# Integration of Data Sources and Visualisation for Apple Production

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## ABSTRACT

Management decisions are often made with imperfect knowledge. Generally data important to the decision already exists but not in a form which is easily accessible. Integration of data capture, analysis and presentation is used as an example of how technology can be applied to improve the quality of information to an apple orchardist. The application of long range transponders (RF tags), Global Positioning Satellites, Geographical Information Software are discussed, with particular reference to their ease of implementation.

***Keywords:*** Information systems, management, geographical information software, product tracking, transponders

## 1.0 INTRODUCTION

New technologies have the potential to revolutionise modern primary production systems with real-time monitoring, databasing and analytical capabilities. Few of these technologies have been applied despite the fact that biological products have a large inherent quality variability which makes them a prime opportunity to implement complex analysis and methodologies. Markets are demanding consistent delivery of high quality fresh produce. Variability in quality attributes such as size, colour, shape, flavour, sweetness, firmness all detract from the value proposition at the point of sale. Knowledge is power and management of consistent quality requires knowledge of production factors such as soil type, weather, pest levels, orchard management practices and postharvest factors such as handling, packaging, coolchain and transport technologies, as they all impact to exacerbate the initial inherent variability of the product. There is already a significant quantity of data captured by sectors of the postharvest chain which, due to technology constraints, are not available to the producer. Increasingly linkage between producers and consumers will also need to be strengthened so that consumer requirements can be more closely met.

The most powerful source of information available to a producer is the on-site information specific to their system (Whitney *et al.*, 1999). The more specific and localised the data collected, the better the quality of the information (Praat *et al.*, 1999). To enable informed decisions it is critical that this detailed data is collated and presented in a format which enables managers to make useful decisions. A critical component is a user friendly visualisation tool. The general approach is discussed with reference to preliminary work in an apple supply chain. The system is built around precision agriculture where crop production factors and yield data are spatially referenced with the use of global position satellites (GPS) and analysed and presented with geographical information software (GIS). This project presents an attempt to integrate all these technologies into a practical system to produce the information most useful to an orchardist.

## 2.0 APPLE PRODUCTION SYSTEM

The profitability of an orchard is primarily determined by the value and quantity of apples produced and the cost to achieve this production. The value of the apples is determined by; the variety; the size of the fruit (very large and small fruit tend to have a lower value); the colour of the fruit (some varieties attract a high red colour premium); and the quantity of fruit which is of export standard (blemishes, shape deformities and other defects have only low value end use).

The apple orchards used for this study had a range of varieties grown in each block and the trees were of differing ages. Fruit were picked into 400 kg bins and transported to the packhouse for grading and packing into 18kg cartons.

Currently the fruit tracking system comprises a range of manual and electronic techniques. Communication between systems is in many cases very difficult. Once fruit is harvested a card is attached to the bin in the orchard with information on variety, maturity and picker data recorded. The bin card is removed at the packhouse before the bin is emptied onto the grading machine. At this point the link between orchard and the apples is lost. A new linkage is established at the apple carton which is bar-coded with a unique number and stamped with grower and variety details. The net result is that most growers only receive general quality information which represents large portions of their orchard. The opportunity to access detailed site specific information such as product quality, yield data and picker performance is lost.

## 2.1 Technology

As a precusor, then, it was necessary to develop suitable techniques to bridge this break in the information chain. This involved capture of data which was not previously recorded (e.g. bin tipping onto grader) and utilisation of other data generated within the present system, but not currently used (e.g. individual fruit count size and colour, export packout percentage per bin, quantity of fruit in a bin).

In order to generate the data in a visual format it was necessary to capture an accurate location of the source of the fruit and then track that fruit into the packhouse. Electronic radio frequency (RF) tags were identified as being suitable for tracking apple bins as they were robust and could be scanned automatically, although the read range of current technology is limited.

## 2.2 How the system works

Every bin in the orchard was uniquely identified by a RF tag stapled to the bin. The quality controller ("QC") was provided with a handheld tag reader, about the size of a large calculator. Specific software was developed for the reader to allow the QC to record the following data at the time the bin was full and the bin card was being attached to the bin:

Grower, Orchard, Q C, Variety, ESP Number, Picker, Card Number, Block Number, Row Number, Tree Number, RF Tag Number, Date and Time stamped

At the packhouse the bin was weighed and the bin tag was scanned again. This identified the bin loading sequence onto the grader. In order to synchronise the bin and grader data a marker was placed at the tail end of each bin group of apples as they moved up the water flume towards the grader. As this marker passed the colour scanner on the grader an operator manually initiated a data capture routine. For each bin a data file was created which recorded the individual fruit statistics of fruit size (count) and colour. In this way each bin was singulated through the grader with an individual quality profile.

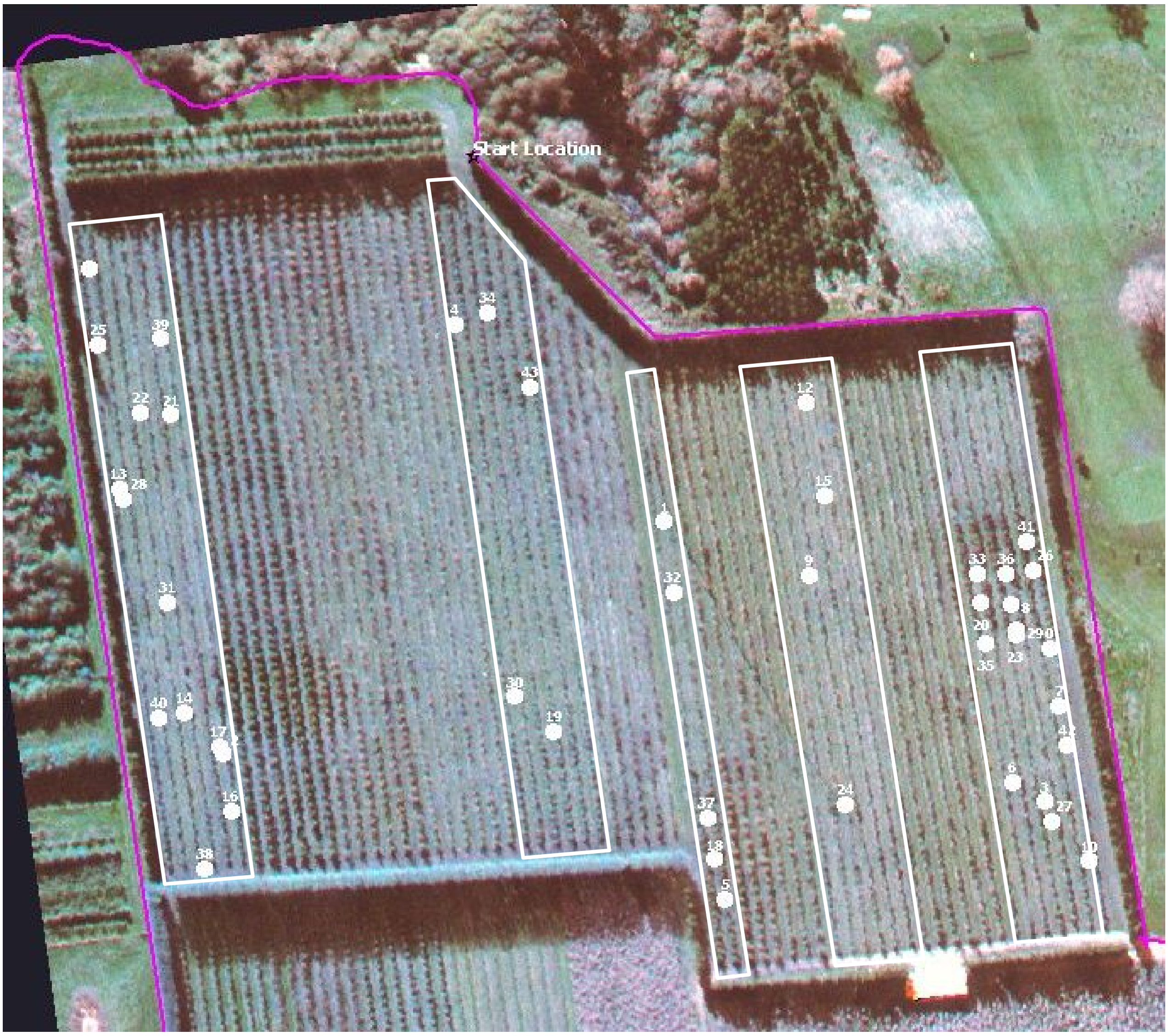


*FIGURE 1 Bin locations in an apple orchard during a harvesting operation (white dots show bin location and number within blocks of Braeburn)*

Each of the orchards involved was surveyed with differential global positioning satellites (DGPS) equipment (sub-metre accuracy) to develop digital maps of individual tree locations. Aerial photographs were also taken and integrated with the DGPS maps. Bin locations were mapped using SSToolbox, a dedicated agricultural GIS package which is compatible with Arcview GIS. Individual bin fruit size and quality profiles were mapped to their orchard locations. Apple yield and quality data was attributed to the row section of trees closest to the bin (to match the picking pattern). Figure 1 shows bin locations in a Waikato orchard for one pick of apples.

Two prices were paid for Braeburn apples in 2000 according to the apple size. Count sizes 80 – 110 were $16.34 per tray carton equivalent (TCE) and count sizes 120 – 135 were $10.22/TCE. Figure 2 shows the variation of apple value (size) across a block of Braeburn in the orchard. This map shows that a higher proportion of the apples on the left hand side (darker colour) of the block were of higher value. Some parts of the orchard were producing more valuable fruit than other parts. As producers use of information management tools develops, they will begin to wish to manage quality from further down the supply chain. For example, red fruit is generally considered to be a valuable quality attribute. By generating data such as shown in Figure 3 growers will be able to start identifying the causes of colour variation across parts of their orchard. The red or dark areas on Figure 3 show orchard sites producing a higher proportion of high grade (redder) apples.

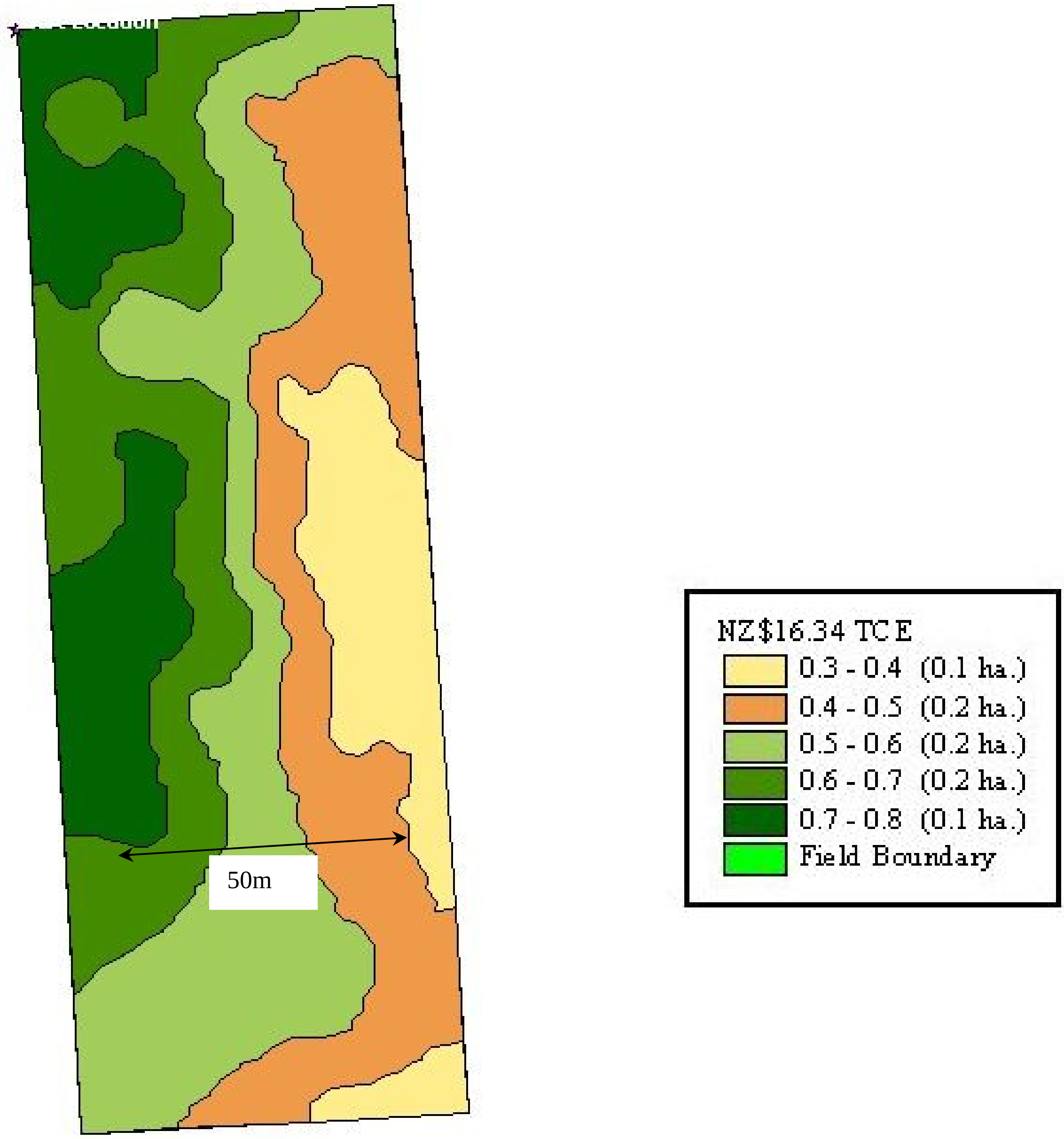


*FIGURE 2 Spatial variation in fruit value (size) across a block of apples*

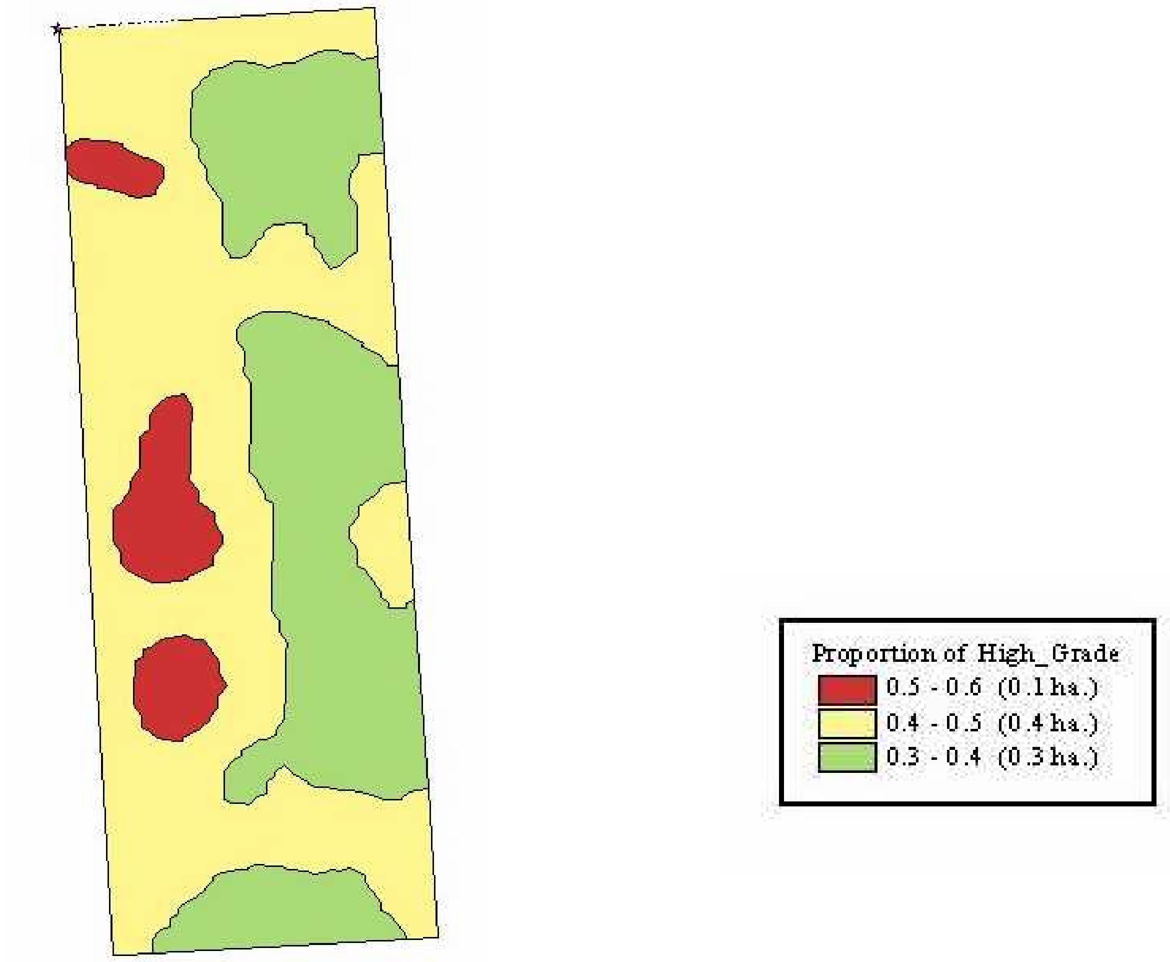


*FIGURE 3 Spatial variation in fruit quality (colour) across a block of apples*

## 3.0 DISCUSSION

The visualisation Tools used for this trial based on the GIS database produced some very useful information which was meaningful to the growers involved. We were able to establish the profitability of small regions within the orchard in considerable detail. This provided the growers concerned with some additional information on how they might change their management for the coming season. We were also able to introduce the concept of consumer awareness. By producing maps which show the profile of attributes which consumers prefer (in this case red colour) the growers can also start to manage to optimise these characteristics as well.

The major issues in terms of implementing a practical system were related to the visualisation tool used and the cost of the data capture

The ArcView tools are not cost effective for an individual orchardist, and the time taken to enter the data and produce the maps was too complex and time consuming. Much of the useful data had to be collected using the complex procedures described above. These were a combination of manual and reasonably expensive electronic techniques which would be too expensive for a practical application. At present this project suggests that while the potential for this technology is clearly demonstrated, the actual value of the information to growers does not justify the costs involved in collecting and presenting it. This is the challenge for the next phase of research. Recent work from the United States describes techniques which may be very useful in this respect (Righetti and Halbleib, 2000).

### 3.1 Linking with other data capture techniques

In order to identify critical factors of production which impinge on product quality, other data capture technologies will also need to be employed such as canopy scanning (laser or ultrasound) and soil sampling (electromagnetic survey, nutrient mapping, aerial infra red sensing). In addition non destructive technologies which can measure internal quality could also be integrated into such a system.

## 4.0 CONCLUSION

The system under development is targeted to improve management of both the production and supply chain. By providing the appropriate technologies for data capture, in time it will be possible to have a seamless information system which will track fruit from the tree to the final market. This will in turn allow transfer of quality information from the market back to the producer. The paper demonstrated the potential power of some of this information in terms of decision and management support for the producer. By discretising the information to small areas within the orchard, and applying new spatial data interpretation techniques the data can be transformed into powerful knowledge tools. The major issue for practical application is the ability to cost effectively capture the data and cheaply produce the visualisation maps. This is the future for applied information management systems.

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