fragmented. With many smaller players entering tree planting, digital representations become essential to get information at the macro and micro levels.

As we continue into this period of rapid change led by technological advancement, two things are clear – we will have more trees in the ground than ever before, and the data undergrowth will be expanded with every tree planted. Once flourishing, this has the potential to spread and grow to deliver insight and exponential value to the forestry sector in New Zealand. The management of our forests and processing practices will be more efficient and mechanised, but people will still be an integral part of the picture. Workers in our industry will be safer and happier going about their work supported by more data and new technology.

Acknowledgements

In writing this paper the authors have combined their perspectives and the insights of those they interviewed. The New Value Digital Forest and Wood Sector Portfolio has four research pathways of the future that strongly link to many of the themes outlined in this paper: 1. Supply Chain Connectivity; 2. Intelligent Forestry Systems; 3. Precision Forestry at Scale; and 4. Future-Proofing Forestry. For questions, comments, or queries about future collaboration opportunities connected to the research pathways, please contact: claire.stewart@scionresearch.com

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