A strategy to extract information from airborne gamma ray spectrometry for applications in plant based industries

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SUMMARY

Radiometrics is a successful natural resource tool; however technology captive projects of the past need to progress to on-ground decisions. This paper has focussed on developing a strategy to bridge this gap. The data to decision strategy involves a four stage process. (1) Be aware of the strengths and limitations of the technology; (2) match the data to the application, (3) target research with an application focus; and (4) evaluate the value of the geophysical information in decision making. This approach was used to bridge the gap between the gamma radiometric technology and 'on-ground' decisions in plant based industries.

Key words: decision making, radiometrics, soil mapping, precision agriculture, agroforestry.

INTRODUCTION

The use of geophysics (for example gamma radiometrics, electromagnetic and magnetics) in the 1990's has progressed from technology evaluation to acceptance as a natural resource assessment tool (George et al., 1998; George and Woodgate, 2002). Throughout this time there have been improvements in data mining (Anderson-Mayes, 2002) and interpretations to aid farm planners make decisions (Street et al., 2002). However studies in the past have not been evaluated in a decision making framework, partly due to the initial emphasis on technology evaluation.

This paper identifies this lack of analysis and develops a strategy to go from data to decision making. A four step process was identified in 2003 and used to bridge the gap between an existing geophysical technology, airborne gamma ray spectrometry (radiometrics), towards a potentially new application in plant based industries.

DATA TO DECISION STRATEGY

The data to decision strategy involved is a four stage process as follows: (1) Be aware of the strengths and limitations of the technology and data; (2) match the technology to the needs of the application with a positive outcome (such as profit or environmental benefit), (3) research with the aim to match the technology to the application; and (4) finally evaluate the value of the information in a decision making framework. This strategy is expected to be relevant to matching new or old technologies with unrealised applications in industries (see Figure 1).

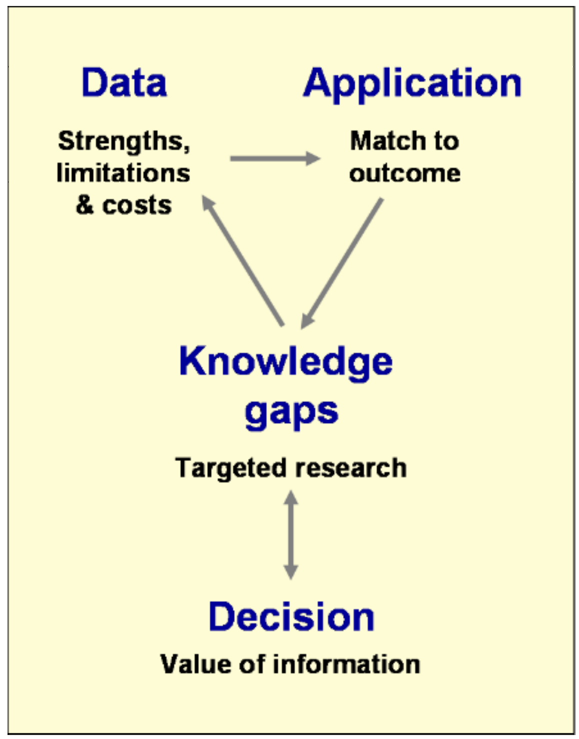

Figure 1. Strategy to extract information from data to decisions.

Data capabilities

It is important to be aware of the strengths and limitations of the technology and data before it can be successfully applied. For example it is important to know what the technology can measure, and under what conditions and sampling configurations.

Radiometric based data outputs include ground concentrations of potassium, thorium and uranium. These reflect geochemical, geomorphic and weathering processes important for understanding and mapping soils (Bierwirth et al., 1996; Dickson and Scott, 1997; and Wilford et al., 1997). Radiometrics is a soil mapping tool that has been applied efficiently at catchment and regional scales for soil type or soil landscape mapping in Australia (Cook et al., 1996; Slater, 1997; Street et al., 1998; Pracilio et al., 1998). Fifty percent of the observed gamma rays originate from the top 0.10 m of dry soil and 90% from the top 0.30 m (Duval et al. 1971). Wet soils attenuate the signal so the technology is suited in dry arid areas or dry seasons. If acquired at sufficient line spacing (~ 100 m) and flying height (20 – 40 m), the potential exists to acquire short-range variation over paddocks and farms that are indicative of soil forming processes and soil parent material. A further advantage of radiometrics is the objective nature of the data. Once interpretation or models of soil properties are implemented using radiometric data, the data can be revisited in time and models updated when new knowledge is acquired. The gamma radiometric data is therefore a suitable technology for soil mapping in dry areas.

In addition to soil mapping capabilities of radiometrics, it has the potential to provide a more cost-effective alternative than actually measuring the soil property of interest (McKenzie and Ryan, 1999). Radiometrics had the highest perceived land management benefit at the catchment scale through a soil map when compared to other geophysical based products (George et al., 1998, 2000).

Matching the technology to the application outcome

The application chosen was plant based present and future agricultural systems. The positive outcome in such applications can be for profit and/or environmental benefits. For example in the profit example, it is the harvesting of the plants that will return money to the farming enterprise. In the environmental example, it is the use of water by the perennial plants that will use water to reduce water tables for salinity management.

Gamma radiometrics is expected to be of value in plant-based industries, as soils influence the growth of plants. For example, the spatial variability, of soil and hydrological properties in the landscape, is reflected in the distribution of vegetation in natural ecosystems (Beard, 1982), yields of annual crops (Adams et al., 1998) and survival rates of perennial plants (Ryan et al., 2002). Site characterisation is therefore important in understanding the management of these systems.

Radiometric data can be important for identifying areas deficient in water which may relate to plant growth. For the growth of native, perennial and annual plants in semi-arid areas such as south Western Australia, a major limitation is water availability. Soil texture is related to water retention and is therefore an important soil site factor for plant growth Wong and Harper, (1999). Linear relationships with specific soil properties such as clay content by Wong and Harper, (1999) and soil texture by Taylor et al., (2002) explained greater than 70% of the variance using gamma radiometric data across two environments in south Western Australia. Traditional soil surveys are extremely expensive and time consuming to perform. Radiometric data has the potential to reduce such input costs.

Targeted research

Once the capabilities of the technology are matched with an outcome of the application, then targeted research can proceed. For example plant based management occurs at the farm scale and a major gap in knowledge in 2003 was the lack of the farm scale mapping with gamma radiometrics. Soil properties directly related to plant functions such as water and fertility at the farm scale were investigated at Yuna Western Australia (Pracilio et al, in press). Soil related to perennial growth was also investigated with ground geophysics at a hill slope scale in Kalannie Western Australia (Pracilio et al, in review).

Risky decisions

A decision problem occurs when you are unsure of the consequences given various options you can take (Anderson et al., 1977). The acquisition of additional information should aim to reduce the uncertainty in decision making. If the information supplied by the radiometric data improves profits or environmental outcomes, then radiometric data is likely to be worth collecting.

Decisions at the farm scale include those made in a precision agriculture and salinity management context. For example defining potential yield zones based on radiometric data for precision agriculture may reduce the uncertainty in defining water and nutrient availability. Once potential yield zones have been identified, soil sampling and inputs can be tailored accordingly for each potential yield zone. Identifying areas where the best perennial plant growth is important for environmental outcomes of farms. Using radiometrics to identify such locations may reduce the uncertainty in where the plants are likely to grow well, so that plants are matched to site conditions.

Geophysical data has been used to aid farm planners make farm scale decisions however a formal assessment of the decisions made have not been evaluated (Street et al., 2002). A formal assessment of geophysical products through the National Airborne Geophysics Project (NAGP) was carried out through a Benefit Cost Analysis, however this study did not formally evaluate farm based management decisions (George et al., 2000). There is therefore a need to bridge this gap in knowledge by formally assessing the value of information of geophysical data in making decisions at the farm scale.

Feedback

Feedback is important to the four step strategy of application, data, research and decision (Figure 1). For example research may identify limitations in the technology that may lead to research in the acquisition technology and lead to new data capabilities. Decisions evaluated today may also need to be revisited in the future when new research reduces the uncertainty in assumptions made during the decision framework analysis.

CONCLUSIONS

A four step strategy was outlined to bridge the gap between technology and on ground decisions. This was based on the application needs, the capabilities of the technology, targeting research to match the application and the evaluation of the technology in a decision making framework. Gamma radiometric data can provide continuous coverage of soil properties at comparatively low cost and offer great potential to enhance understanding of the distribution of materials at scales of interest to farm managers. The data provided by the radiometrics is likely to be related to plant growth, which is the economic output of farms and a major water user in the environment for balancing the hydrology for positive environmental outcomes. There is now a need to evaluate radiometrics in terms of a decision making framework, to identify if the data is worth collecting for plant based industries.

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