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Programme of Presentation

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2001: AG Innovators Odyssey

Grant Mangold, AgInnovator

It's 2001. Agricultural innovators have come thus far on a two-decade odyssey with personal computers aboard a fledgling information technology industry. We now embark on a new millenium, faced with more questions than answers. But it is the power of question that fuels our quest. Twenty years ago, the revolutionary spreadsheet let us ask 'what if' in myriad ways, and personal computing took a quantum leap.

Today, with the dawning of the "Wearable Wireless Web" we can be part of the 'telecosm' - in the office, field, or on the go. With bio-receptors, our products will communicate as never before. We will equip ourselves with a wide range of data-driven devices, to empower us to make more dollars as we turn our data into decisions. We select software and harness hardware to gain answers to our questions. We forge new links in the farm to food chain, as we get plugged in to the planet with conduits of information piping data to and from our fields and herds, and channels of communication connecting us with a global community of consultants and customers.

With our gray cells in charge of the black boxes, we pursue precision as we aim at accuracy to achieve "appropriate agriculture"- by integrating economy and ecology with the goal of doing the right thing at the right time in the right place in the right way. Innovation is part of the culture of agriculture. The innovators' odyssey may be just beginning… Where will you take us?

Precision AG. OZ Style

Alex B. McBratney & Brett Whelan, The Australian Centre for Precision Agriculture, The University of Sydney

Precision Ag practitioners continue their pursuit of precision through "turning data into decisions." Economic studies are now beginning to show advantages of precision management. Precision agriculture terms are defined for Australia and elsewhere. We discuss a model for precision agriculture and review the management zone concept for site-specific crop management. The key areas of research for obtaining data layers and linkages, some of which is world-leading, are reviewed briefly.

The principal industries involved are those cropping industries of highest value where yield monitors have become available, i.e., grains, cotton, sugar, viticulture and horticulture. Commercial activities include the provision of hardware for information gathering, software for information management and data generation and information management services. The future of precision agriculture in Australia requires the plugging of knowledge gaps, the development of new areas such as precision organic farming, and most importantly vigorous promotion and investment. The application of geospatial information technology to agriculture through precision agriculture is profitable, can create jobs in the bush, is environmentally friendly, and can give consumers a deserved confidence in the production process.

Remote Sensing for Broadscale Weed Mapping - is it Possible?

Ian McGowan, Paul Frazier & Peter Orchard, NSW Agriculture

Reliable, up to date information on weed abundance, distribution, and change over time is essential for all aspects of broadscale weed management. Such information is necessary to evaluate control strategies, prevent spread to clean areas, and to improve weed management. Conventional weed mapping techniques are expensive, time consuming and are generally not repeated frequently enough to monitor important changes in infestations. They are also inefficient where the target weeds cover a wide geographic area.

Remote sensing offers a low cost, repeatable alternative for mapping and monitoring weed infestations over large areas, although with several limitations. For remote sensing to be successful, the target weeds must have distinct reflectance differences from background vegetation, soil and stubble. For detection by current multispectral sensors, these differences must be great enough to compensate for the broad spectral bands and the pixel size of the sensor. Detection may also be limited by the density of the weed infestation. Despite these limitations, mapping of infestations is possible.

In a recent study, up to 80 - 86% of Scotch thistle infestations in pasture were detected across much of a Local Government Area, at an infestation density of down to 20% groundcover. Similarly, 72 - 82% of serrated tussock infestations were also detected, at an infestation level of down to 30 - 40% groundcover. However, in each case, attempts to map various weed density classes gave poor accuracy, due to confusion between the classes. Such studies indicate the potential of remote sensing for weed mapping over large areas. The reliability of remote sensing for weed mapping will improve as imagery from new high resolution sensors becomes available.

Terrain Mapping in Real-Time: Sensors And Algorithms

S.Scheding, Jeff Leal, Mark Bishop & Salah Sukkarieh,The Australian Centre for Field Robotics, The University of Sydney.

This paper presents an overview of the work being conducted at the Australian Centre for Field Robotics (ACFR) into sensors and systems used for real-time terrain mapping. The trade-offs between various spatial sensors is discussed within the context of terrain mapping at a local level. The development of field deployable 3-D scanners capable of scanning an area in seconds (real-time surveying) is also highlighted. Finally, algorithms for storing and visualising the terrain data are presented.

Characterizing Soils For Plant Available Water Capacity And Yield Potential Using Airborne Remote Sensing

Thomas Selige & Urs Schmidhalter, Technical University of Munich

Multi-spectral airborne remote sensing was used to improve the inventory of soil heterogeneity at the sub-field level. Ground measurements of crop parameters were collected from representative soil sites. Spectral information at visible, infrared and thermal wavebands was recorded from the airborne scanner Daedalus AADS 1268. The spectral information was transformed into soil information using bio-indicative transfer functions, based on cause and effect relationships of the soil-plant system.

This procedure enables the spatial detection and the quantification of soil properties. The available water capacity of the rooting zone accounted predominantly for the heterogeneity of crop stands and yield formation of winter wheat. At specific development stages the crop stand conditions were identified as sensitive bio-indicator of the plant available soil water capacity. The thermal emission and its relationship to the transpiration of crops was recognised as most suitable to detect quantitatively soil properties via crop stand conditions of winter wheat.

The soil map derived from remote sensing and bio-indicative transfer functions explained the pattern of nitrogen uptake and yield formation. Maps as developed in this study will support farmers and agricultural advisors to practice precision farming using site-specific management.

RTKDGPS and Autodesk Land Development Desktop; A Powerful Combination for Rapid Accurate Surveying and Land Development Planning

Ian J. Yule, W.R. Woodgyer & R. Murray, New Zealand Centre for Precision Agriculture, Massey University.

This paper provides an example of how modern GPS and GIS technology can be utilised to significantly increase the productivity for surveying in land based applications. The particular example of land subsurface drainage is used.   A Real Time Kinematic Differential Global Positioning System RTKDGPS has been utilised with Autodesk Land Development Desktop as a means of rapid survey and subsurface drainage system design.

The topographic survey is completed with a Trimble AG214 RTKDGPS receiver linked to a Trimble AG170 field computer. This system provided an ideal platform for the capture of accurate topographic data. The system is mounted on a 4WD quad bike which is provided with lightbar driver assistance. Additional sensors can be linked to the system to collect further data, an EM 38 sensor has been used in this case.   Land Development Desktop has many capabilities suitable for professionals involved in land development. It allows analysis to be performed on a wide range of data types relating to land topography and attributes. Initially the system has been used in planning land drainage but is proving to be a versatile tool capable of many other design functions. The system has dramatically increased the survey output as well as providing a much richer data environment. Previously, a laser was used and measurements taken on a 40 m grid. With the RTKDGPS the survey is completed from a 10m swath width with data being collected every second.

Satellite Imagery as a Data Source for Prescription and Precision Farming in Australia

Brian J. Button, Agrecon

Important differences between prescription versus precision farming are highlighted. Satellite sensors designed for earth resource monitoring offer an important source of data for utilisation in prescription and precision farming. The relative advantages of satellite imagery over aerial photography, airborne video, thermal and other forms of long wave energy sensing are presented by highlighting technical and data integrity problems of these alternative forms of data acquisition.

Satellite imagery is available at a range of different revisit frequencies, from a range of different providers, under a range of different conditions attaching to the use of this data, at a range of different spectral and spatial resolutions, at a range of prices that reflect the range of different product formats, accuracies and reliabilities. Selection of the appropriate imagery at a date of image acquisition that is appropriate to the task and stage of development of the crop under consideration are particularly important decisions affecting the utility and accuracy of the resulting analyses.

Remote Sensing as a Potential Precision Farming Technique for the Australian Rice Industry

Sarah Spackman, David Lamb, John Louis & Gary McKenzie, Charles Sturt University

The rice crop growth model 'maNage Rice' is commonly used by NSW Ricefarmers to estimate mid-season nitrogen application rates for their fields based on a suite of basic plant measurements completed at panicle initiation.

Currently most rice growers treat their crops as being spatially uniform at the bay scale. This paper describes the use of multispectral airborne imaging to provide spatially referenced input data into the model as a potential means of quantifying within-field variability in nitrogen demand.

As a first step, an evaluation of errors associated with the process of estimating crop dry-weight biomass from remotely-sensed imagery and subsequent incorporation of this data into the model, will be outlined.

Moving to PA Management in the Grains Industry

Brett Whelan, The Australian Centre for Precision Agriculture, The University of Sydney

Techniques for gathering data on spatial variability and the presently available options for differential treatment suggest that the technology for Precision Agriculture is developing well. The critical link between these two operations is the agronomic rationale or decision on which to base spatially variable treatments. This is the most conceptually diverse component in the Precision Agriculture management system, and where the greatest information gap resides.

Initially causal relationships between soil/crop factors and yield must be established at the within-field scale along with the extent to which these relationships vary across the field. This information should be used to determine whether the observed variability warrants differential treatment and if so, direct the decision methodology to be followed.

Delineating management zones with some certainty is a useful method for beginning the process of scientifically evaluating the options and benefits of precision agriculture.

Vineyard Sampling for More Precise, Targeted Management

Rob G.V. Bramley, CSIRO Land & Water

Decisions as to the use and timing of many viticultural operations are dependent on accurate vineyard sampling - the scheduling of harvesting and irrigation, and whether or not to use leaf plucking or crop thinning are examples. Crop forecasting, and the payment of premiums for fruit meeting certain quality specifications, also depends on an ability to representatively sample vineyard performance. Growers seeking the best prices for their fruit want to be confident that it is being assessed in a robust manner and harvested under optimal conditions.

Yield mapping over three vintages in a number of Australian winegrape growing areas shows vineyards to be highly variable, with grape yields in single management units typically varying by 8 or 10-fold. A number of indices of fruit quality and vine performance have also been seen to be highly variable, as have vineyard soils.

With examples from contrasting Australian vineyards, this paper discusses the impact of this variability on the assessment and prediction of vineyard performance.

Precision Agriculture in Australian Cotton 2001

Broughton Boydell, Craig Stewart & Alex B. McBratney, The Australian Centre for Precision Agriculture, The University of Sydney

The accuracy of proximal cotton yield monitors was evaluated along with their operational reliability with results indicating a error of +-3% on a spatial scale of 6m x 6m is typical. Yield estimates derived from imagery collected with satellite based sensors (Landsat-7+ETM) was compared to proximally sensed yield measurements with results indicating that satellite imagery is capable of identifying the relative yield variability within fields.

Consecutive yield maps over 11 years were compared for three fields and analysed to determine whether the yield zones (relatively higher and relatively lower areas) were stable from year to year. Results indicate that for cotton fields which are typically irrigated, yield estimates from 3-5 irrigated years will produce a good map indicating the relative yield expected within a field. These stable regions may then be used as a basis for potential management zones.

Where the field is occasionally managed without the addition of irrigation, dryland management zones must be created using only previous years which were also managed without irrigation. Managing for yield variability within single cotton fields was examined by implementing fertiliser strategies aimed at applying nitrogen according to local requirement. Results to date showed no yield improvement but increased fertiliser efficiency use by employing the variable-rate strategies. These results were due mainly to the inadequacy of the current fertiliser recommendations for predicting site-specific requirement. At both sites, fertiliser rates were much too high.

Encouragingly, the management zone approach was very successful at dividing the field up based on yield potential. Once fertiliser recommendations specific to a management zone have been developed, the benefits of a variable-rate approach should be forthcoming.

Opportunities For Increased Profitability From Precision Agriculture

M.D. Craighead[1] & Ian Yule[2]
[1]Ravensdown Fertilizer Co-operative [2]New Zealand Centre for Precision Agriculture

A three year study using three sites in Canterbury New Zealand has shown that there is financial (and environmental) advantage in adopting site specific farming methods. Most of this benefit is derived from managing the crop in a way that is sympathetic to the variation in the paddock, variation such as soil depth and moisture retention.

This means varying the timings of nitrogen applications as well as the rate and protecting this investment with appropriate plant protection measures. The work has also highlighted 'at risk' areas of the crop as far as disease, invasive weeds and nitrate leaching is concerned.

Greater effort needs to be devoted to helping growers derive crop management strategies which go beyond the concept of simply varying rates of fertilisers or other chemical inputs at the time of application.

Interdisciplinary Research for Precision Agriculture Preagro: the German Joint Project for an Integrated Management System

Thomas Selige, Armin Werner, Thomas Muhr & Urs Schmidhalter, Technical University of Munich

Since January 1999, site-specific crop production has been studied throughout Germany in a BMBF-funded joint research project, "Management system for precision agriculture to increase the efficiency of farming and promote its environmental compatibility". The central goal is to exploit the arable land more economically according to the principles of good agricultural practice and at the same time to cultivate it in a more environmentally responsible manner.

With 22 sub-programs operated by 13 research institutions, 2 service companies, 2 software companies and 16 farms, Preagro (www.preagro.de) is developing the base for decision support systems for crop management in precision agriculture.

At eight regions across Germany, the available and necessary data are analysed for their possibility to be used in determining the appropriate cropping measurements for sub-units within fields. Algorithms and rules for this crop management are developed and will be provided as software modules to be implemented in any farm software for precision agriculture. Different methods to identify and describe conditions of site or crop stand are compared. New methods in soil survey, remote sensing or optical sensor systems at the fertiliser spreader are developed or tested. The algorithms and rules to manage the crop site-specifically are derived from agronomic knowledge and actual experiments.

The rules are developed for managing crops spatially variable with soil tillage (chisel ploughing), sowing density, fertilisation (N, P, K, lime), growth regulators and herbicides. Prototypes of the algorithms are applied on the test farms and will be validated for accuracy as well as the economical and ecological effects. The economical effects of managing crops site-specifically are determined especially for winter wheat and compared with adjacent fields which are managed uniformly.

The impact of site-specific management onto vertical and regional flow of nitrate in the soil is also studied. The opportunities to adopt environmental requirements to site-specific crop management are analysed for local objectives of nature conservation. The way to integrate these tasks is a cross-program linking multi-disciplinary research with industry and stakeholders from the public and the private sector (as farm managers, local governmental agencies, consulting companies, mechanical and software engineers) towards an interdisciplinary and comprehensive outcome.

Integrating Yield and Protein Spatial Information: A Framework for Analysis and Interpretation

R. Kelly, W. Strong, T. Jensen, D. Butler, S. Norng, S. Cook & B. Town, Department of Primary Industries Qld & others

Although precision agriculture tools employed by farm managers have the capability to provide data-rich information, agronomic interpretation of this information lags well behind. Protein mapping, using remote or on-board sensor technology, is set to improve this interpretation, but a framework is needed that can extract the maximum value from these data.

We have collected coincidental yield and protein data sets across cereal crops in northern Australia for 3 years, and a number of useful strategies have been demonstrated that maximise the extraction of agronomic information for advisers and farm managers. Nitrogen (N) management, using N removal, N supply and N deficit maps, and probability maps, that estimate the likelihood of response to applied N, can be obtained with coincidental yield/protein maps. Water use efficiency and starting-soil moisture supplies, using reverse-cycle modelling, can also be verified from these layers. Economic interpretations, using gross margins and sensitivity analyses, can similarly be provided. Issues still to be resolved in mapping coincidental maps are discussed.

Precision Management of Fertiliser Application to Pasture

Allan G. Gillingham, AgResearch

On most pastoral farms in New Zealand, fertiliser is the single largest expenditure item in the annual budget. Means of improving the efficiency of return from fertiliser use is of constant concern, however on most farms common fertiliser forms and rates are generally applied over the whole property or large blocks. Variability in pasture productivity and associated soil and plant characteristics occurs on all farms.

To date this has usually been recognised as being present but ignored as being relatively unimportant, or unable to be differentially managed. The advent of precision agriculture technology has produced two advances. The first is the ability to precisely identify and map small-scale variability, and the second is the development of variable rate fertiliser application technology. The challenge now is how to use these advances to improve on-farm economics.

The optimum differential application of fertiliser to pasture will require a more sophisticated basis for recommendation than has sufficed to date. Most models use generalised response curves derived over a number of contrasting seasons, and or from a number of sites with contrasting growth potentials. Such response curves are inadequate to fully exploit the potential from differential fertiliser application to contrasting growth zones. New models should be developed which incorporate the growth potential, together with the associated economic analysis, into the fertiliser recommendation for contrasting sites. From the results to date there appear to be worthwhile opportunities for adoption of PA approaches into pastoral farming.

Application Of Remote Sensing and GIS for Improving Vineyard Management

Sarah Pitcher-Campbell, Mike Tuohy & Ian J. Yule, New Zealand Centre for Precision Agriculture, Massey University

A case study was completed on the Stoneleigh vineyard in Marlborough as the initial phase of a project to compare three methods that might be used to produce surrogate maps of soil texture on a field scale.
The objectives of the study were to:

a) To map soil variability within the Stoneleigh Vineyards by image analysis of colour infrared aerial photographs.
b) To complete a detailed contour and electromagnetic survey of certain blocks of the Stoneleigh Vineyards.
c) To make a visual comparison of the maps produced in the two above objectives.

Colour infrared aerial photography was digitised and then interpreted using digital image analysis to delineate stony (drier) soils from silty (wetter) soils. The pattern of ridges and meander channels was easily identified visually on the aerial photographs and the classified image could be used in lieu of a traditional soil map. A high resolution digital elevation model was produced using a real-time kinematic GPS. An electro-magnetic (EM) survey was also carried out to provide additional data that could be used to map the pattern of soils.

Using the digital map, management decisions can be made with more accuracy and confidence. For instance, a more efficient irrigation system could be designed or a soil sampling regime for fertility assessment could be determined.

Airborne/Spaceborne Remote Sensing for the Grape and Wine Industry

David Lamb, Andrew Hall & John Louis, Charles Sturt University

The emergence of precision agriculture technologies and methodologies (data mapping) in the grape and wine industry have catalysed renewed interest in airborne/spaceborne remote sensing as a means of rapidly identifying spatial variations in productivity (yield and quality).

Although remote sensing in agriculture has undergone a revival since the early nineties, a significant proportion of this has been in applications involving full-cover crops such as cereals and pulses. Quantifying crop vigour is often simply a case of discriminating and measuring regions of differing crop density. In practice this is achieved by identifying different mixtures of crop and underlying soils/stubble/water spectral signatures.

Grapevines, however, are typical of row crops in that vigour is expressed not only as canopy density, but also in canopy dimensions. Algorithms capable of quantifying vine density as well as the spatial extent of the canopy are necessary to allow integration of remotely-sensed imagery with on-ground biophysical data in the search for possible indicators of productivity. This presentation examines the potential of airborne/spaceborne remote sensing, in the context of basic performance criteria, for measuring and mapping variability in vine vigour and, subsequently, productivity.

Hyperspectral Remote Sensing for Vineyard Management

Sedat A. Arkun, Iain J. Dunk & Stephen M. Ranson , Ball Advanced Imaging & Management Solutions

Ball Advanced Imaging and Management Solutions (AIMS) has been involved in the acquisition and processing of CASI-2 hyperspectral imagery for vineyard applications since 1999. The image products developed so far provide an additional tool in aiding vineyard managers and growers alike in the application of precision viticulture practices.

Atmospherically corrected high-resolution imagery is used to produce a number of image maps. Namely; graded vineyard greenness index, vine-canopy gap identification and quantification, vine-variety classification and identification and Normalized Difference Vegetation Index (NDVI). These image maps can either individually or collectively help vineyard managers and wine-makers alike to make more informed management decisions regarding the high-value vineyard plantations.

The graded vine canopy greenness image presents the observable vine vigour (greenness) variations within each vine block. Separation of a vineyard into discrete management units facilitates better targeting of vineyard practices such as irrigation, fertilization, spraying, pruning and harvesting. The result of targeted management practices through prior knowledge of the location and the condition of a management unit can lead to significant savings in resources, i.e. water, chemicals, fertilizers and effort, as well as providing the means to improve the vineyard uniformity and hence yield and quality consistency.

Another significant advantage of the use of such imagery is the ability to harvest segments of a vineyard block at optimum times in terms of ripeness which may be dependent on the condition of a given management unit. Partitioning harvesting times according to vine condition also avoids the mix of higher quality grapes with the lesser ones increasing the overall value of the harvest, which can be significant in the premium wine market.

Environmental Management of a Viticultural Irrigation District – A 'Top-Down Bottom-Up' Model

James A. Taylor & Alex B. McBratney, The Australian Centre for Precision Agriculture, The University of Sydney

Many agroecosystems face the dilemma of managing potential environmental risk at a farm scale whilst monitoring the same risk at a catchment scale. A model is proposed that enables the use of both broad-scale and fine-scale data sources in modelling local environs.

A case study from the lower Hunter Valley is presented as an example of the application of the model in the real world. The study aims to predict digital terroir (local environs) through a) the deconstruction of existing broad-scale soil information and recombination with derived landform attributes and b) the aggregation and extrapolation of fine-scale data.

The two models are used to refine each other and are further verified with independent ground-truthing. Results are still preliminary however strong spatial patterns are evident in the preliminary models.