LIDAR and its use in agriculture

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Introduction

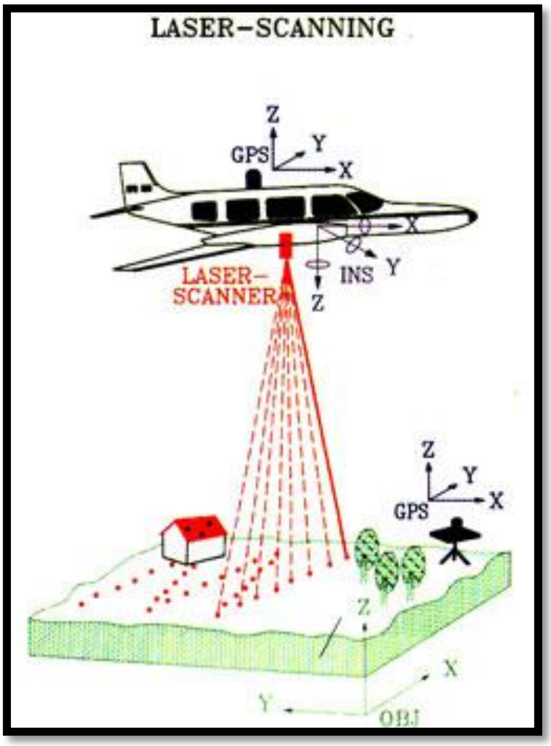
This report is prepared as a submission to the House of Representatives Standing Committee on Agriculture and Industry for an inquiry on Agriculture Innovation.

LIDAR is a remote sensing tool that has numerous applications, including agriculture. Both NSW and Qld governments have been capturing LIDAR since 2009 and have ongoing LIDAR capture programs. Unfortunately the data has seen little use in agriculture due to the current cost structure. This is in contrast to the USA where the federal government has commenced a programme to cover the entire mainland states with LIDAR and provide free access to the data for the public via the internet.

What is LIDAR.

LIDAR is a powerful tool that provides high resolution, three dimensional, spatial information about the land. It can be used to identify areas for differential management from the generation of:-

- digital elevation models (image and map slope, elevation & aspect)
- vegetation models (map location, image canopy height)
- erosion control (map water flow, water catchments, simulate Revised Universal Soil Loss Equation)



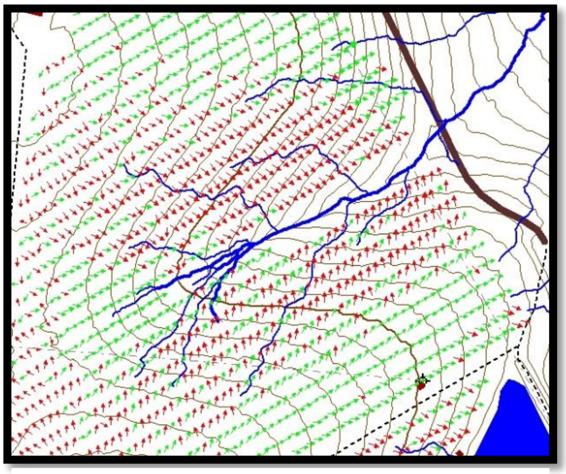
LIDAR (LIght Detection And Ranging) is a an accurate surveying system that incorporates:-

- airborne scanning laser rangefinder,
- differential GPS, and
- Inertial Navigation System

The output from a LIDAR survey is a point cloud where every point has an x, y and z coordinate together with a number of attributes such as classification (building, ground, vegetation, water, etc), intensity, scan angle , return number, etc.
Other attributes can be calculated (height above ground) and RGB colours for every point can be merged from aerial photography.

Agriculture use of LIDAR

LIDAR can be used to create three dimensional digital models of a farm and from these produce incredible accurate maps of the natural resources. For example it can be used to map the water flow, define the water catchments, locate all the trees in an orchard, show the water flow direction at the base of each tree and show the division between water flowing down the tree line or across the tree line.

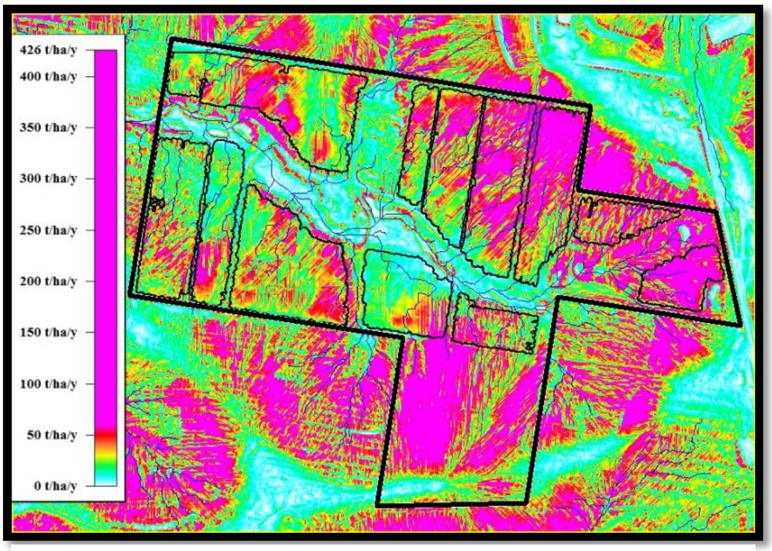


Macadamia orchard showing 1m elevation contours, water flow lines and direction of water flow at the base of each tree coloured for flow down the tree line (green) or across the tree line (red).

We all know that farms are not uniform. There is natural variability in soil, moisture levels and microclimate due to landscape features. LIDAR allows us to observe, measure and map out the variations in slope, aspect and elevation (Appendix 1) and use the results to modify management practices to address limitations to production.

Soil erosion is a widespread environmental challenge facing many farmers today. Erosion by water can be dramatic during storm events, resulting in wash-outs and gullies. It can also be insidious, occurring as sheet and rill erosion during heavy rains. Most of the soil lost by water erosion is by the processes of sheet and rill erosion. Erosion causes both on-farm and off-farm problems for farmers. The off-farm impacts of sediment, bacteria from organic matter, nutrients and pesticides on the environmental quality and economic capability of surface water ecosystems are substantial and well-documented. On-farm impacts of erosion concern not only the immediate loss of topsoil (plus surface applied crop inputs), but also a long-term loss of productivity and higher production costs.

The Revised Universal Soil Loss Equation (RUSLE) is designed to predict the long term, average, annual soil loss from sheet and rill flow at nominated sites under specified management conditions. It is widely used throughout the world. It was developed with agriculture in mind and has been extended into the construction industry. Maps of soil erosion risk can be generated using LIDAR and the RUSLE (Appendix 2). Drainage Management Plans can use the results to design control measures to minimise the impact of intensive rainfall events.

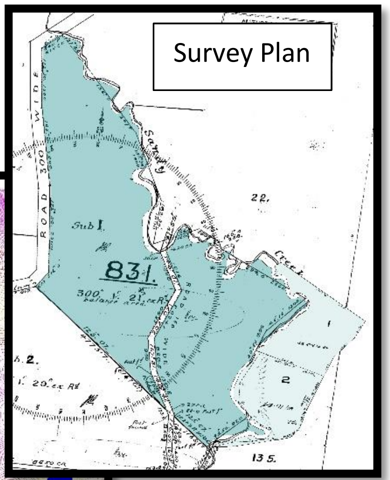


Map of soil erosion risk when there is no grass cover.

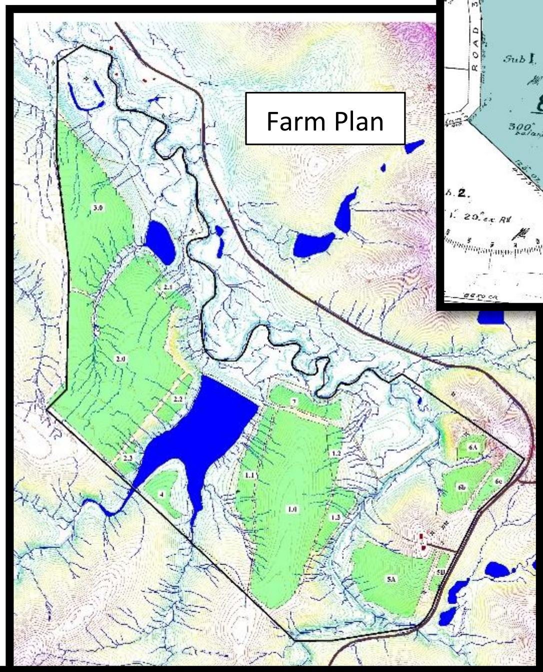
Location information

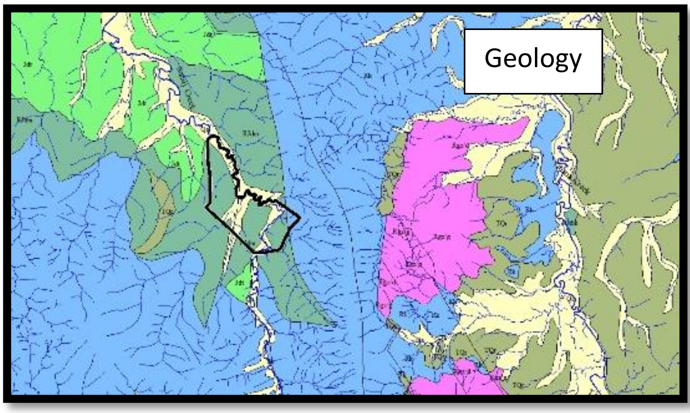
All farmers should have a basic farm map showing infrastructure, elevation contours, drainage lines, etc. and with the current technology, all farm maps should be in a digital format. The recent development of geospatial PDF files provides low cost digital maps with embedded geographical coordinates. This means the maps can be printed at multiple scales, used on a PC with Adobe Reader allowing distances, bearings and areas to be measured and used on mobile devices with Pdf Maps to record locations and farm activities.

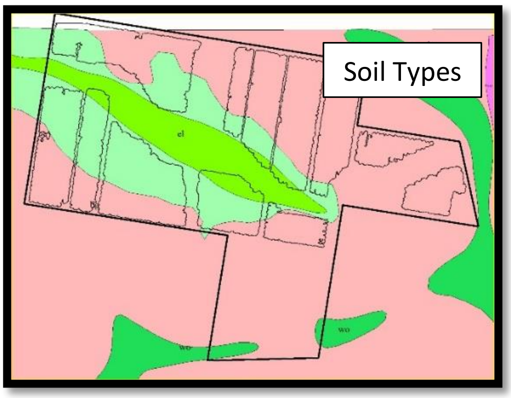
As LIDAR is essentially a survey tool, it can be used to generate accurate farm maps and then integrate the data with other government digital datasets.

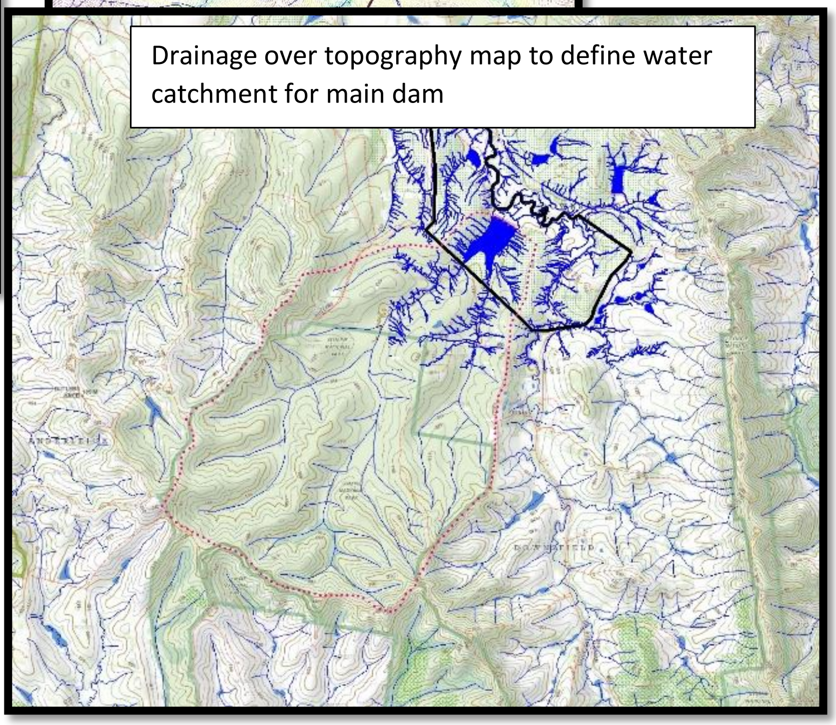


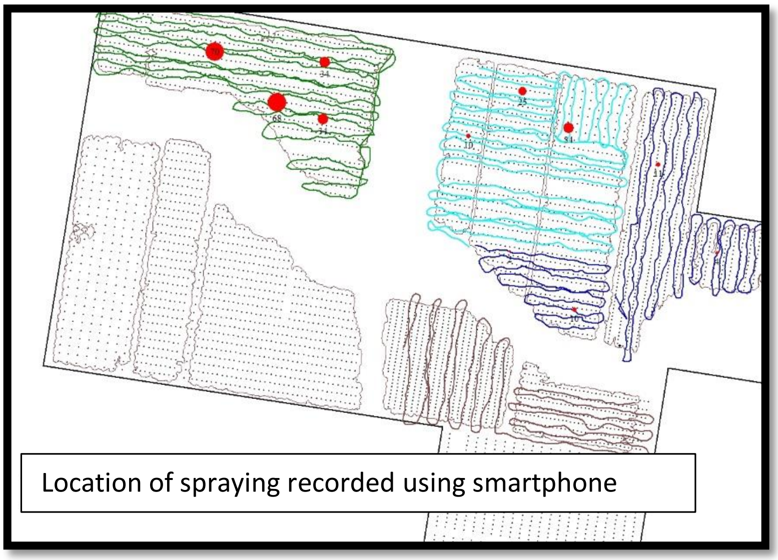
For example, a property survey plan can be plotted onto the same coordinates as captured LIDAR and all fences accurately located to confirm the boundary fences are in the correct location. All infrastructure (buildings, roads, fences) can be accurately mapped and added to a Farm Plan. The property boundary can then be plotted onto government available digital data such as geology and soil types.





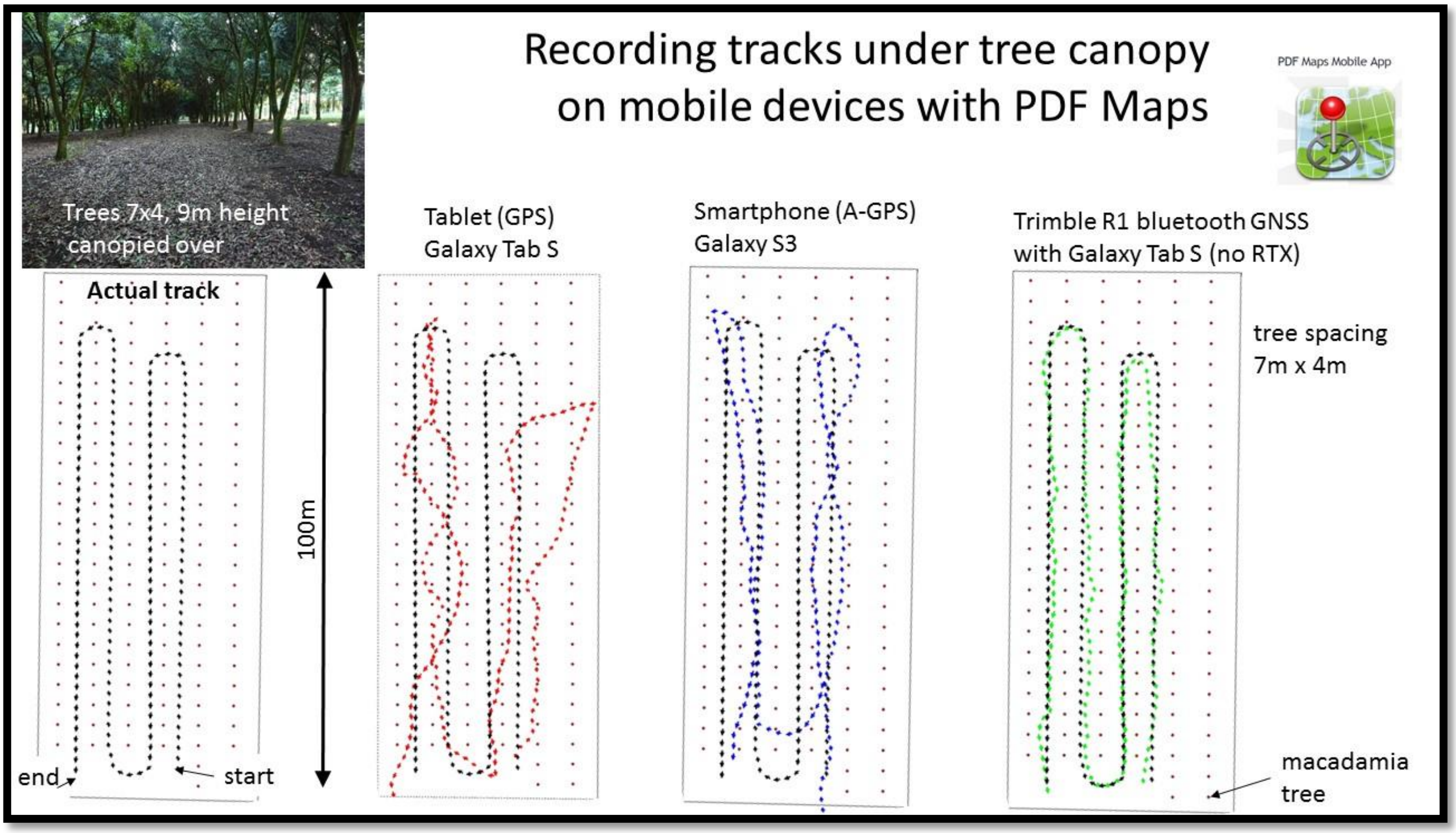






Location of spraying recorded using smartphone

There are many reasons to use GPS located data on a farm. Locating positions on a map is useful for monitoring and recording results of pests and diseases. Recording the location of farm activities such as fertilising and spraying is useful for comparing with yield results and for compliance purposes. Geospatial PDF files provide a low cost method of having maps in the field and recording activities in real time on any mobile device (iPhone, iPad, smart phone, tablet). Unfortunately the location accuracy of such devices in Australia is significantly less than Europe and USA as Australia has no publically available Satellite Based Augmentation System (SBAS). The subscription based Aus Continuously Operating Reference Station (CORS) is widely used in the cropping industry but is too expensive for the smaller farms. Technology has again come to the rescue with the development of bluetooth GNSS receivers that have the ability to turn mobile phones into survey grade instruments at a fraction of the cost of normal subscription services.



Barriers to the adoption of LIDAR

Although the Qld and NSW sates have been capturing LIDAR for over 5 years, the coverage is limited to a coastal strip from the Victorian border to Cairns together with the larger rural towns (Appendix 3).

The main barrier to using LIDAR is the cost of government captured LIDAR.

	NSW	QLD
Min cost per order	$656 includes 20 2km tiles	$715 includes 25 1km tiles
Bulk purchase	$732/project	$24.20/tile/LGA
Bulk purchase example	Nambucca 1564 sq km $732	Gympie 3,523 sq km $85,256

In NSW the minimum order costs $656 and includes 20 tiles. In Qld the minimum order costs $715 and includes 25 tiles. For larger areas such as a catchment areas, tiles are sold as a Project area (NSW) or LGA (Qld). The Nambucca Project area in NSW covers 1,564 sq km and will cost $732 while the Gympie LGA in Qld covers 3,523 sq km and will cost an exorbitant $85,256.

In 2012 the USGS completed an extensive National Enhanced Elevation Assessment (http://nationalmap.gov/3DEP/neea.html) which recommended capturing LIDAR for all mainland states and providing the data to the public. The 3D Elevation Program (http://nationalmap.gov/3DEP/) commenced this year and the data can be downloaded for no cost via the website http://earthexplorer.usgs.gov/. The National Enhanced Elevation Assessment found over 600 uses for LIDAR with Agriculture ranked number 4. Agriculture was also determined to have the greatest value in potential benefits in using the data.

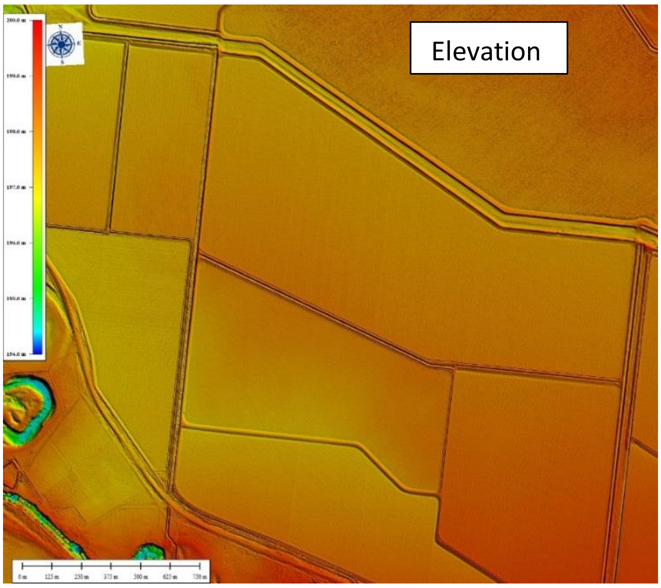
Conclusion

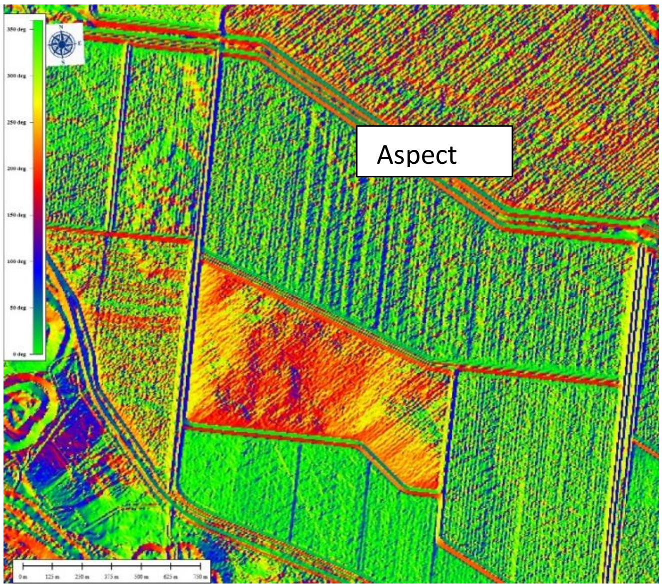
There is a clear benefit in using LIDAR to generate maps for erosion mitigation. There are many other benefits in having accurate digital farm maps. The existing dataset of captured LIDAR will degrade with time as vegetation grows or is removed and earthworks change the land surface. The dataset only has a benefit and value if it is used. To gather “dust on the shelf” simply because it is too expensive to be used is of no benefit to the State or farmers.

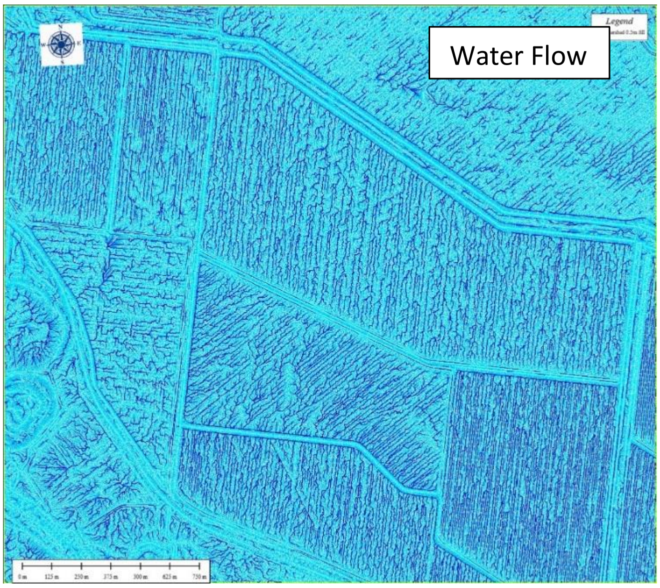
Appendices

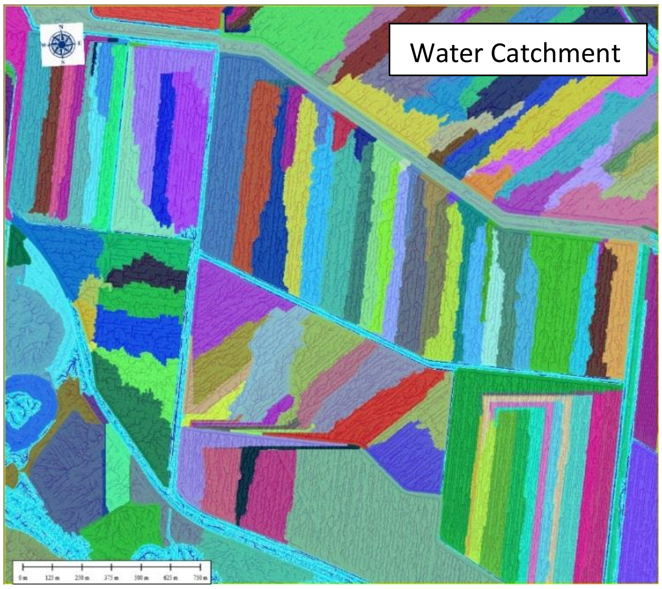
1. Examples of Natural Resource Mapping
2. Example of RUSLE simulation
3. LIDAR coverage programs

Appendix 1. Natural Resource Mapping using LIDAR. Example 1 :- Cropping farms, Warren NSW

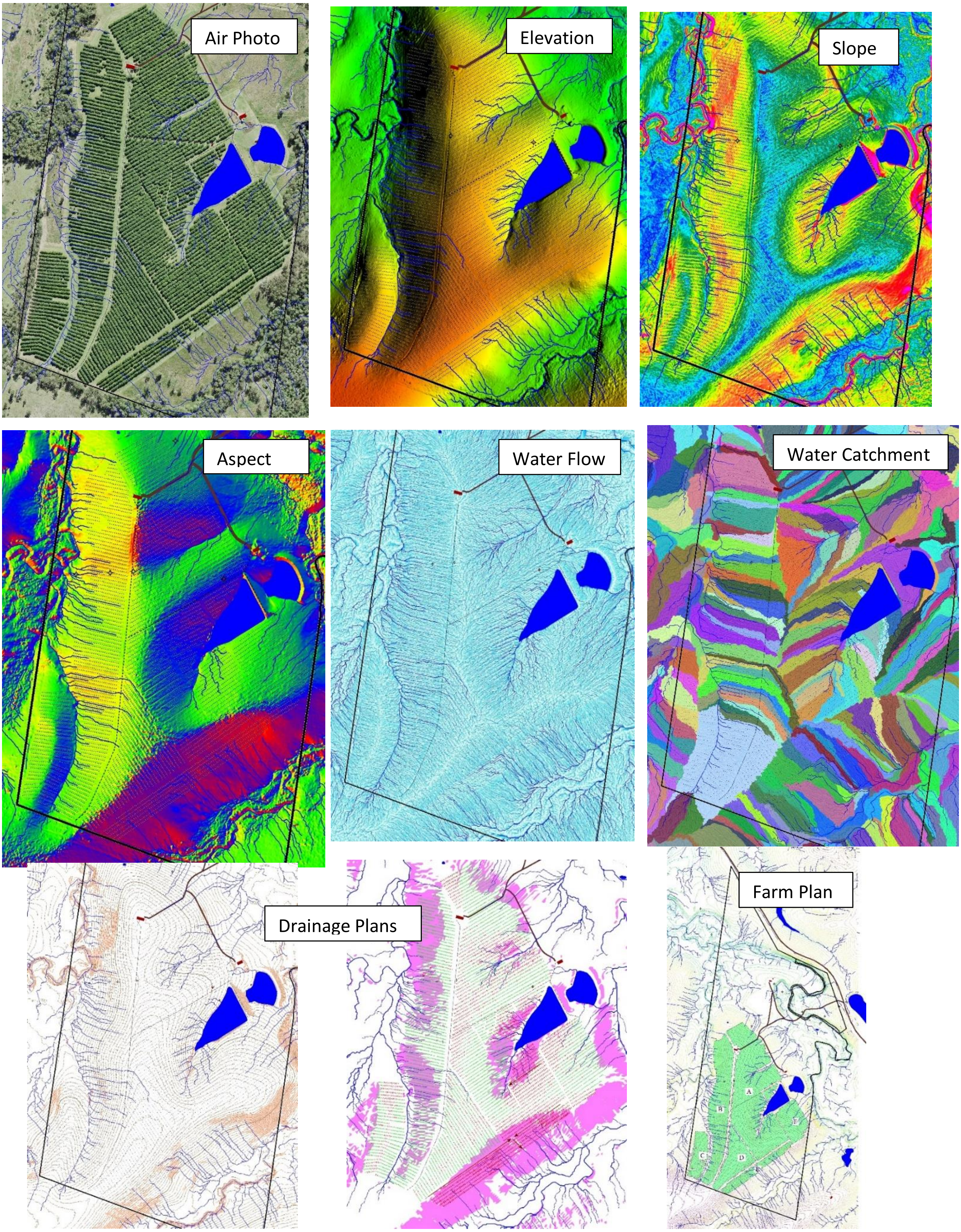




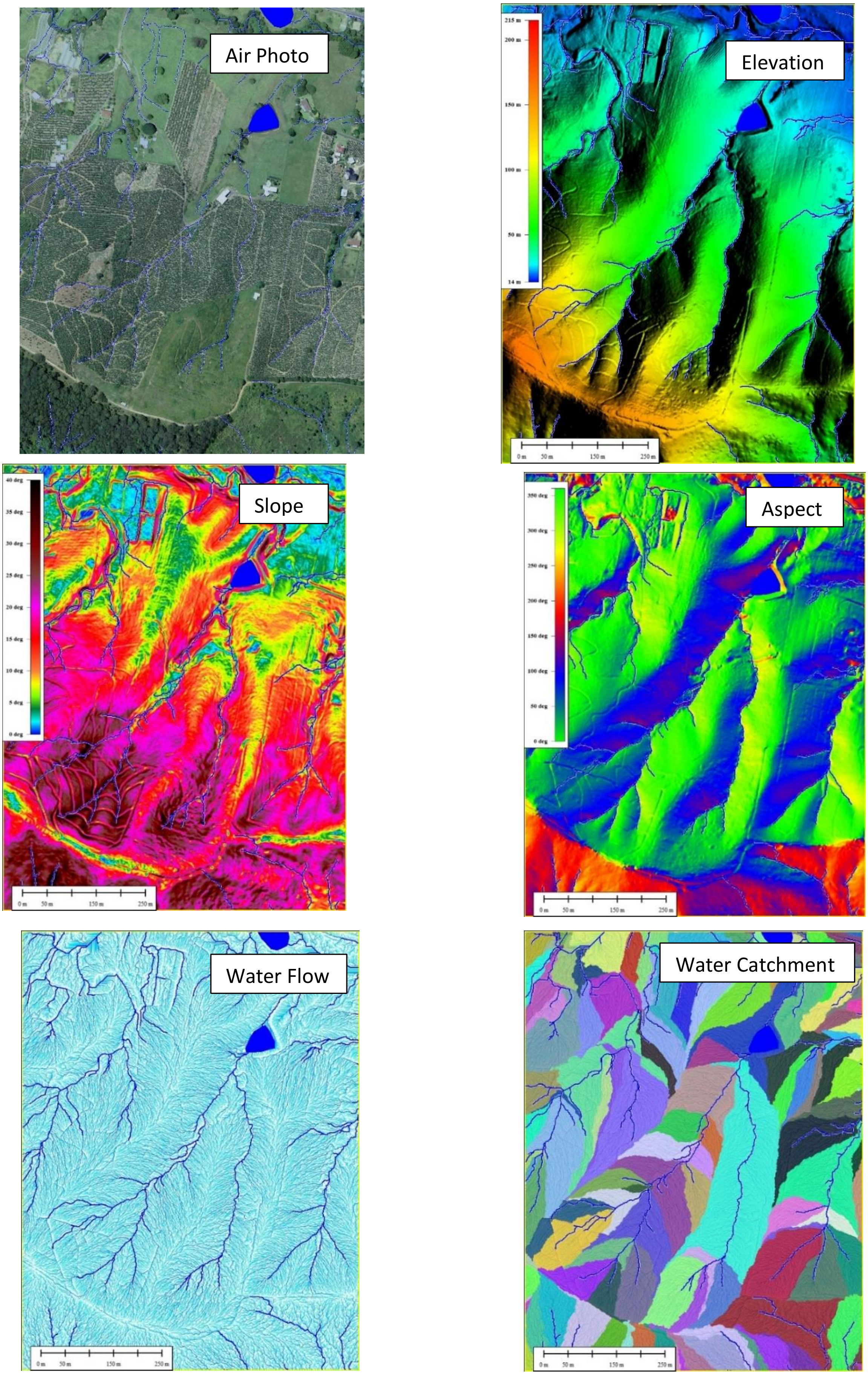




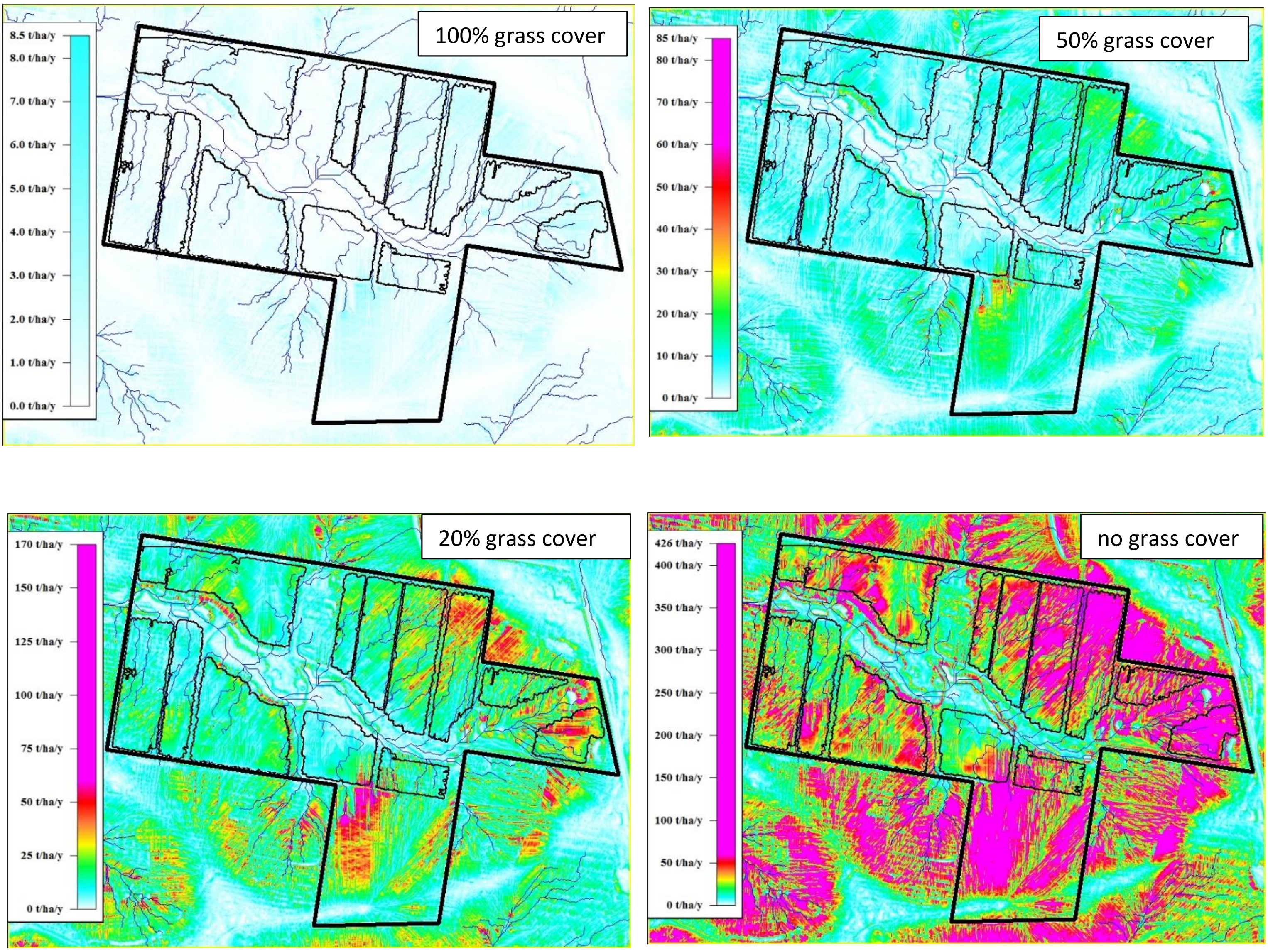
Appendix 1. Natural Resource Mapping using LIDAR. Example 2 :- Macadamia Farm, Gympie, Qld



Appendix 1. Natural Resource Mapping using LIDAR. Example 3 :- Banana Farm, Coffs Harbour, NSW



Appendix 2. RUSLE SIMULATION – Mapping computed soil loss with variable ground cover



Quantifying and mapping potential erosion problems on a farm can be achieved by the use of the Revised Universal Soil Loss Equation. Once defined, a number of mitigating measures can be utilised to neutralise the problem.

Revised Universal Soil Loss Equation

The Revised Universal Soil Loss Equation (RUSLE) is designed to predict the long term, average, annual soil loss from sheet and rill flow at nominated sites under specified management conditions. It is widely used throughout the world. It was developed with agriculture in mind and has been extended into the construction industry. It is not designed for gully erosion however macadamia trees should not be planted in gullies or areas of concentrated water flow.

The equation is represented by:
A = R K LS P C

where, A = computed soil loss (tonnes/ha/yr)
R = rainfall erosivity factor
K = soil erodibility factor
LS = slope length/gradient factor
C = ground cover and management factor
P = erosion control practice factor

While it does have great practical value, its limitations should be recognised.

- It predicts average annual soil loss and not that for a particular storm event;
- It is effective for erosion through sheet and rill flow only on short slopes (<300m) and not for concentrated flow or long slopes; and
- It does not adequately take into account soil dispersibility in assessment of the K-factor.

Rainfall Erosivity Factor – R

The rainfall erosivity factor, R, is a measure of the ability of rainfall to cause erosion. It is the product of two components: total energy (E) and maximum 30-minute intensity for each storm (I30). So, the total of EI for a year is equal to the R-factor.

R-factor numbers for New South Wales are available from The Blue Book (Managing Urban Stormwater: Soils and Construction Landcom NSW).

Soil Erodibility Factor – K

The soil erodibility factor, K, is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. Soil texture is the principle component affecting K, but soil structure, organic matter and profile permeability also contribute. In the RUSLE, it is a quantitative value experimentally determined.

K-factor numbers for New South Wales are available from the blue book.

Slope Length/Gradient Factor – LS

The slope length–gradient factor, LS, describes the combined effect of slope length and slope gradient on soil loss. It is the ratio of soil loss per unit area at any particular site to the corresponding loss from a specific experimental plot of known length and gradient.

LS-factor numbers are site specific and can be calculated from digital elevation models generated from lidar.

Cover Factor – C

The cover factor, C, is the ratio of soil loss from land under specified crop or mulch conditions to the corresponding loss from continuously tilled, bare soil. It is a measure of the relative effectiveness of soil and crop management systems in preventing or reducing soil loss. It is affected by:-

- crop canopy (leaves and branches of the crop, which intercept the raindrops and dissipate some of their erosive force),
- surface cover (crop residues and live vegetation on the soil surface),
- soil biomass (all vegetative matter within the soil; residue helps to improve the flow of water into the soil and the soil water-holding capacity),
- soil disturbance (profiling, sweeping ; surface roughness and compaction),

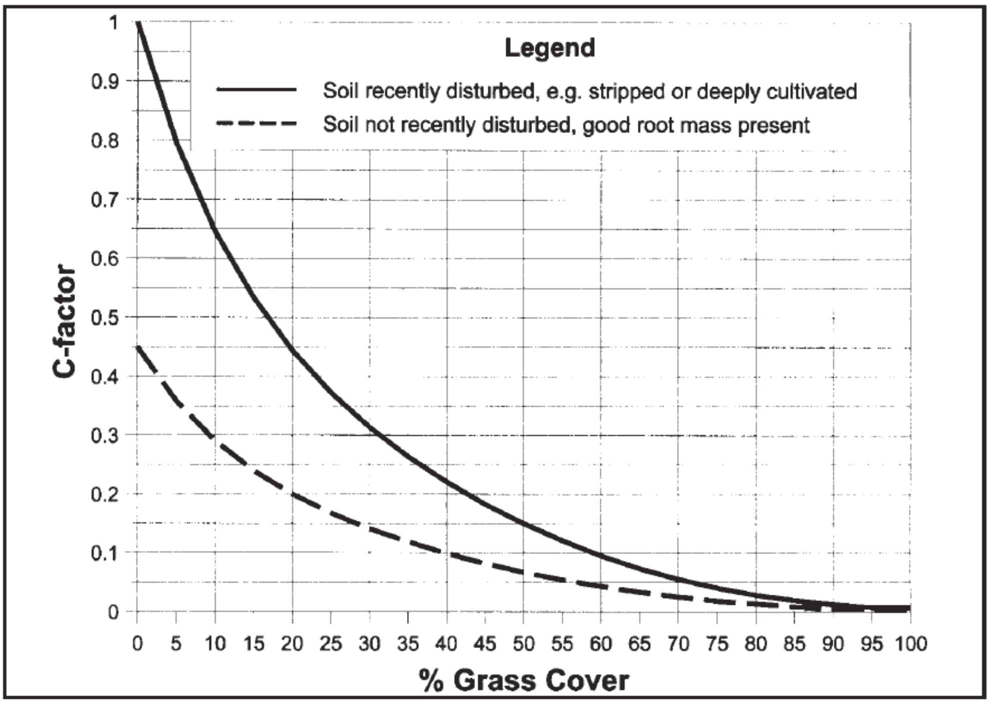


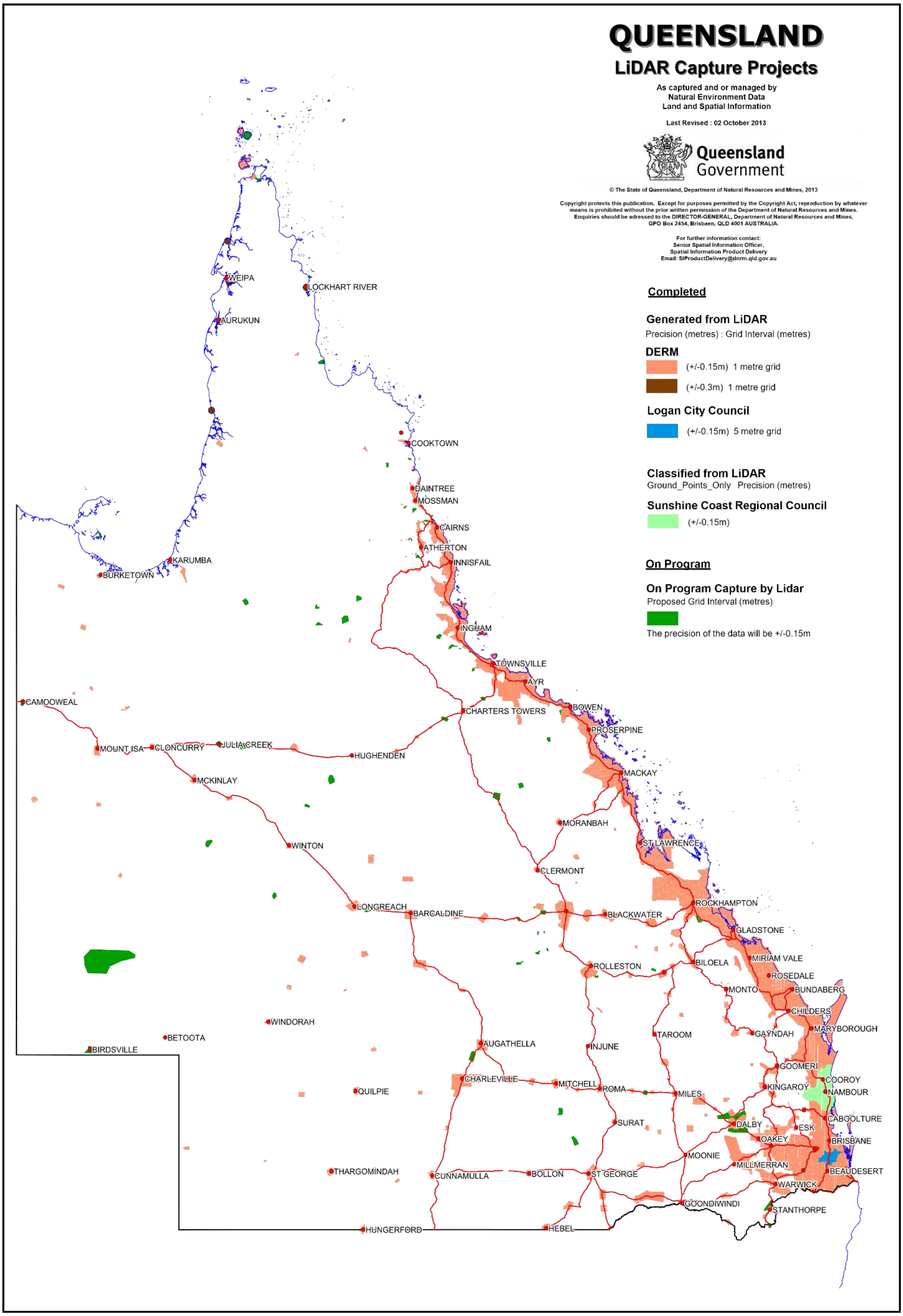
Figure A5 C-factors for established grass cover

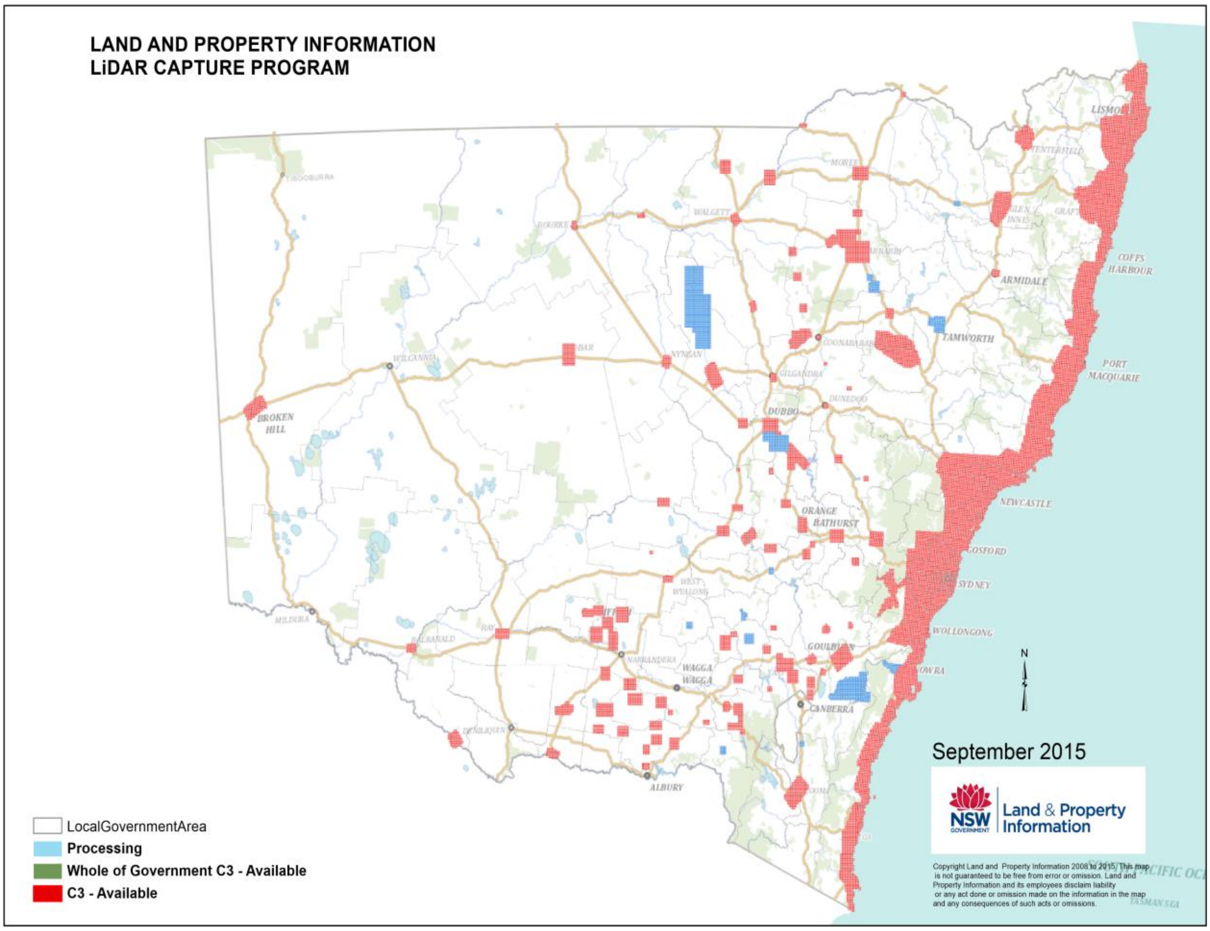
C-factor numbers are site specific and can be determined by the grower.

Erosion Control Practice Factor – P

The erosion control practice factor, P, is the ratio of soil loss with a nominated surface condition ploughed up and down the slope. It is reduced by practices that reduce both the velocity of runoff and the tendency of runoff to flow directly downhill. Unfortunately there is little information available for P factors on undisturbed soils. For this exercise it is left as 1 (no disturbance) and is reduced by management practices that reduce water flow such as applying compost or mulch on the tree line. Major reductions can be achieved by contour banks, headwater drains and cross drains to reduce the length of the slope.

Appendix 3. LIDAR capture programs




LAND AND PROPERTY INFORMATION
LiDAR CAPTURE PROGRAM
LISMORE
TENTERFIELD
MOREE
WALGETT
BOURKE
GLEN INNES
ARMIDALE
COFFS HARBOUR
TAMWORTH
PORT MACQUARIE
COONABARABRAN
GILGANDRA
DUBBO
DUNEDOO
BROKEN HILL
WILCANNIA
NYNGAN
ORANGE
BATHURST
NEWCASTLE
GOSFORD
SYDNEY
WOLLONGONG
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CANBERRA
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