



Multi-scale monitoring tools for managing Australian tree crops

Industry meets innovation

Horticulture Innovation Australia Limited

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This summary is an excerpt from the [final report](#), with minor edits made to ensure it meets departmental style and accessibility requirements.

Summary

The Horticulture Innovation Australia led Multi-scale monitoring tools for managing Australian tree crops industry meets innovation project successfully delivered on the objectives of the Federal Government Rural Research and Development for Profit program.

The project successfully engaged with a number of industries including avocado, macadamia, mango and banana to identify a range of applications that were relevant, practical and therefore adoptable.

These priorities included:

- mapping the distribution and extent of all commercial orchards across Australia (avocado, mango and macadamia)
- improved pre-harvest yield forecasting and yield and quality mapping of each tree crop
- the improved monitoring of abiotic and biotic stresses.

To deliver these applications, a diverse collaborative group of industry bodies, universities, research and government agencies, growers and consultants was established.

Together, the project team evaluated a range of commercially available and emerging technologies including satellite, airborne, unmanned aerial system (UAS) and ground-based remote sensing and robotics, with over 120 field campaigns conducted across four states. Research outcomes are relevant to a range of scales including national, regional, farm and individual tree.

National level

The development of the 'Australian Tree Crop Rapid Response Map' and the 'Australian Tree Crop Rapid Response App', now freely available online, not only provides each respective industry with improved knowledge of orchard distribution and area, but serves as an important layer for post-disaster monitoring.

Already the map has been used by the respective industries for estimating the impact of cyclones Debbie (Qld) and Marcus (NT). This information is important for revising annual production estimates required for meeting forward selling targets, both domestically and overseas. Also the information may help growers quantify lost production for insurance purposes following a natural disaster.

Improved response to plant biosecurity incursions is also a significant benefactor of this project output. Access to a freely available map that identifies the location of specific cropping types can greatly assist with the coordination of on-ground surveys and the establishment of exclusion zones following the confirmation of an incursion.

This will ultimately improve response time and reduce potential spread. This project output provides a strong example of how industry, academia and government can work together for mutual benefit.

Industry level

Whilst making grower information publicly available through the national tree map would not be appropriate, the development of a geographical information systems (GIS) that did house additional attribute information such as tree species, tree age, row spacing, and historic yield does offer significant benefit to each respective industry. In its simplest form, an industry level GIS database provides a more refined spatial delineation of orchard boundaries.

With a more exact area of production, more accurate pre-harvest yield forecasts can be made both at the regional and national level. The inclusion of additional attribute information would assist the respective industry bodies to better understand current and historic grower demographics, such as defining areas of new plantings, cultivar distribution, spatial and temporal variability in yield and quality.

The information would also support improved decision making around harvest, transport and labour logistics. Through this project, a prototype industry level GIS was produced for a small region of the intensive macadamia growing region of New South Wales. By project completion, macadamia processors servicing 40% of the industry had commenced using the system to capture detailed data.

The development of an industry level GIS, can also serve as an interfaces for growers to record farm management operations, and crop inputs, as well as access and interrogate spatial layers such as tree health, fruit maturity, and productivity data generated from a range of technologies, such as those mentioned below.

Farm level

Improved pre-harvest yield mapping and forecasting was identified as a primary requirement by all industries engaged in this project. In response to this request, a range of commercially available and emerging technologies were investigated. These included satellite, unmanned aerial system (UAS), proximal remote sensing technologies and LiDAR. Ground-based sensors included those that were hand held, mounted on utility vehicles and on robotic platforms such as the University of Sydney's 'Shrimp'.

The ground-based optical sensors proved to be accurate for counting individual fruit and flowers on mango trees, whilst satellite imagery calibrated by on-ground sampling proved

accurate for yield mapping and forecasting for all three tree species (avocado, mango and macadamia).

In the absence of a commercial yield monitor, understanding the spatial and temporal variability of yield supports the adoption of improved management practices such as the variable rate application of crop inputs including nutrient, water, insecticide, and herbicide. Additionally, improved forecasting accuracy at the farm level supports more informed decisions around labour requirements, harvesting scheduling, post-harvest processing, storage and transport, and forward selling.

Corresponding with the accurate measures of yield, was the ability to measure fruit quality and fruit size of the varying mango and avocado tree crops. A handheld NIR sensor was found to be highly accurate for measuring the dry matter accumulation of Mango. This information when accompanied with an App developed through this project, provides mango growers with a greatly improved method for optimising harvest timing. Considering the harvest window for mango is only 4-5 weeks, and a miscalculation can potentially equate to a 30% yield loss, this outcome offers significant benefit.

The evaluated technologies also proved to be highly beneficial for mapping tree health including specific diseases such as Phytophthora in avocado, and tree canopy structure. An understanding of the latter, measured by LiDAR technologies, allows for the light interception of individual trees to be modelled, thus providing growers with the opportunity to better implement targeted limb removal for optimising fruit quality.

Recommendations for future research and development

The outcomes generated from this project provide a range of direct benefits to the respective industries across varying spatial scales. In some cases these have been well developed, whilst in general further development, commercialisation and extension is required. For The National Tree map, the further refinement of orchard boundaries would greatly assist the national forecasting of yield, whilst the annual maintenance of the layer would allow new plantings to be included.

Considering the success and multi-purpose benefit of this output, there is also the opportunity to include additional industries in the future. For the industry level GIS, substantial development and industry engagement is required to incorporate attribute information for all growers as well as to deliver a commercial framework to industry. Satellite imagery was an accurate tool for mapping tree health, disease and a range of yield parameters.

However, further development and commercialisation is required to bring this technology to the farm. The development of an App that allows growers to access and calibrate imagery in-field for the purpose of yield mapping is currently being investigated. The success of the various machine vision approaches for counting individual mango fruit presents an opportunity for the development of an autonomous harvester. This outcome would offer significant benefit in addressing current shortages and costs of labour.