Precision Silviculture Programme

Evaluation of Smart Technologies for Manual Tree Planting Accuracy and Quality Assurance

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FOREST GROWERS RESEARCH

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EXECUTIVE SUMMARY

Background

This study examined potential GPS location systems that can be used in manual tree planting operations to record where every tree is planted. There are operator and technology considerations to consider when assessing which systems will be viable and valuable and we aimed to include this in our evaluation of technologies. Several companies in New Zealand and offshore have produced systems at various stages of maturity. There are also systems that while not directly transferable to spade planting of trees are worth a mention to inform the reader of all the alternatives in the field.

Findings

The investigation into the use of GPS technology in silviculture revealed several key insights:

- **Established Yet Evolving**: While GPS technology is not new, its application in silviculture for enhancing the accuracy of manual tree planting is an evolving area, with potential for significant impact on operational efficiency and plantation quality.
- **Variable Adoption and Innovation**: Across different regions, the adoption and innovation levels of GPS technology in tree planting vary, reflecting a spectrum of operational practices and technological integration within the sector.
- **Promise Pending Practical Validation**: Preliminary feedback suggests that GPS technology shows promise for improving tree planting outcomes. However, its value is contingent upon demonstrating practical utility and cost-effectiveness in field operations.
- **Technological Viability:** Several GPS-based technologies have demonstrated potential in improving the spatial precision of manual tree planting, offering real-time tracking of planter movements and accurate recording of tree planting locations.
- **Stakeholder Interest:** There is a strong interest among contractors and forest management companies in adopting technologies that can provide real-time quality assurance and accurate tree location data.
- **Barriers to Adoption:** Despite the potential benefits, several barriers to technology adoption were identified, including cost considerations, the ruggedness of devices for field use, and the need for technologies that function effectively in remote and connectivity-limited terrains.

Summary and Recommendations

This report underscores the significant potential of smart technologies, particularly GPS, to enhance the efficiency, accuracy, and quality of manual tree planting efforts. However, the realization of these benefits is contingent upon overcoming identified barriers to technology adoption.

Recommendations include:

1. **Pilot Testing:** Conduct field trials with selected technologies to assess their practical application and effectiveness in improving planting accuracy and quality.
2. **Cost-Benefit Analysis:** Undertake a comprehensive cost-benefit analysis to determine the economic viability of adopting these technologies in manual tree planting operations.
3. **Customization and Development:** Encourage the customization and further development of GPS-based technologies to meet the specific needs of New Zealand manual tree planting in various terrains, focusing on device ruggedness and functionality in areas with limited connectivity.
4. **Stakeholder Engagement**: Foster collaboration between technology developers, forestry contractors, and forest management companies to facilitate the exchange of knowledge and ensure the technologies developed are aligned with end-user needs.

In conclusion, the integration of smart technologies into manual tree planting represents a forward-thinking approach to addressing the challenges of reforestation efforts. By advancing these technologies and tailoring them to the unique requirements of the field, it is possible to significantly improve the outcomes of manual tree planting initiatives.

Next Steps

Trials in the 2024 season could be performed with several products identified in this study which include the international platforms developed by Optix Technologies (Arbor-X devices) or Teralabs (STA-Logger) as their devices and data analysis solutions are at a purchase ready stage. Each have some weakness that may need to be evaluated through field trials. None of them are custom built for the NZ applications which will mean some level of technology enhancement will be required for the NZ market. Blinkhorne and Carolle's and also HA Fear Ltd devices, both developed locally, are the closest to meeting NZ conditions, but may need engineering development for the device and development of data upload and management software. Stream Forest is also a local company developing a prototype manual planting system but may not be available for the 2024 planting season.

If GPS accuracy proves to be insufficient, further research is possible into additional technologies using GPS and non GPS hybrid methods such as; differential (e.g. RTK, real time kinematic) GPS (local and on line services[1]), 'pedestrian dead reckoning' or visual odometry[5], map matching[1,2], lidar[3,4], computer Visual SLAM[6,7] (simultaneous localisation and mapping) and computational models[8–10]. Some of these technologies can be realtime and some can be a post processing step. RTK uses a second GPS unit in a fixed location to determine errors that are passed to the moving, or kinematic, GPS for increased accuracy. Pedestrian dead reckoning uses computer vision to track the movement of objects from the perspective of the robot or person to determine location, similar to how a human uses their vision. Map matching uses a map to determine the likely possible paths for a moving object e.g., an increase in height means moving up the contours on a map and hence gives likely directions of travel. SLAM is a computational method to use all available sensor data to build a map of surroundings and calculate possible routes.

[1] https://www.u-blox.com/en/technologies/ppp-rtk-gnss-correction-services-pointperfect

INTRODUCTION

Manual tree planting in New Zealand (NZ) will continue to play an important role in reforestation alongside mechanised solutions. The key reason for this is challenging and steep terrain and the cost of change from manual planting to mechanised solutions. To enable real-time quality assurance systems and tree location identification at the time-of-planting the adoption of GPS (Global Positioning Systems) technologies for individual tree location data is strongly desired by many contractors and forest management companies[11,12]. Such technologies have the potential to ultimately enhance spatial precision of manual planting systems[13], provide critical data for quality control, human operator understanding[14] and underpinning data connectivity from planting to harvesting at the level of the individual trees. Industrial applications for monitoring workload and location of workers has been well published[15] and researchers[16] have studied the combination of GPS and accelerometers for over a decade to automatically detect tree planting, yet to date there are no products available that are designed specifically for this purpose. Ideally the technologies should be cost-effective, rugged, and contain highly accurate GPS[17,18] technologies for manual tree planters, particularly when operating in remote and connectivity-limited terrains.

This report outlines an evaluation of the available technologies (national and international) for capturing tree location during manual planting. The evaluation took a global view and involved phone interviews with manufacturers, contractors and forest management companies (local and global) to get the right level of information on what is available for development or immediate adoption in New Zealand. A use case was developed to work through how a system could be used and give an example scenario based on information from interviews. From this, requirements were developed and used to assess the market analysis of product suitability to manual planting in forestry.

Lastly, recommendations where made towards a demonstration of technology with the goal to recommend systems for adoption for manual planting in New Zealand forestry.

METHODS

This research adopted a multifaceted approach to assess the current state and availability of GPS technology in manual tree planting operations within the global silvicultural sector. The methods employed were designed to provide a comprehensive understanding of current technological capabilities, stakeholder perspectives, and the potential for operational enhancements for application in NZ. Below is a list of the methods followed:

Conducting Interviews

Process: Interviews were conducted with selected technology providers, forestry contractors, and other stakeholders identified during the product identification phase. These interviews were designed to gather in-depth insights into the practical application, benefits, and limitations of available GPS technologies for tree planting operations.

Significance: Engaging directly with stakeholders through interviews enriches the research with practical perspectives and first hand experiences. It also helps validate the findings from the use case development and product identification phases, ensuring that the research outcomes are grounded in real-world applicability.

Market Survey

Evaluation Against Criteria: Products identified during the search phase were later assessed against established evaluation criteria, including price and deployment platforms. This assessment aimed to determine how well each product aligned with the operational needs of manual tree planting in silviculture, as illustrated in the use case scenario.

Outcome: The market survey method highlights products that show promise for the intended application and identifies areas where further development maybe needed to meet the sector's specific requirements.

Use Case Development

Purpose: The use case section is used to consider all aspects of the systems' potential real-world deployment. It serves to contextualize the research, offering readers insight into practical scenarios where GPS technology could significantly impact tree planting accuracy, efficiency, and quality.

Why It's Done: Developing use cases allows for a grounded evaluation of technology by simulating its deployment in a typical planting operation. This helps identify specific operational needs and challenges that GPS technology aims to address, making the research outcomes more relevant to practitioners and decision-makers in the field.

Evaluation Criteria Establishment

Criteria Development: The evaluation criteria were established through a combination of literature review, market research, expert consultations and use case development. This approach ensured that the criteria are comprehensive, covering aspects from technical specifications and environmental ruggedness to user-friendliness and economic viability.

Inclusion of Price: Evaluation criteria, including the cost of technology, are detailed to guide the assessment of the GPS solutions. Price is a critical factor for widespread adoption, influencing the cost-benefit analysis for silviculture operations considering GPS technology integration.

Identification of Products

Search Methodology: A search for relevant GPS technologies and products was conducted using internet resources, industry publications, and existing knowledge within the research team. This method allowed for the identification of a wide range of solutions, from commercially available products to emerging technologies still in development.

Purpose: Identifying a broad spectrum of products and developers is essential for understanding the current landscape of GPS technology in silviculture. It provides a basis for evaluating the extent to which existing solutions meet the operational needs identified in the use case scenarios.

RESULTS

This chapter of results covers; an example use case, requirements definitions, a discussion on GPS technologies, interviews and the market survey.

Use Case Description

Below is a use case for GPS enabled manual tree planting. In systems engineering, use cases are employed to systematically capture and describe the functional requirements of a system from an end-user perspective, ensuring that all stakeholder needs and interactions with the system are considered and integrated into the design. They facilitate a clear understanding of how the system should behave in various scenarios, guiding the development process towards solutions that meet user expectations and operational objectives.

Use case narrative begins…

Crew chief, wakes up, checks all units are charged in the charging station. One unit didn't charge, so he re-clicks it into the charging unit and takes all the other GPS units including a spare.

The crew chief arrives at the planting site with the crew in the company van. On the laptop he allocates a unit to each person by reading the clearly labelled Unique ID (UID) number printed on the front of each GPS unit and allocates it to the crew person's name on the screen.

Each unit is switched on by a crew member, it beeps to indicate it is on and flashes green to show over ten hours of battery time and a good GPS signal. Each person clicks the unit onto their spade.

A planter, called Paul, loads up his trees and starts planting. Every time he digs a new hole the device detects a new hole, beeps, and records the location along with estimated solid type, depth of hole and level of effort.

Chris, the crew chief, monitors the location of each person planting up the slope and checks the data are sent back to the laptop in the van. As each crew member goes outside radio range (which is 1 km line of sight), the wireless signal strength shows zero for that device. When each crew member comes back for more trees or lunchtime their device uploads to the laptop using a radio receiver attached to the laptop lid.

After lunch Paul comes back to the van early and tells the Chief his unit isn't beeping each time he digs a hole and the green GPS light is off and a red error light is on. Paul easily unclips the device, clips on the spare and Chris allocates the new device number to Paul. Paul is motivated to make sure all his planting is recorded as he gets a bonus based on planting results reported by the device.

In the afternoon Paul loses GPS signal as he plants in a steeply sided gully, the device shows a red GPS signal icon, still detects a hole dug, beeps and the unit counts ten trees planted before reacquiring a GPS signal. When this information is uploaded the software detects 10 trees without GPS so places the estimated locations based on accelerometer movement where the GPS signal was lost. This is within 10% of Pauls approximate planting in that area so a 90% confidence with "non GPS" location is added to the metadata for those trees. On the screen round dots are coloured Blue for Paul with diamonds showing no GPS signal. GPS signals at the stationary van are recorded during the day and used as a differential GPS signal to increase accuracy when the planters' log files are up loaded, along with SBAN correction data and individual planter GPS metrics such as visible satellites, dilution of procession and estimated distance from the accelerometer.

At the end of the day the crew drives back into town and when the laptop sees a WiFi signal at the office it uploads the data to the cloud.

The plantation manager, Molly, logs onto the system and sees they are on schedule, she is interested to notice the tree density is a bit low on some north facing slopes and calls Chris the crew chief to discuss. Chris explains the ground was rocky and the crew had to find the best soil possible. They both look at the data map overlay and can see the detected soil was rocky and the crew fatigued faster than usual when on that particular slope. Their digging energy was 150% normal showing they tried their best. Both Molly the manager and Chris the crew chief agree everything is okay and will update the blanking forecast for next year taking into account expected lower survival in that area. When the drone goes out in 6 months they will update the location of the trees, taking particular care for the trees planted in the gully with no GPS signal.

Chris is reminded via a text message that he hasn't plugged the units into the charger and so goes out to the van to collect the units and plugs them in the gang charger before going home. That was lucky as he will be away for 3 days planting tomorrow and will need a full charge to last the duration of the job. This next job is for replanting dead trees and spraying based manual planting tree locations collected a few months earlier.

Requirements Definition

Based on discussions with planting contractors and forest managers, this section outlines the requirements we identified for an ideal system.

Hardware Requirements

1. **Size and Weight:** Optimized for ease of use, considering the spade's inherent weight. The GPS unit should add minimal additional weight.
2. **Ergonomic factors:** The unit should not change how the spade is transported or used during planting. It should not require a change in posture or technique when planting.
3. **Power and Battery:**
   - Battery Life: Extended operational time (over 10 hours, preferably 3 days).
   - Charging Indicators: Clear indicators for battery status, including 'fully charged' signal.
   - Gang Charging: Capability to charge multiple units simultaneously in a charging station.
4. **Communications Technology:** Utilize LoRa technology (an upgrade from Zigbee) for long-range, low-power wireless communication. Voice VHF/UHF radios could also be adapted. Real time spade to truck communication is useful. Wifi to the cloud is an option with in-office upload when charging.
5. **Environmental Durability:**
   - Rating: MIL-Spec[2] or IP65[3] for dust and rain resistance (not immersion).
   - Durability: Robust construction to withstand dust, grease, drops, crushes, etc.
   - Drop testing to 1 m onto concrete.
6. **LED Guidance:** LED indicators to assist in planting, such as maintaining straight lines or indicating next planting spots.
7. **Connectors:** Designed to resist wear from dust and grease. Connectors with no cavities for dirt etc is preferred.

Software and Data Management

1. **Logging and Location Tracking:** Accurate logging of each planting spot with GPS coordinates, with up to 10 cm location accuracy considered ideal. Metadata such as dilution of precision (DOP) and number of satellites is preferred.
2. **Store and Forward:** Ability to store data locally and forward it when in range of the base station, with one month storage preferred.
3. **Operator Allocation System**:
   - In-Field Allocation: Software for allocating units to crew members in the field.
   - Spare Unit Management: Process for reallocating spare units as needed.
4. **Cloud Upload and API Integration**:

[2] https://en.wikipedia.org/wiki/MIL-STD-810#Scope_and_purpose_of_MIL-STD-810
[3] https://en.wikipedia.org/wiki/IP_code

- Automatic Upload: Capability to upload data to the cloud when connection (Bluetooth/WiFi/LoRa hub) is available.
- API Integration: For downloading and integrating data with other services.

5. **In-Field Software:** For checking system functionality and confirming operational status. May be simple on-unit lights and sounds.
6. **Map Data –** open source availability of mapping data for customers and researchers.

Additional Considerations

1. **GPS Integration:**
    1. GPS functionality must be independent of the spade handle's functionality to avoid interference.
    2. RTK or other corrections provided after collection to reduce size and weight of device is recommended.
    3. SouthPan compatibility is preferred.
2. **Training and Support**: Provision of adequate training and support for the crew in using and maintaining the units.

GPS Accuracy Technologies

This section summaries GPS, SBAS, South PAN and RTK GPS technologies which give different accuracy and difference on product design and how they are deployed in the field.

SBAS stands for Satellite based augmentation system, it transmits atmospheric correction information to GPS devices to increase accuracy (Figure 1).

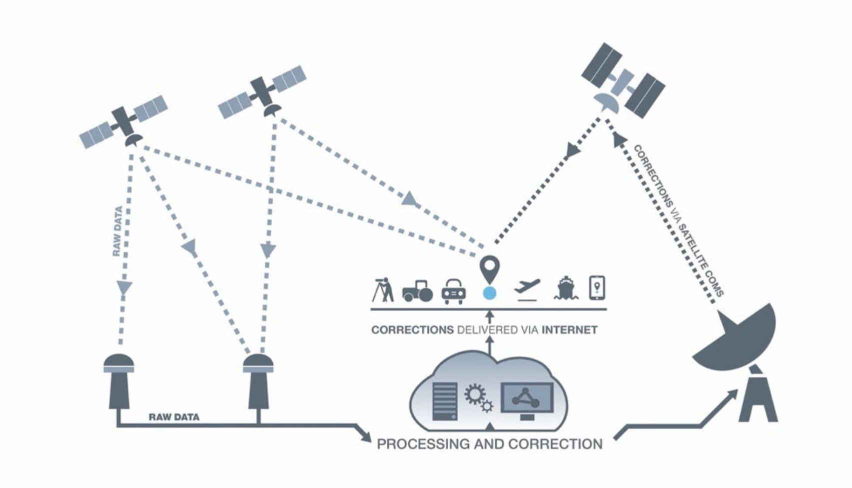


Figure 1. (source: frontiersi.com.au) SBAS illustration.

The performance of Global Navigation Satellite Systems (GNSSs) can be improved by regional Satellite-based Augmentation Systems (SBAS) such as SouthPAN,. SBAS improves the accuracy and reliability of GNSS information by correcting signal measurement errors and by providing information about the accuracy, integrity, continuity and availability of its signals.

SBAS uses GNSS measurements taken by accurately located reference stations deployed across an entire continent. All measured GNSS errors are transferred to a central computing centre, where differential corrections and integrity messages are calculated. These calculations are then broadcast over the covered area using geostationary satellites that serve as an augmentation, or overlay, to the original GNSS message (Figure 2).

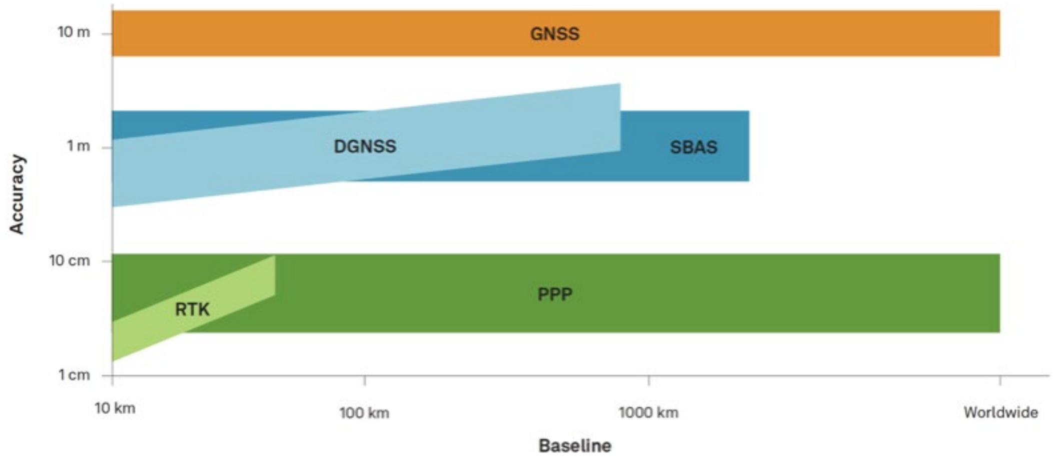


Figure 2. (source: novatel.com) Comparison of GPS correction methods.[4]

DGNSS and RTK require base stations for live corrections. In some cases the stations can provide their correction data over the internet or alternatively a stationary base station can be deployed to the field.

Interviews

Interviews were carried out with several groups around the world that have been involved with “GPS spades” in forestry. All groups are actively involved in forestry services, however, the more mature products are not based in New Zealand and may lack requirements needed locally. Details of any products discussed in the interviews are listed in products section of this document.

CEO, Optix Technologies[5], USA, along with engineering team on the calls. Optix Technologies work in parallel with a spraying and planting service company (IVM Solutions) and with Optix Technologies formed to provide location products and services. The company sees more revenue in spraying technologies with planting technologies a secondary market. The company’s hardware planting product, the suite of **Arbor-X** devices, includes quite a few features which saves on development expenses for different projects, however, this may result in a device that is a bit too large for a spade. Field trials in 2024 will indicate size acceptance by users. The company’s connected services show deep end user knowledge and are potentially valuable to forestry owners in addition to tree location.

R&D Manager, Weyerhaeuser[6], USA. Weyerhauser is a large forestry company that also evaluates emerging precision technologies. The head of R&D confirmed that STALogger has been approved by Weyerhaeuser for spraying. Also, they are in discussions with Optix for use of the planting technologies and drone technology to support various silvicultural operations.

CEO and Founder of Teralab[7]**,** Australia. Teralab is an experienced company in geospatial and ecological services. The **STA Logger** was initially developed for back-pack sprayers and has been adapted to fit the Pottiputki, a Finish developed planting spade for container grown stock. The company includes a group of six people that have data analytics and electronic engineering skills. The planter has been used in Argentina and ‘the largest forest in the USA’. They know the device needs to be made smaller for planting and are open to replacing the manual trigger with sensors and an algorithm to detect planting actions.

[4] https://novatel.com/an-introduction-to-gnss/resolving-errors/which-correction-method
[5] https://optixtechnologies.com
[6] https://www.weyerhaeuser.com
[7] https://stalogger.com

H.A. Fear Ltd, NZ **–** while not interviewed, this developer has been in discussions with NZ FGR for several years with the protype GPS spade, so should be listed as an option. It is anticipated that the company will supply a spade for the demonstration this year.

Braitonas, Lithuania. Braitonas is a start-up company with silviculture experience from their company Skogan in Lithuania. They are developing the 'For GPS' product that attaches to a Finnish Pottiputki[8] tree planter. The team has silvicultural knowledge and technical engineering experience for product design. They have fully thought through the work process for the manual planter, motivation based on digital planting systems to worker payments and analysing the planting operation. One limitation of the device is it needs cellular connection, is not adapted to spade at this stage and is not yet in full production as the company is currently raising capital.

Stream Forest NZ, Stream Forest has been working with a silviculture services company, to track workers for health and safety and monitor planting operations. Planting location is part of the considerations for their product in development. The company has technical partners that use off the shelf components and products. Adapted to forestry applications.

Blinkhorne and Carolle Contracting, Wanganui NZ runs a 40-person crew and has developed several products including a GPS spade. The company have field tested a protype planting tool and has highlighted certain design features that would need to change if the product were to be deployed. This developer does not intend to commercialise the design but would be a valuable team member. Blinkhorne and Carrolle have started development of a GPS sprayer in partnership with Jacto, a Brazilian company with products that include GPS. The GPS spade has components working but may require development to provide a demonstration and, if selected, to enter into production.

Customer of STALogger, Melbourne**.** Customer has used the STALogger for spraying for several years and finds the data easy to use and very valuable for the business. The system charges and downloads data easily. One point was made the GPS may not be sufficiently accurate and occasionally wonders off, this is likely an issue with all GPS not using RTK.

Market Survey

The desktop search was restricted to products that could be worn by a person. The mechanical planters such as M-Planter[9] GPS (NZ), Risutec[10] TK (Finland) were not included as they use a digger. Vehicle tracking was not included as the battery and size constraints are not common to the spade project. Drones such as the Katam system[11] where not included.

Braitonas, Optix Technologies and Teralabs all have off the shelf solutions available with integrated software analysis. Braitonas may not work outside of cell coverage, the Optix Technologies Arbor-X devices size on the spade handle is an open question and Teralabs STAlogger may need to make their box smaller, which they admit and have indicated they are currently in design. Blinkhorne and Carols' prototype is a very good fit but needs engineering development and has no mapping solution software. HA Fears product is a potential solution, if available for testing and deployment.

The comparison below (Table 1) shows the products designed for the job score better as would be expected. All have good location abilities, but there are differences in their gaps that need to be considered for the NZ forest environment. Note for this assessment there is an assumption the products perform for the task as advertised and all development is completed e.g. the Garmin watch has a tree planting app.

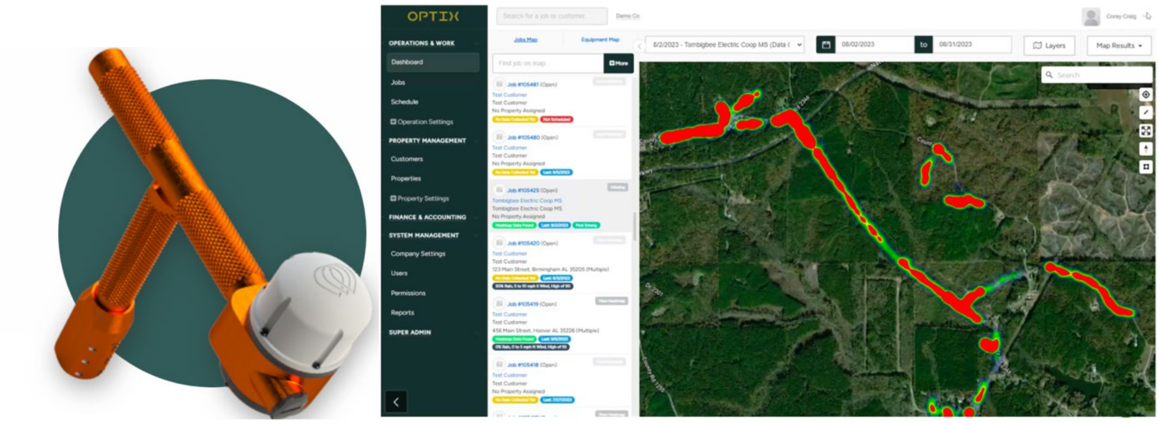
Table 1. Evaluation of products ability to meet ideal specifications

[8] http://pottiputki.com
[9] https://m-planter.co.nz
[10] https://risutec.fi
[11] https://www.katam.se/2022/06/10/katam-launches-new-revolutionary-solution-to-acquire-forest-data-with-autonomous-flying-drone/

		Airseed	Braitonas	Garmin Watch	Jacto	Juniper Syste	Optix	Patrick Carol	Phone + App	Teralabs
Wearable	1 = No, 5 = Yes	0	0	5	0	0	0	0	0	4
Spade compatible	0 = No, 5 = Yes	0	5	0	0	0	5	5	2	4
Stage of Development	TRL Level	0	4	3	0	0	5	4	0	5
Accuracy		4	4	5	0	5	5	5	5	5
Signal integrity	rough conditions		3	5	0	5	5	5	5	5
Measurements	location		5	5	0	5	5	5	5	5
	soil type		0	3	0	0	0	3	0	0
	planting quality		0	3	0	0	0	5	0	0
Workflow	Robust connectors		3	5	0	4	4	4	1	4
	Gang charging		1	0	0	0	0	4	0	0
	Logging with no comms		1	5	0	5	?	4	5	5
	Unobstructed use of spade		2	5	0	0	2	5	2	2
Plantbox scanning				0	0	0	0	0	5	0
Problem understanding				3	0	0	5	5	3	4
Team technical Capability				3	0	5	5	5	3	5
Ruggedness	Durabilioty			5	0	3	5	4	1	5
	Water and dust			5	0	3	5	5	3	
Cost	0=>$1000, 5 = < $500			4	0			5	1	3
		4	28	64	0	35	51	73	41	56

OPTIX- Arbor-X devices

The only spade handle available to purchase. It possibly has ergonomic challenges, but everything else is there and near ready to deploy. The company is working on a smaller product.

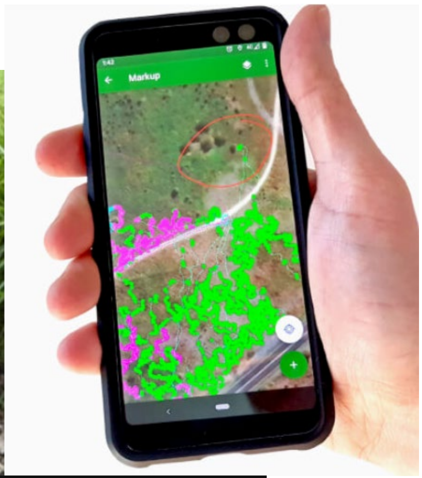


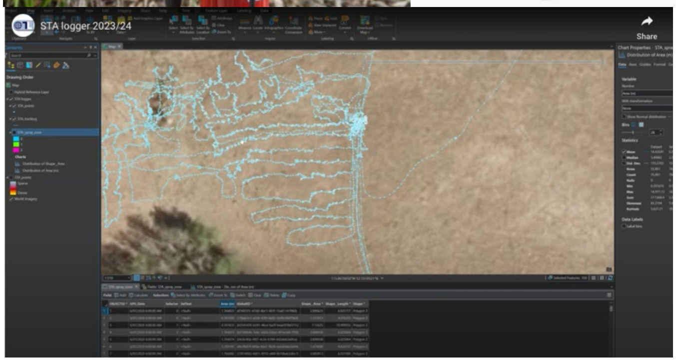
Smart Phone

A Phone app is possible for this project using machine learning algorithms[14], however, caution is recommended for this approach based phone location on the operator that may give variable results. Clearly a phone in a strong case could be placed on the spade but may be an encumbrance, catch gorse and may be too fragile in the field.

Terralab STA Logger

Website: https://stalogger.com





The product is a repurposed weed sprayer tracker.

Product Specifications:

- Works with no radio
- Rechargeable battery (3 days lifetime)
- When in recharging it connects via WiFi to server and ESRI.
- Weight is 250 gm housed in a rectangular box that will need a bracket for spade.
- Currently used on mechanical planters in America, like the Pottipuki planter. Released in 2019 with shipped over 500 units.
- Automatically turns on.
- Connected to spray trigger or Pottiputki trigger to indicate location.
- GPS 1 second logging
- Designed for forestry and conservation work.
- Price AUS$890 with 1 yr free service. After the $365 per yr per device. Spade mount $350.
- Data output is CSV.
- ESRI mapping is available from the supplier.

Connect Easily to **Equipment**

A STA logger device is equipped to your land management equipment. On sprayers, it includes an integrated switch system fixed to the trigger. We support popular brands of equipment and customise setups for less common brands (for an additional cost).

Once awakened, the STA logger automatically begins tracking your location. The location of trigger presses (i.e. weeds that have been sprayed) are mapped as you work (no additional input required). Optionally, a 3-way toggle switch is present which you can use to group and categorise weed species if you are spraying more than one type.

Automatic Location & **Spray Tracking**

Hands Free Data **Uploading**

Once back in the office, the STA logger is plugged in to charge the battery where it will automatically search for its home Wi-Fi network and begin uploading the data to the cloud. The data is processed and delivered straight back to your reporting portal. It's so simple, anyone can do it.

Once your data is uploaded, simply log in via a browser to view the tracklogs, spray areas and planted trees from all your units. Easily click on spray points to view the details, turn layers on and off, as well as export maps too. Open on a mobile device so that field workers can also use this data to continue on from previous day's work, or navigate to historic infestations to follow up and ensure there is no regrowth.

Visualise **The Data**

Monitor **Manage & Report**

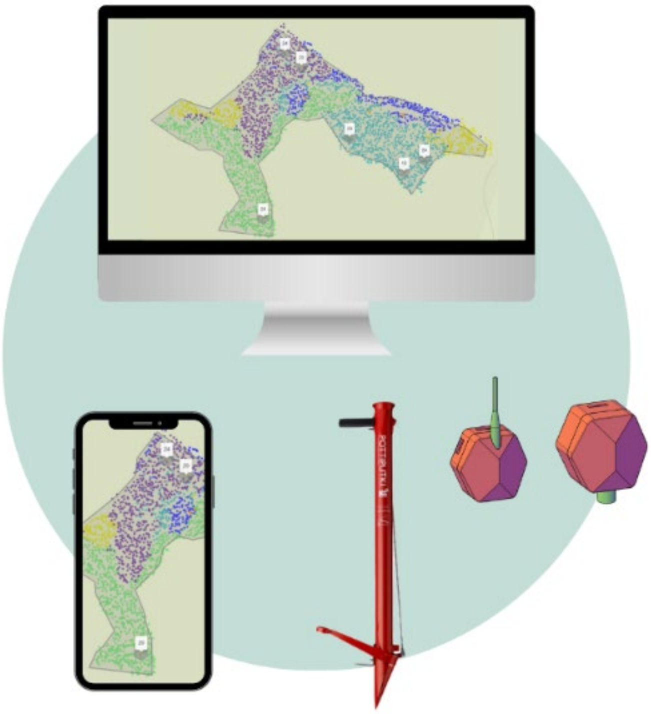
Office workers can monitor their crews progress and analyse metrics such as the distance traversed, area sprayed or trees planted. Anyone can quickly and easily publish maps of their teams work into a variety of formats (e.g. jpg, pdf, tif & more) for inclusion in reports or updating clients. Or simply load into your org GIS.

By TerraLab
Geospatial Specialists

www.STAlogger.com

Braitonas For GPS

A ground up design for tree planting, using a Pottiputki. Custom housing and data analytics from a service company that works in forestry. Built in Europe this may require full time cellular.



Blinkhorne and Carolle device

Prototype not planned for production. Custom designed for the NZ market. A few features may need to be updated such as radio system, SBAS and battery capacity.

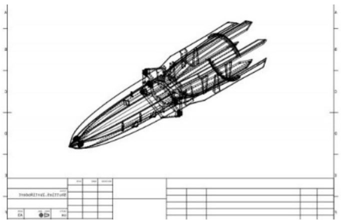
JACTO

DJB sprayer is non-GPS activated, but the company also does GPS control for equipment. The company is knowledgeable in forestry and has product in NZ. This could be worth a discussion with the company as they have all the pieces to build what is required.

Airseed

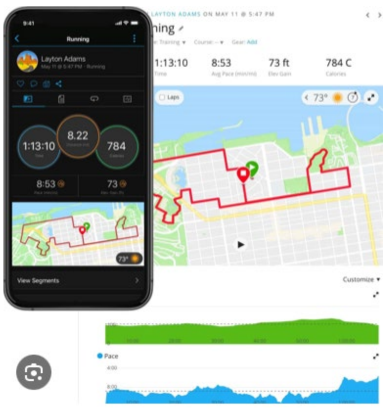
www.airseed.com

A different approach from Spain. Airseed is an automatic planter and design house with plantation services. Automatic planting vehicles and "land life cocoon" for seeds, not seedlings. A planting module that stays with the plant.



Garmin Watch

A Garmin[12] watch (or Samsung or Apple etc) could be programmed to detect digging activity and log a waypoint. This could then sync to a phone and upload to the cloud when the phone and wifi/cellular is available. Obviously, the app and mapping software requires development, but this is the most 'wearable' solution along with any other smart watch designed for outdoor use.



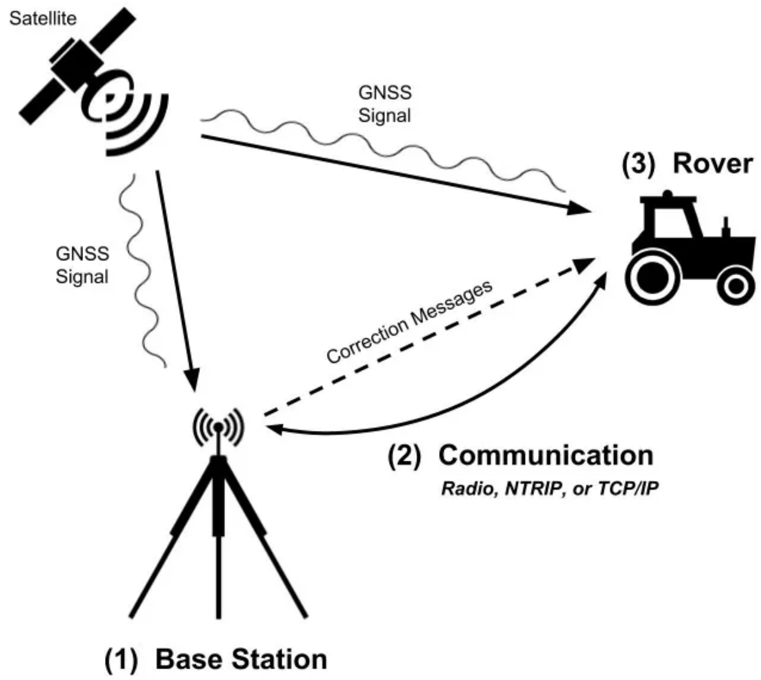
Juniper Systems

[12] https://www.garmin.com/en-AU/p/775697

This is an example of a product solution that would only need a product format change, location and mapping software exists.

GPS TECHNOLOGIES

Figure 3. RTK explained - (source:AGGPS.CA)



Real time accuracy requires a second RTK base station or reception of the SBAS signal in an SBAS enabled GPS. However, for tree planting post processing can be used where the correction information (precise clock and ephemeris data) can be post processed in the cloud to correct the information after downloading logs.

A third option of sensor fusion can be used which adds inertial measurement units or cameras but this is probably not applicable to the GPS spade project.

The Ublox[13] GPS receivers show horizontal accuracy as 1.5m GNSS and 1.0m with SBAS and 1cm with RTK[14]. This can be improved with a differential GPS correction signal transmitted to the module over a separate radio link.

It's worth noting that RTK requires the continuous reception of the corrected signal which may not be possible in some areas due to the topography.

[13] https://content.u-blox.com/sites/default/files/ZED-F9P-04B_DataSheet_UBX-21044850.pdf
[14] https://www.u-blox.com/en/technologies/rtk-real-time-kinematic

CONCLUSION

While GPS technology is established and widely used in various sectors, its application in tree planting, particularly within challenging and the steep terrain of New Zealand, holds unique promise and challenges. The key findings of this report highlight both the evolving nature of GPS technology applications in silviculture and the variable levels of adoption and innovation globally. The research identified several GPS-based solutions that demonstrate potential to meet the operational needs, alongside a keen interest among contractors and forest management companies in technologies that offer real-time quality assurance and precise tree location data.

However, the successful adoption of these technologies is contingent upon overcoming several barriers, including cost considerations, device ruggedness, and functionality in remote areas with limited connectivity.

The next steps proposed, focus on trials with selected technologies such as Optix, Teralabs, and potentially local innovations like Blinkhorne and Carolle and HA Fears devices.

The trials will be evaluated during the upcoming winter planting season, aiming to test up to five distinct products. The selection will cover:

- At least one product that is nearing commercial availability.
- At least one prototype developed locally, if available.

Two main types of evaluation will be carried out:

- System performance assessment, including measures like accuracy, battery life, durability, , troubleshooting, and data gathering capabilities.
- User experience testing with a small group of end-users to gauge aspects such as ease of use, ergonomics, reliability, data access, and overall performance under various conditions.

The research to date shows New Zealand is on par with global practices in the adoption and innovation of manual tree planting technology. The systematic exploration of GPS technology, underpinned by design thinking and a comprehensive methodology, sets a foundation for future advancements in the sector.

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