# INDIVIDUAL TREE DATA VALUE PROJECT

**Phase Two**

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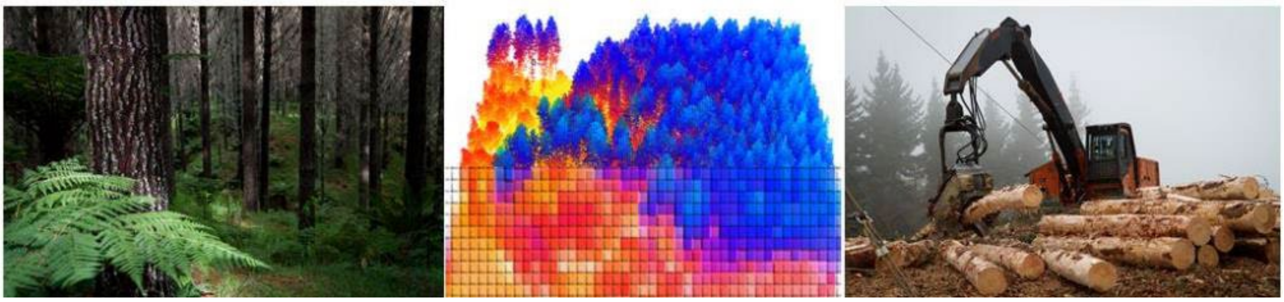

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# 1. INTRODUCTION

The forest industry in New Zealand has historically focused on capturing forest information at a stand or compartment level, generally providing weighted averages or population sampling to represent entire stands or even forests. This generally involved physical measurements through manual plotting at certain times throughout the life cycle of the forest. Generally, these sampling methodologies have led to a low-resolution dataset that represents large areas of forest resource.

More recently, there has been a shift to the adoption of spatial information to represent forest crops. New technologies, either already available or emerging, now allow forest managers and contractors to capture forest location and tree-demographic data at the level of the individual tree, from the time of planting until harvest.

Examples of individual tree data capture can include remote sensing and/or aerial imaging technologies (manned or unmanned) that allow for the capture of individual tree location, health and tree demographics data soon after planting; or mechanical planting machines with precision GPS units that are able to capture individual tree location data at the time of planting.

The Precision Silviculture Programme, managed by Forest Growers Research, has identified a need to understand whether the New Zealand Forestry Industry including Forest Owners, Forest Managers, Silvicultural Contractors, and any other potential stakeholders, perceives a benefit or value in capturing data at the level of the individual tree: Individual Tree Data (ITD). To this end, Forme Consulting Group undertook a project to interview key contacts within the New Zealand Forest industry to understand the value of collecting and using ITD. Throughout this report, ITD will refer to all of the technologies that enable capture of data at the individual tree level, for example LiDAR and Aerial Photo capture techniques from UAV, fixed wing or satellite.

This report encompasses the results of Phase Two of the ITD project which involved interviews with key contacts across the industry based on the key themes identified in Phase One. The purpose of Phase One was to conduct an assessment and review of existing practices and technology being used for collecting tree and stand inventory data through a high-level review of existing technology used both in New Zealand and internationally. This review developed key questions and themes that allowed for a more concise, streamlined and informed interview process with the key stakeholders in Phase Two.

# 2. PHASE TWO SCOPE

The Phase One review identified three key themes, challenges or potential barriers that drove the initial conversations with New Zealand Forest Owners, Managers, Contractors and other stakeholders to gain an understanding of their perceived value of ITD.
It was anticipated that there would be differing levels of knowledge of ITD and potentially perception of value, as well as opinions that may result in them providing more information under one or another theme. The three themes that were identified from Phase One are listed below:

1. Understanding of Individual Tree Data:
    - Key stakeholders' understanding of what ITD is;
    - What ITD can be used for?
    - Initial impressions of ITD;
    - Look to identify where the interviewee perceives ITD can add value (if any);
    - At what stages ITD would provide value throughout the forestry life cycle (young forest vs. semi mature);
    - Identify their willingness of adopting ITD as part of their strategic direction if they are not already.
2. Understanding of Individual Tree Data technology:

- Gain an understanding of the interviewee's awareness of the types of data collection technologies required and available for ITD data collection;
- Identify understanding of the current status and capabilities of that technology and whether it seems adequate for them to adopt;
- Identify any knowledge gaps between the research surrounding ITD and its appropriateness in an operational use case;
- Understand the performance of existing ITD technology and underlying issues (if any) from using this technology.

3. Barriers and Keys to Adoption:
   - Address what types of resources, procedures (workshop, online seminars or written materials) or even personnel are required for the interviewee to further adopt use of ITD;
   - Identify any barriers (such as remote connectivity) they perceive will slow their adoption or even stop them adopting ITD;
   - What event or influence is required for a significant drive in the uptake of ITD throughout the forest industry in New Zealand.

# 3. INTERVIEW RESULTS

## 3.1. Interview Overview

At the time of writing this report, Forme has interviewed 20 forestry industry representatives including Large Forest Owners, Service Providers, Forest Management Companies (representing the management of small to medium forest growers) and forestry contractors.
The interviewees were made up of:

- 12 Large Forest Owners
- 5 Forest/Investment Managers
- 3 Forestry Contractors/Technology providers

The total managed interviewed estate area of 1.24 million hectares represented approximately 68% of the total national exotic forest area of 1.83 million hectares as stated in the latest 2022 NEFD survey. Response from the industry was strong, with keen participation from interviewees indicating this research area as currently important and relevant to the industry.
Forme believes that the sample interviewed represents a strong sample of the NZ Forest industry and has attempted to canvas a wide scope of industry participants.
There were no participants who refused to participate in the study, however, some people who were approached either did not reply or were too busy at this time to participate. A couple of other silvicultural contractors/other industry stakeholders (such as industry bodies or Real Estate Agents) were approached at a high level for some thoughts, however, as they were generally not involved with any ITD and could not provide any further insight they have been excluded from any further discussions within this report. However, we believe it is worthwhile to mention this as it is an indicator that not everyone in the industry has been exposed to ITD and will likely need upskilling as the industry moves forward in this space.

# 4. COMPANY CLASSIFICATIONS AND STRATEGIC DIRECTION

Throughout the interview process of all 20 participants, Forme was able to gain a general understanding of three main categories that we could apply to the companies and their adoption of technology in relation to ITD. These could be split into three generic categories that also relate to how the companies perceive the strategic importance of ITD:

1. Industry Leaders: companies that are forging ahead in this space because they see value in these data and believe it to be the future. These companies are trying to introduce workflows, procedures and processing capability to adopt this technology throughout their forests. Industry Leaders have identified ITD as a major part of their strategic direction, where significant resources and research have been put into the application of ITD. They

currently have or are developing the full in-house capacity to capture, process and analyse ITD or are at least building relationships with 3rd party providers (Skylab for example).

2. Fast Adopters: companies that are beginning to adopt this technology and are willing to accelerate adoption if the technology can be proven to be accurate in an operational setting. Fast adopters have generally identified the uptake of ITD as of significant strategic importance. However, it is possible to split this category into two further categories:
   a. Significant Strategic Importance: where trials have been deployed with capture of ITD routinely carried out, however, while companies may have some in-house capabilities to capture, process and analyse ITD they will mainly out-source the processing.
   b. General Strategic Importance: where a lower number of trials have been deployed but no routine ITD capture procedure yet established. However, these companies can still see the importance of adopting this technology and just need some further guidance or resource to uptake the technology. These companies currently require ITD capture and processing to be outsourced when required.

3. Slow followers: companies that can ultimately see a benefit in this technology, however, it is not high on the list of priorities or importance and will therefore allow the rest of the industry to iron out the kinks and sort out any issues before adopting it themselves. Slow Followers have identified ITD as a low strategic importance, with very limited to no trials completed and are reluctant or hesitant to invest any time or resources in the technology until there are proven benefits.

Forme's assessment of the companies that were interviewed were categorised as below:

**Table 1: Participant classification**

| Classification | Industry Leaders | Fast Adopters | Slow Followers |
|---|---|---|---|
| Number of participants | 7 (35%) | 9 (45%) | 4 (20%) |

# 5. FOREST OWNER AND MANAGER KEY FINDINGS

The following findings summarise the answers to the key themes from the 17 forest owners and managers out of the 20 total interviewees. Forest owners within this review are companies that own and manage their own forests, and forest managers are companies which manage other owner's (usually small to medium size, i.e. less than 1000 hectares) forests on their behalf.

# 6. AWARENESS OF ITD

All 17 interviewees confirmed that they are aware of the concept of ITD. Most, 82%, described their understanding as good or even a strong understanding while the remaining participants outlined only a shallow understanding of the idea and terminology.

### 6.1.1. ITD Usage

All the interviewees confirmed that they are aware of use cases for ITD, with 35% of the participants confirming they are actively using some form of ITD throughout their business on a regular basis, with the implementation of active workflows (or trial attempts). Up to 45% indicated a small degree of ITD adoption and 20% of them have not yet trialled any ITD.

## 6.2. ITD Capture Timing

Trialling and adoption of ITD did not follow any particular trend, with companies or contractors adopting it based on where they perceived the technology to add value to their company or operation. This can be broken down as follows:

- Eight companies are capturing ITD (however, at differing commitment levels - from only giving it a couple of trials all the way through to complete rollout) for survival assessment after planting, with an operational age ranging from 8 months post-planting through to a crop age of 3 years old.
- Eight companies are using ITD for pre-silvicultural operation assessment. This was generally covering thinning operations due to the modelling limitations for pruning assessment at this time.
- Eight companies are using ITD for post-silvicultural operation assessment, again with a focus on thinning due to reduced pruning in general throughout the country as well as technology limitations, such as delivering accurate information of pruned heights from aerial based LIDAR.
- Ten companies have used ITD for volume imputation for inventory purposes i.e. Mid Rotation Inventory (MRI) or Pre Harvest Inventory (PHI).

All respondents identified that they have not yet managed to completely substitute traditional measurement processes with a replacement form of ITD assessment. All operations are still requiring manual data checks for accuracy or substitution. However, this is getting better and the confidence in the process is increasing, especially among the few companies which are leading in this space. **The most progress in the use of ITD is in replacing the manual operations of post-planting survival assessments and post-thinning assessments.** However, there is still a significant reliance on 3rd party outfits for AI algorithms and deep learning protocols to process the data.

## 6.3. Technology Used

We have summarised how many of the 17 interviewees use each of the main forms of technology that were discussed and identified in Phase One of this project. These technology types are generally used to capture ITD, either through photogrammetry or LIDAR purposes.

**Table 2: Technology Used by Forest Companies**

| Tech Used | Public Lidar | UAV Photogramm-etry | Lidar UAV | Fixed wing | High-Res Aerial Imagery | Satellite Imagery | AI Tree detection | MLS[1] | TLS[2] |
|---|---|---|---|---|---|---|---|---|---|
| No of Participants: | 17 | 17 | 7 | 14 | 17 | 14 | 12 | 3 | 1 |
| Percentage of Study: | 100% | 100% | 41% | 82% | 100% | 82% | 71% | 18% | 6% |

1 - Mobile Laser Scanning; 2 - Terrestrial Laser Scanning

Importantly, **we identified that only one of the interviewees is confident that they have the ability to process this data in-house or are in the process of building this capability. Otherwise, other companies use service providers either in New Zealand or overseas to process this information, even if the company themselves captures the data**.

## 6.4. Willingness to Pay for ITD

We have classified the participants willingness to pay for ITD in the current stage into three categories:

1. **Willing to pay more than the existing cost**: Companies in this category believe that ITD will benefit the company and if there are extra costs, these can be offset by the value-added benefit associated with a better understanding of their crop throughout the forest lifecycle, which ultimately provides more certainty through tougher economic times. **Seven companies fall into this category, representing 41% of the total interviewees.**

2. **Willing to pay up to an equal amount of their current operating costs for inventory**: Companies in this category are willing to pay for ITD if it costs the same as their current practices. Most in this category identified that they are willing to pay for some initial R&D over and above this to get it off the ground and consider them a cheaper substitution for manual measurement.
   **Six companies fall into this category, representing 35% of the total interviewees.**

3. **ITD should cost less or unable to decide**: Companies in this category either wish to pay less than current practices for them to spend the time and effort to change to it, i.e. they require a specific cost saving, or they do not necessarily understand in which part of the business the benefit of ITD can be reflected and until the understanding is clear, they are unable to comment if they are willing to pay more or less than their existing capture method.
   **Four companies fall into this category, representing 24% of the total interviewees.**

The willingness to pay more for these data is generally supported by the majority of the participants even if some of them are not using it yet. Participants can see the value in having a greater understanding of their forests and believe that if ITD were to cost more than it does now then the value proposition would offset this. This is elaborated on further in Section 4.

Importantly, while most participants (76%) said they would pay the same or more than current costs, there was a general distinction between a forest owner being able to cover this cost and or invest in R&D for their own forests, and a forest manager who likely had to pass this cost onto their client. Forest managers all said they would struggle to justify to clients' any higher costs than current but if they can prove there will be additional value seen by the clients it will be easier. There appeared to be a general correlation between forest managers being in category 2 above and also being "fast adopters" of the technology.

## 6.5. Costs

Forme attempted to get an understanding of the costs that are incurred to use ITD data capture processes throughout the industry so that this could be compared to traditional forest inventory capture methods like MRI and Pre/Post (planting, pruning or thinning) assessment data plots. This proved to be challenging, as while a generic cost range can be easily identified for traditional practices, as seen in Table 3 below, a lot of the ITD data capture costs to date have been completed under Research and Development (R&D) programmes, with no way to correlate this information to an operational $/ha scale. However, where possible, interviewees gave costs for specific processes (AI Tree detection for example) as can be seen in Table 4.

It is important to note that while the costs below cover data capture and external processing (such as AI Tree detection), it does not cover the cost of manipulating this data in-house once received from any external parties (whether this is a raw inventory file or LiDAR dataset). This will still need to be assessed and used by an in-house staff member such as a technical forester or GIS Analyst to be able to manage this data into usable datasets such as yield tables or mapping layers. The cost of any in house labour is not included in the below due to the range and complexity of costing this variable out.

**Table 3: Traditional manual data capture method costs**

| Traditional Inventory Operation | Cost Range $/ha |
|---|---|
| Manual Survival Plot | $20/ha - $40/ha |
| Manual Pre-Silvicultural Assessment Plot | $40/ha - $100/ha |
| Manual Post-Silvicultural Assessment Plot | $75/ha - $100/ha |
| Manual PHI/MRI | $50/ha - $200/ha |

**Table 4: Estimated cost range for ITD data capture methods**

| ITD Operation | Cost Range $/ha |
|---|---|
| Fixed wing Lidar Capture (with data processing) | $3/ha – $50/ha (heavily dependent on area of interest) |
| AI Tree detection (post data capture processing) | $5/ha - $8/ha |
| Drone Photogrammetry | $12/ha - $50/ha |

The costs above are purely based on information provided by interviewees throughout the interview process or other information available to Forme. All interviewees were of the opinion it was a matter of when, not if, that costs to capture and process ITD type data, using drones or satellite platforms to capture images or LiDAR, will come down and there was a general consensus that the processes will be cheaper and provide a larger richer dataset that may provide multiple uses.

Participants undertaking manual operations all commented that external pressures were generally driving the costs of these operations up, with labour costs and a lack of labour compounding the prices per plot upwards. Some companies were using students in their summer breaks to try and get through their inventory programmes, however, a lack of experienced people with the appropriate work ethic to complete what is sometimes hard physical work was reported nationwide.

An important aspect which was raised by all interviewees was that the cost to capture the data may be the smaller part of a bigger picture and that managing the data and storing this information is going to require additional capability and cost if they need to develop or license software to access and manipulate the data. This will be discussed further in the barriers to uptake section.

We have attempted to complete some cost comparisons over the life of a rotation based on information provided in this study. This cost comparison ignores any additional software or licensing costs required to manipulate or interpret the data which is required for both manual and ITD capture methods or the cost of an in-house staff member to manage this data once received (as outlined previously) but does include the cost of processing this data where applicable (AI tree detection for example).

**Table 5: High level cost comparison between traditional manual data capture methods and a proposed ITD data capture structure**

| Cost comparison between manual and ITD costs $/ha | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Operation: | Survival Plot | Lidar Capture | Pre-Thin | Post-Thin | LiDAR Capture | | MRI | LiDAR | PHI | Total Cost $/ha |
| Age of Operation: | 1 | 4 | 7 | 9 | 12 | 15 | 18 | 21 | 24 | |
| Total Manual Cost | 30 | | 80 | 80 | | | 150 | | 150 | **490** |
| ITD Costs $/ha | | | | | | | | | | |
| Drone Capture/Processing | 15 | | 12 | 12 | | | | | | 39 |
| Tree Detection/Data Processing | 5 | 10 | 8 | 8 | 10 | 10 | 10 | 10 | 10 | 81 |
| LIDAR/Processing | | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 160 |
| Total ITD Cost | 20 | 30 | 40 | 40 | 30 | 30 | 30 | 30 | 30 | **280** |

In this high level analysis we have estimated that the data processing cost for LiDAR is higher than that of photogrammetry ($10/ha vs $8/ha) due to higher levels of data captured by a LiDAR sensor than a photogrammetric sensor on a drone.

The above cost analysis is based on averages of the returned costs by the participants. It identifies that even with a middle of the road capture cost in today's terms, the total capture cost over the life of the forest has the potential to be significantly cheaper than that of manual methods, even with LiDAR captured every 3 years throughout the rotation which may be more frequent than necessary**. However, the cost of in-house capability needs to be considered as it is highly likely that the companies do not currently have the capacity to manipulate this data effectively in-house and extra labour units such as data scientists may be required to understand these datasets. This would be an additional cost to the costs identified above and is difficult to quantity in this broad analysis.** Further discussion on the capacity of the companies is provided in the Tech Transfer section below.

With increasing pressure on availability of labour and labour costs, the manual costs above may even continue increasing while ITD data capture costs should reduce as the technology gets cheaper and more readily available.

# 7. CONTRACTORS AND SERVICE PROVIDERS

Forme formally interviewed three silvicultural contractors and/or service providers to round out the interview process. These included:

## 7.1. Company One: A forest technology and innovation company

This company provides UAV and LiDAR based services and were able to provide insight into the development of the technology and trends they are seeing throughout the industry at this time. As an adopter and provider of all the ITD technology outlined in this project, it is fair to say this company saw value in the technology and will be adopting it going forward.

## 7.2. Company Two: A technology focused silviculture contractor

The silvicultural contractor interviewed is widely adopting drones and multispectral imagery throughout their workflows. The company was an early adopter of drones and believe it is a key part of professional forest contracting moving forward. They use drones and multispectral imaging for everything from counting trees, slash modelling, fire management and control and forest health properties. They have successfully used multispectral imagery to determine nutrient deficiencies, moisture content, weeds and forest health. They believe it can also be used to determine operational requirements such as weed control and fertiliser.

The contractor highlighted that if this technology is run by a suitably competent operator and contractor, then operations like quality control (QC) can be minimised as there will be less need for double ups in planting QC for example, where both the contractor and forest manager will complete QC operations. This presents a quantifiable cost saving if undertaken correctly. However, they also highlighted that there is limited information for how to adopt this technology and it is both a costly and steep learning curve to undertake this operation. The contractor highlight they have spent close to $250,000NZD in startup costs to get this going and there is another $40,000-50,000NZD requirement to keep their pilots licensed and with the appropriate software on an annual basis. This may not be viable for all contractors to undertake and there will likely need to be a mix of forestry companies and forestry contractors operating this gear.

In this contractor's experience to date, the larger forest owner companies they have dealt with are reluctant to stray away from their status quo and do not want to spend money, however, they can see a direct value in capturing ITD for pricing blocks correctly for operations, especially when it comes to thinning rates. Contractors and companies will benefit from this and there is a need for NZ companies to collaborate with other national and international companies and industries (Fire fighting for example) to develop this technology at a faster rate.

## 7.3. Company Three: A production thinning contractor

A production thinning contractor who has been involved in the adoption and development of ITD as a way of determining post-thinning stocking information and subsequently contract performance in the Hawkes Bay was interviewed to gain an understanding of their experience in the shift to this new technology.

The contractor has been working with a large forest owner to implement drone-based tree detection after production thinning. Forme reached out to get their perspective of how implementing ITD went from their perspective as a contractor and how it has affected their business, if at all.

The contractor highlighted that it was very important for the forestry company to involve the contractor from the beginning and bring them along for the ride. The process was originally sort of thrust upon the contractor and this resulted in some tension and questioning of the results of the process at the beginning.

The contractor wanted some verification that the technology was working right as initially the contractor had doubts on the results presented to them by their forest company based on their own information and data from the block. After assessing the quality of the outputs, the technology and tree detection algorithms needed further calibration. After a few iterations resulting in further calibration, the technology was becoming more accurate, and the stocking estimates began lining up with the contractor's other information and observations.

After this trial process, the contractor actually believes in the technology and has stated that they are happy with the final outcome and thinks it will provide a fair indicator for contract performance. However, this process highlights that if this technology is going to be used as a contract performance indicator, then it is going to require many trials and iterative versions, and that the initial results cannot be relied upon, at least at this stage, to be accurate enough without any ground truthing with the contractor. This will prove the concept to the contractor and in theory allow the modelling to get more accurate and require less ground truthing in the future.

Ultimately the contractor sees merit in this system and can also see the benefit of having this complete stocking information prior to thinning as it will provide an accurate overview of the state of the thinning block in which case the contractor should be able to price the block more fairly, resulting in cost savings and profitability for all parties involved. More accurate thinning rates can be correlated to a direct cost saving for the forest owner, presenting a tangible and measurable value proposition.

# 8. VALUE OF INDIVIDUAL TREE DATA

Every participant (100%) saw ITD as adding value and generally being transformative for the forest industry within New Zealand. We have summarised the five most prevalent themes that came up in discussions with the participants. Key value-add ideas that were encompassed within these themes were identified as: reducing costs, saving time, increasing knowledge, and better decision making.

## 8.1. Forest Monitoring and Management

Eighty eight percent (88%) of participants identified that the ability for remotely collected high resolution geospatial data (via manned or unmanned platforms) to underpin forest monitoring and management is a key value proposition of ITD.

Participants identified that ITD providing a higher level of data at planting for example, will allow for better decision making for forest management operations such as blanking and monitoring survival rates. This reflects the fact that many of the companies have already completed and implemented or are starting to do trials of post planting survival stocking assessments. Company Two identified that by using drone imagery and multispectral information at a contractor’s quality control level, this could mitigate the need for forestry owners or managers to repeat this process themselves, potentially saving operational management and assessment time.

## 8.2. Silvicultural Decision Making

Sixty five percent (65%) of the participants view ITD as an important part in facilitating future informed decisions regarding forest silvicultural practices. In a silvicultural operation, such as thinning, it is likely that the ability to have a better understanding of the forest prior to the operation will allow for a more accurate thinning rate calculation, potentially saving money for the forest owner. The ability to capture exact stockings post thinning will also result in a more precision managed crop which will mean that silvicultural regimes and practices can be targeted to specific areas within a forest, potentially related to growth, slope, aspect, etc.

## 8.3. Volume Prediction

Fifty three percent (53%) of the participants are optimistic about ITD's potential to enhance volume prediction accuracy as well as provide an alternative to manual based methods. All interviewees identified they see increased costs impacting the forest inventory space through traditional manual measurement methods, and there will inadvertently be value in capturing higher quality individual tree volume estimations throughout forest, potentially at a lower cost. A few participants also commented on how sampling methodology can be influenced by human bias and is becoming a rare skillset, with some areas such as forest mensuration generally requiring lots of experience and training to be accurate. With this skillset diminishing, the value in having technology capture this information is hard to quantify but could be vital for the industry to pursue should capturing this information through manual methods continue facing further challenges.

## 8.4. Silvicultural Operation and Quality Control

Though not as prevalent, 35% of the participants identified a notable confidence in ITD's ability to improve quality control in silvicultural operations.

## 8.5. Cost Reduction

There's a shared belief by 18% of participants that ITD can lead to decreased costs by streamlining operations and management processes, however, it was clear that initially this is more directly related to the potential cost savings outlined in point 2 above (silvicultural operations), rather than data capture itself. Most participants believed ITD to cost the same or more than current operations, albeit with no specific examples of the costs of ITD in comparison to an equivalent manual method.

**While all interviewees have acknowledged ITD will add value to the industry. There were no interviewees that were able to quantify the value, whether in specific $/ha value recovery or costs reduction, or any quantifiable decrease in operational management, or what value they may receive from having a better understanding of the forest resource. Cost implications of any new staffing resource (as identified in the Tech Transfer section below) to implement and manage these datasets were not discussed.**

# 9. VALUE THROUGHOUT THE FORESTRY LIFE CYCLE

We have classified the participants' views on where the value of ITD can be reflected throughout the forestry life cycle into three stages; Establishment, middle and late.

1. Establishment (approx. 0 to 5 years old): Nineteen companies, representing 95% of the total interviewees fall into this category, who believe that ITD can help facilitate precise early forest monitoring that will enable early detection of issues such as inappropriate spacing, poor establishment, disease outbreaks, or pest infestations. Ultimately this should allow for early intervention to avoid any significant issues going forward.

2. Mid-rotation (approx. 6-19 years old): Eighteen companies, representing 90% of the total interviewees fall into this category, who believe that ITD can provide detailed information on tree health, size and spacing. The goal would be to enable informed decisions for silvicultural operations and reliable quality control processes for operations such as pruning and thinning based on individual tree characteristics.

3. Late-rotation (approx. 20 years old to the time of harvesting): Fourteen Companies, representing 70% of the total interviewees fall into this category, who believe that ITD will provide better volume and log grade mix estimations, giving forest managers/owners the information needed to optimise harvest operations based on log grades splits and volume recovery.

Overall, thirteen interviewees (65%) believed ITD will add value to the entire forestry life cycle. However, most of the interviewees commented that the value in ITD will come as early as possible in the life cycle and should be followed throughout the whole life cycle, for both better early decision making for crop management which will ultimately be reflected in value at the time of harvest. Once the window for silvicultural operations is closed, ITD is mostly considered as a tool for continuous forest monitoring and value estimation. Zero interviewees could provide comprehensive examples of how this data could be used outside of the forestry industry itself and this is likely down to the infancy of ITD and the applicability and utilisation of the rich datasets it can capture.

One interviewee did not provide any comments on this due to lack of utilisation to date and knowledge of how ITD can be applied but didn't discount the use of it at their company in the future.

# 10. BARRIERS AND CHALLENGES

One of desired outcomes of the interviews was to attempt to document the barriers or challenges the participants identify to the further adoption of methods that enable collection of Individual Tree Data. This varied significantly by organisation type. Even within the same category (Forest Owners or Forest Managers), different organisations have varying measures of success, whether that be financial results for shareholders/stakeholders, optimising workflows, more efficient forest managing, costing less for small forest owners or simply better forest management practices. We have categorised the barriers identified into similar categories in the sections below.

## 10.1. Tech Transfer

**There was an overwhelming response (as reported by 89% of respondents) from the participants that the industry is struggling with what is known as "Tech Transfer" and this is currently the largest barrier to the adoption and use of ITD capture methods**. This barrier is the difficulty in transferring research innovations into practical and scalable adoption within an industry.

All participants were aware of the potential to collect ITD and had seen the research and examples presented at conferences such as ForestTECH in New Zealand or Australia. However, applying the technology at scale and efficiently is proving to be a key issue for NZ foresters. We have broken down this 'Tech Transfer' category into further subcategories below.

### 10.1.1. Limited familiarity or guidance

**There's a lack of familiarity and experience with ITD technology, which is hindering its adoption.**

The absence of clear guidance or support on how to implement and use technology for ITD capture is effectively deterring faster adoption. A lot of foresters are aware of the technology and research but do not know how to implement it within their organisation. This reflects the research found in Phase 1 of this project and highlights the need for some sort of supporting material to assist foresters to scale out the information.

Ideally companies want to be able to complete these workflows in-house and with their own employees, so while external support and collaboration with other forestry organisations (especially service providers like Interpine, Indufor or Scion), is currently beneficial for capturing data, ultimately companies want to build autonomy and drive innovation internally going forward. Each company has different workflows, reporting requirements and even levels of confidentiality, so there will always be a requirement to manage this data internally and potentially waiting for a "One Size fits all" software suite is not going to be the right option.

Company Two made reference to "Tools for Foresters", an online resource where foresters were sharing Standard Operating Procedures (SOP) for how to use drones, or Lidar information etc. There could be scope in furthering something like this initiative to get the operational knowledge out to foresters who wish to use it.

### 10.1.2. Operational applications

Building on from a lack of familiarity and guidance on the technology, five companies specifically said that applying this technology to day-to-day operations has not been ironed out yet, so while there is a barrier in how to actually capture the information, there is also a low level of understanding in how to roll this technology out on an operational basis, with no idea of how and what to do with the information once it has been captured.

### 10.1.3. Workforce capacity

Twenty nine percent (29%) of the participants (all large forest owners) explicitly stated that they would not currently have the capacity or correct people in-house to capture and manage ITD. This was not a specific question as part of the interview process, and so was not discussed in all interviews however this highlights that it is likely that most if not all organisations do not currently have the internal capacity to manage these datasets. Currently they may outsource some of this data management, however, as previously identified the general belief is that the companies would want to manage these processes in-house (with perhaps the exception of AI data processing which could be completed by a third party company or tool to run the AI models) so they would need to invest in training and potentially hire specific roles (technical foresters or data scientists for example) to develop in-house expertise in ITD capture methods, management and analysis.

Multiple participants said that the roles of ITD development within the company was falling upon existing foresters that already had very busy work schedules and the time to fly drones and compute this data was extensive. Therefore, it is likely that building further internal capability is crucial for maximizing the potential of ITD technology throughout the forest industry, however, this will likely require proof of the concept for companies to recruit more staff and therefore there is potentially a vicious cycle forming of what is required first – the workforce or the accurate technology.

## 10.2. Technical complexity and challenges

Similarly to Tech Transfer, 89% of respondents believed they do not currently have the technical solutions, either hardware or software to manage and integrate ITD data in-house, especially to incorporate into existing data management systems and workflows. Three participants had made significant investment into hardware like supercomputers or roles like data scientists to begin scaling up for ITD in their businesses, however, none of the respondents believe they were there yet.

One of the challenges in integrating ITD data into new or existing data management systems is the significantly higher technical complexity of working at an individual tree level rather than the stand level reflective of currently sampling methodologies. Existing workflows using sampling methodology and associated software (e.g. Forecaster, YTGen) can be relatively simple, however, even large datasets can make these processes prohibitively slow. Often these software packages directly relate to business operations such as forest valuation or estate modelling and the uptake of ITD in this context will ultimately require the same outputs to drive similar models and business functions, meaning that any new software will likely need to provide outputs in a similar manner as what is seen today.

Included in this category is the general consensus that significant investment in Data Management Infrastructure will be required to handle the vast amount of data generated by ITD technology. There is uncertainty around whether current software products like GIS (ArcGIS or QGIS) can handle the level of data required.

## 10.3. Costs

The uncertainty around the potentially high costs associated with adopting processes that underpin use of ITD is seen as significant barrier, with 47% of participants citing cost as a barrier to further adoption. This is especially prudent if the benefits are not clearly understood or quantified.

Some companies stated they will require a thorough cost-benefit analysis to ensure that the investment in ITD technology provides tangible benefits and without a clear understanding of the returns, some organisations are hesitant to commit resources. As previously presented within this report, the potential for lower costs than currently incurred by manual methods could be possible, however, there are very few external resources available for foresters to refer to ITD costs that allow the cost-benefit analysis to be captured.

In general, the costs for ITD data capture are not well understood within the industry and may also requires a few other metrics such as technological adoption and familiarity with the processes to be sorted first.

## 10.4. Accuracy or capability limitations

Some participants identified previous experiences that resulted in poor results when using the technology as a barrier to further adoption. One particular instance was a low level of accuracy when using AI algorithms for tree counting in rugged and steep terrain, which resulted in such poor results that the company decided to halt any further investment until proof that the concept had worked better in other instances. This company, however, also said they would be happy to facilitate a trial in their difficult terrain should the opportunity arise.

Overall, 16% of participants identified accuracy as a potential barrier, with the above experience highlighting a common barrier faced by the fast adopters and especially the slow followers, that the technology will need to get better and have highlighted success stories with improved accuracy in difficult and common operating environments for companies to adopt it further.

## 10.5. General hesitation to adoption

Generally, participants were eager to see the adoption of methods that allow collection and use of ITD, however, 21% of participants identified a general hesitation to adopting an ITD level approach. These participants generally required further convincing that adopting ITD capture was required. They perceived that the added complexity of managing the data may not be returned in the value of the data captured at the individual tree level and there was a need for demonstrated value and practical applications before widespread adoption.

There was also a general commentary that there is no need to capture data for the sake of data capture, and that the adoption of assessments and monitoring that underpin operating at the level of the individual tree will need to be outcome based, with data collection serving specific purposes and leading to actionable insights. Without clear objectives, collecting data could be inefficient and wasteful.

In some instances, interviewees identified that there will be some organisational conservatism to overcome at their respective organisations, with a resistance to change apparent. This is relatively common in the forestry industry in New Zealand with an older generation of workforce potentially resisting change, however this is likely to decrease with increasing numbers of younger workers coming through the industry.

# 11. CONCLUSION AND KEY MESSAGES

In conclusion, while there's substantial enthusiasm and support for the potential benefits of using ITD in forestry within New Zealand, further demonstration of projects working successfully operationally, as well as how to achieve this, is required for further adoption throughout New Zealand.

Out of the 20 participants all of them were aware of technologies that support capture of ITD, with varying levels of adoption and use to date. Some (35%) of participants are actively striving towards use of ITD in their business and leading the charge, others (45%) are beginning to adopt it to a lesser extent or are willing to adopt it quickly should more accurate information or confidence in value and/or costs become apparent. Only 20% are awaiting a more compelling business case and wider industry adoption with proven cost savings or value propositions before further adoption. Despite progress in this space, manual processes still prevail throughout the industry and are required to supplement capture of ITD, especially in data accuracy checks. At the current stage, most participants are outsourcing data processing due to limited in-house capabilities.

Overall, participants recognised use of ITD will be transformative for the industry and identified value in a future ability to reduce costs, save time, and enhance silvicultural decision-making. There was no consensus on how to quantify this value apart from specific examples like gaining a better understanding of the silvicultural costs for a thinning operation across a block.

Current barriers revolve around technical complexity and tech transfer which is the ability to roll the technology out on an operational level. A lack of guidance and strategy with key outcomes is hindering a widespread adoption of the new high resolution geospatial technologies. There is also an uncertainty of the costs of this technology, however, basic cost comparisons between traditional methods and those that support collection of ITD (Aerial Lidar, AI Tree Detection etc) showed that there could even be potential cost savings across the life of the forest rotation. Twenty nine percent (29%) of participants highlighted that having the appropriate internal workforce capacity and resources is going to be an immediate issue. A few participants identified that we should be looking overseas to gain an understanding of what is already happening as their international counterparts have made progress in this space.

Ultimately, participants are very willing to pay, with 76% of participants willing to pay more or up to their current costs should they have a richer dataset to make decisions with. The value of precision forestry is to manage forests as a raster dataset and not a large polygon dataset, with a better understanding of the total forest asset providing value for optimisation which is becoming more important as the economics of forestry are squeezed through higher labour costs and volatile markets.

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