THE AUSTRALIAN NUFFIELD FARMING SCHOLARS ASSOCIATION

SATELLITE IMAGERY AND GIS SYSTEMS

A STUDY OF THE USES OF SATELLITE IMAGERY AND GIS SYSTEMS

REPORT PREPARED BY:

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EXECUTIVE SUMMARY

A significant portion of my life had been spent living and working in Southeast Asia, so my initial thoughts were such that I thought the most benefit for me would not start until we got to the UK. I could not have been more wrong. With the Nuffield Scholarship our group was given access to levels of the business world that I had very little experience with. In both Malaysia and Thailand I was able to see the bigger picture and by speaking to the groups of producers, academics and embassy people it gave me a better understanding of each country and how the fundamentals of international trade impacted on all parties. Even better was the debriefings our group undertook at the end of the tour as we discussed what we had heard and seen that day. I was actually a little embarrassed to think that I would not learn much during this portion of the core study time.

Similarly the UK and European part of the core study was also very informative. I had gone over to Europe believing that the English farmers were spoilt by the production subsidies. Again I was wrong, and I quickly began to see that farming in the UK was no easy task and that traditional farming, as I understand from my father and grandfather, was no longer. To me the English farmers are keepers of the landscape/environment, and that sometimes ridiculous agricultural policies from the European parliament place unrealistic constraints on an already tired establishment. The effects of the BSE and Foot and Mouth disease also showed that the Farmers Union lacked any real political strength to combat pressure placed on the government from an urban population that had lost touch with their country cousins. If the same happens here in Australia, I shudder to think of the consequences!

After the core study tour I returned to Australia to make plans to visit the US where I hoped to meet people involved in using satellite imagery and GIS systems in agriculture.

Before leaving for the US I looked at the NAMP model for Bluetongue forecasting here in Australia, that although it did not use satellite imagery as opposed to the Rift Valley Fever model and other malaria based models, it provided information that was already being used as a tool by the Biosecurity Australia to help negotiate certain health protocols for the export of livestock.

The US is the biggest user of satellite imagery and owners of the majority of the world satellites. I also contacted the author of a book I had picked up in a library in the UK who knew a lot about GIS systems and their applications, George Korte. This was an invaluable contact in the USDA/FAS in Washington and allowed me to focus on the Production Estimates and Crop Assessment Division, (PECAD) which gave me an insight in just how far the US had gone by using GIS and satellite imagery to their benefit. Their ability to forecast global crop production, at all stages throughout its growing stages, allows them to manipulate and renegotiate domestic pricing and policy, is quite unbelievable.

Aims and Study Goals

At the presentation of the 2001 Nuffields, I had hoped to pursue precision agriculture as an area of study, but when Ben Bootle presented his report, I saw myself reinventing the wheel, so mournfully I told the other scholars sitting at my table that I thought I had washed out before I had even started. However they reassured me that normally what a new scholar thought about doing before they went away was on average not what they ended up studying in the end. At the time it didn't reassure me a great deal, but they did make me realize that maximum benefit from the scholarship would be achieved by keeping an open mind.

Study Goals

Goal 1

Study current satellite imagery, GIS packages, and systems models, presently being used or to look at the possibility of using current systems and adapting them to produce an end product that could assist in the development of a disease forecasting system for the North Australian beef industry.

Goal 2

Study GIS systems that could assist farm management practices.

Goal 3

Study GIS systems that could assist with the logistical organisation of road transport for stock movements in the Northern Territory.

Goal 4

Whatever the study or whatever the outcome it had to have application to the community and it had to give the users some benefit to their current system.

Generally speaking I covered most of the goals I set myself, however in hindsight I probably spent a little too much time on the technical side of what I was looking at rather than looking for ways in which the end products could be used. In Washington I had a meeting with Bob Tetrault, in the Foreign Agricultural Service (a service seconded to the USDA) who probably summarized it best by saying “we need to see the forest not the trees to make our decisions”.

People say, “Money makes the world go round”. I don’t agree with this statement because money is a result of a decision. To make money you must make the right decisions or choices. Decisions that are made on current, correct, and up to date information, yield the best outcomes. Admittedly – sometimes we luck it, but I’d think most people would prefer not to run their enterprises using luck as their preferred choice of management!

Information makes the world go around – money is the highly prized result of correct information!

Introduction

Before I left to start the Nuffield studies, the only prior knowledge I had of work relating to the field I was interested in, was a comment by a friend that he had heard of someone in the FAO who had used satellite imagery to try and forecast outbreaks of Rift Valley Fever in east Africa. I had also heard that the preliminary work had been quite successful although, a recent outbreak had caused some speculation to surface about the accuracy of the model. There had been significant economic loss to the country involved and that there had been several human fatalities. Generally speaking I did not know what I was going to find, but if there was a framework for some kind of working model already in existence, then I thought the technology could be reshaped to look at the Bluetongue virus. By pure chance the National Arbovirus Monitoring Program (NAMP) model, although not using satellite imagery, was almost exactly what I had hoped to find – I didn't think I would have to fly around the world looking for a relevant model only to find it in Australia, where one of the main collection and collation centers, was in my home town!

The use of GPS and GIS systems and their uses and applications in agriculture was going to be my area of study. I began to look more into the many different applications of this technology. This was when I discovered that satellite imagery or remote sensing, coupled with the technical aspects of GPS and GIS software could be, and is in fact, a very powerful and valuable tool in agriculture. Imagery taken by satellites, use GPS navigation, and GIS software helps to manipulate the data/imagery.

The primary goal of my study was to look at the possibility of combining all three to see if it was possible for this technology to predict disease outbreaks, and if that was possible, to use the output as a negotiating tool to enhance market access to importing countries and to allow access to areas of cattle within Australia that are prohibited because of the Bluetongue status.

While it was my primary goal to and end up with a functioning end product, I did not want to get to the end of my study without knowing "how" this was possible. To clarify this point it's a bit like somebody driving a car to work everyday and not know what's under the bonnet! So I wanted to look at the satellite imagery separately, various GIS packages and the basics of computer modeling.

The people I met in the United States and down in Canberra was very obliging and very patient with me, and at the end of my travels I was extremely pleased with what I been able to learn. This would have been impossible without the Nuffield Scholarship.

Satellite Imagery & Remote Sensing

Why Use Satellite Imagery?

The quick answer to this question is that it is faster, better and cheaper than aerial photography, field surveys and paper maps.

The Advantages of Satellite Imagery

- **Digital**
  - Nearly all satellite imagery is acquired digitally. This reduces expensive data conversion costs, scanning and digitizing.
- **Fast**
  - In the time it takes a field crew to unload its equipment or a pilot to do a preflight check of the aircraft, a satellite can map an entire geographical scene. Satellites are easy to schedule because they are constantly in orbit.
- **Inexpensive**
  - Because satellites can take scenes of large areas, the average cost of raw satellite imagery usually averages out well below $US1.00 per image.
- **Global**
  - Nobody owns space! There are no boundaries in space that restricts the coverage of a satellite, and because they are in polar orbit, any point on the face of the earth can be imaged.
- **Current**
  - By the time a paper map is finally published and released to the public, the information can be outdated. Satellite images are current and can be updated every 24 hours in some cases.

- **Accurate**
    - A satellite sensor does not lie. There is no human involvement in the generation of raw satellite imagery.
- **Flexible**
    - The imagery can be manipulated in many ways with the various GIS software packages available in the world today.

The Fundamentals of Remote Sensing

In the very early days of satellites, images were returned to earth on photographic reels ejected from the satellite and recaptured in transit as it parachuted back to earth. This was mostly spy satellite information, (Lanyard, Argon and Corona Satellites). Reading the mission reports from these satellite programs, (President Clinton signed a Presidential Decree opening this archived information to the public, where in the past it had been declared Top Secret or Classified), quite a few reels were not recaptured, and reportedly sank to the bottom of several oceans – or that's what they would have you believe!!

These days, satellites acquire their images with digital sensors, not with photographic film. These sensors work on the same principles as a digital camera, but each sensor has thousands of smaller detectors that measure the amount of electromagnetic radiation, (i.e. Energy), reflected from the earths surface or from objects on it. These are called spectral measurements, GEOIMAGE (1999). Each spectral reflectance value is recorded as a digital number. When this information is transmitted back to earth, a computer converts the data into colours, or levels of greyscale brightness to create an image that looks like a photograph.

Depending on the sensitivity of the detectors, sensors can measure the reflectance of energy in the visible, near infrared, short wave infrared, thermal infrared, and microwave radar portions of the electromagnetic spectrum, GEOIMAGE (1999). Most remote sensing satellites measure energy in specific, well-defined wavelengths of the spectrum. See Figure 1 below.

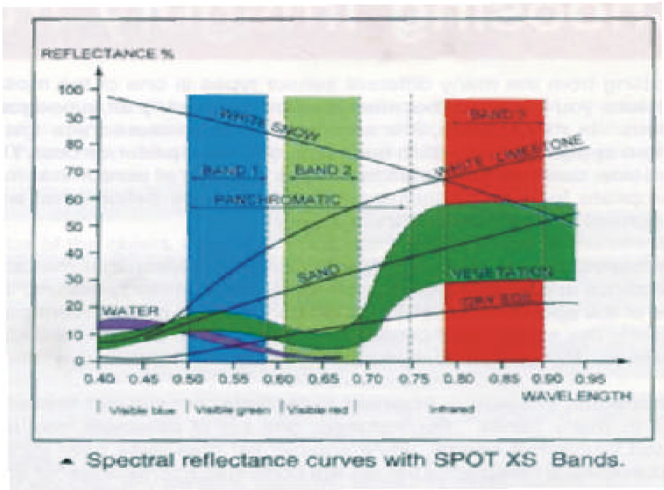


Figure 1: Spectral Reflectance Values, GEOIMAGE (1999)

Wavelengths and their Applications

Although each satellite system, SPOT, LANDSAT, etc. have slightly different ranges of sensitivity the spectral ranges can be grouped into the following categories.

Band 1

Visible Blue (0.45 - 0.52μm)

- Coastal Water mapping, differentiation of soil from vegetation. A limiting factor of this wavelength is that it has poor penetration through haze.

Band 2

Visible Green (0.52 - 0.60μm)

- Vegetation vigour assessment.

Band 3

Visible Red (0.63 – 0.69μm)

- Vegetation discrimination, also has also has high iron oxide reflectivity.

Band 4

Near Infrared (0.76 – 0.90μm)

- Determining biomass content and delineation of water bodies.

Band 5

Middle Infrared (1.55 – 1.75μm)

- Vegetation and soil moisture content, differentiation of cloud and snow.

Band 6

Thermal Infrared (10.40 – 12.50μm)

- Vegetation heat stress analysis, soil moisture discrimination, thermal mapping, although limited to daytime use, as greatest portion of thermal radiation reflected during this period.

Band 7

Middle Infrared (2.08 – 2.35μm)

- Discrimination of rock types and hydrothermal clay mapping.

Panchromatic Band (0.52 – 0.9μm)

- Mapping of man made features, delineate land and water boundaries, and classify land use.

Spatial vs. Spectral Information

These two features are essential to understanding how various types of images differ from one another.

Spatial Content of an Image

Reflectance measurements that provide images of surface features or ground objects as they would appear to the naked eye, (shape, size, colour, and overall appearance), is known as the, spatial content, of the image.

Spectral Content of an Image

Whereas the spatial content of an image is visible to the naked eye, the spectral content of an image is generally invisible to the naked eye. These are things like mineral content of rock masses, moisture content of soil, health of vegetation, even the physical composition of buildings. Applications for this type of imagery, has many obvious uses in a broad range of fields and industries, such as military, agriculture, meteorology, mining and engineering, disaster management etc.

Making the Right Choice

Selecting the right sensor when choosing the type of imagery that best suits your needs is very important. There are several different types of sensors, each operating and yielding output slightly different to other sensors.

Panchromatic (PS)

This sensor normally operates in the single broad band between visible (<0µm) to near infrared (+/-1.1µm), and is represented as black and white imagery. This sensor is particularly good for locating, identifying and observing spatial information, (shape, size, colour and orientation).

Multispectral (MSS)

MSS imagery is acquired by a digital sensor, which measures reflectance in many bands. For example, one sensor may look at only energy that is reflected in the visible red band while another looks at the near infrared band. When data is viewed together, it produces a colour image. This leads on to a Hyperspectral sensing which looks not only at one or two bands but hundreds at a time, as the name suggests. The benefit of this type of sensing is that it can pick up very subtle differences in surface features. In particular, soil, vegetation and rocks. This sort of feature is not currently available to the commercial world, however it is readily used by the military and security agencies of the world.

Disease Forecasting

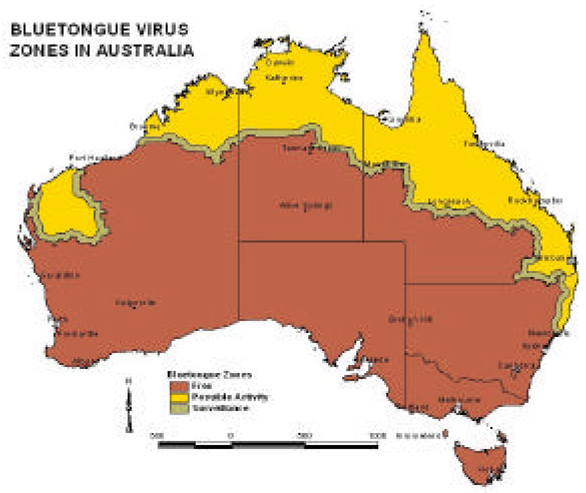


Figure 2: www.namp.com.au (2003)

Bluetongue

Bluetongue is an arthropod-borne disease of all ruminant species – sheep, goats, cattle, buffaloes, antelope and deer. They are all susceptible. Of the domestic species, sheep are the most affected. Infection in cattle, is generally sub-clinical although it is of great epidemiological, and economical significance, (because of import bans). The arthropod vectors of Bluetongue are cullicoides (biting midges). The virus was thought to be isolated in Africa but in the last 50 years Bluetongue has been increasingly recognized wherever large populations of ruminants occur, both in the tropics and sub tropics (Cameron 1996). Bluetongue was first isolated in Australia from a pool of Culicoides insects trapped near Darwin in 1975 (pers com Melville 2002, pers com Hunt 2002).

NAMP Model

Models have been published, i.e. NAMP, which link vector distribution patterns and dispersal after winter from endemic areas to a series of ground measured meteorological data (temperature and rainfall) as well as wind direction and speed in Australia (Bishop et al 2000, Cameron 2000).

This system includes central data processing (vector and serology) from a large number of sentinal herds around Australia. It should be noted that this system does not use satellite imagery as part of the model, although initially a Normalized Difference Vegetative Index (NDVI), application was considered. Figure 3 below shows how the model functions with the data collected. This data is then run with "Plug n Play" GIS software to produce the NAMP map above in Figure 2.

Below is an illustration of how the concept of "Plug n Play" software is employed in the modeling of this data. During the time I spent researching this topic I found there to be two popular GIS software products MapInfo (www.mapinfo.com) and ArchView (www.archview.com). While the models used by NAMP and the GIS farm management program, "Pinpoint," used ArchView8, it is not the aim of this report to suggest which one is better. Both have their advantages and disadvantages, but there seems to be a growing trend towards ArchView8.

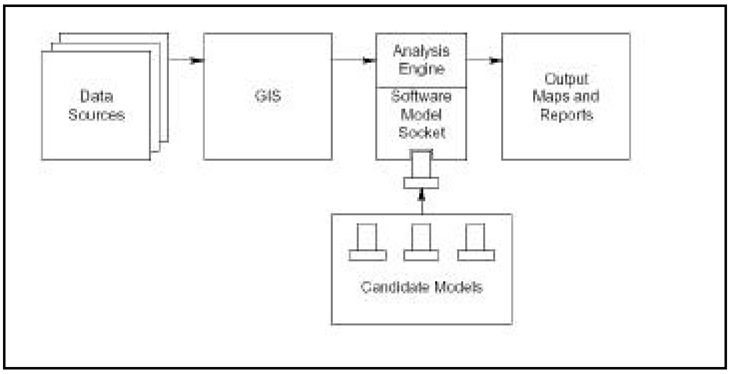


Figure 3: Concept of Plug n Play Software (NCEEP, 1999)

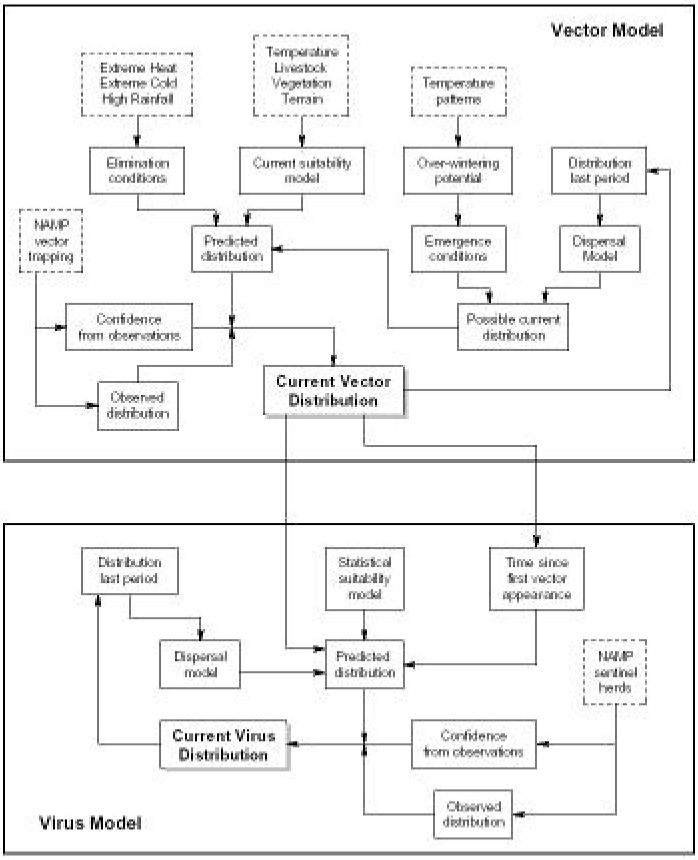


Figure 3: Flowchart of NAMP Model (Cameron, 2000)

The results of NAMP are used for zoning and the preparation of the bluetongue map. This zoned map is based on World Organisation for Animal Health (OIE) guidelines, and defines areas free from viral activities for at least the past two years, www.namp.com.au (2003). The map (Figure 2) above is the current map, but this can change without notice, which is very important when making decisions about the status of bluetongue within a given area at a particular point in time. For example a Chinese dairy shipment is worth in the vicinity of 3 million US dollars. All cattle sourced for China must be free of bluetongue or come from bluetongue free areas. If the mapped zoned areas moved while an exporter was buying for a shipment and was not aware that as a result the health status of the cattle had changed – the loss to the exporter would be disastrous. The risks involved to the exporter (economic), and the live export industry (National disease status, welfare and public image) cannot be over exaggerated.

Economic Perspective

The live export markets of Korea, Israel and China have import health protocols that prohibit the export of livestock that have been exposed to the Bluetongue virus. If a model similar to the ones used in the medical field could be used as a tool for our policy makers to renegotiate these protocols, by showing the importing countries governments livestock health services that Australia had a tool that could predict or forecast periods in the year when the viral activity in the animal populations was very low, then perhaps during these low risk periods, animals in these areas could be exported. The roll on benefits of this would put more money back into the pockets of producers and the Australian economy.

Current Progress

To see what progress had been done along these lines I traveled to Canberra to speak with Dr Angus Cameron – NAMP and AUSVET PLAN and the team from AQIS/Biosecurity, Graeme Garner, Louise Kench, Greg Oliver in Biosecurity Australia for their comments.

A lot of work had been done with the Chinese to try and get them to accept that through our monitoring systems, the threat of Bluetongue could be minimized or at the very least could be done at a time in the north Australian cattle producing areas when seroconversion was at its least risk. For example trucking cattle directly through to the wharf for loading when insect activity was least likely (early hours of the morning) and that the export depots were in an area below the prevailing Bluetongue zone. However it is prudent to mention here that the negotiation of any health protocol with any country is a very slow and often frustrating prospect. So a speedy result would have been remarkable, if not amazing!

It is also ironic that the Chinese protocol asks for stock that are free of Bluetongue, no seroconversion to the virus, when in actual fact if they had antibodies to the virus they would stand a better chance of fighting the virus as opposed to stock that are completely naïve to the virus.

While in Belgium I stayed with the people from Avia – GIS, who recently completed a study in South Africa about the "Tsetse Fly Presence – Absence Prediction Model of Glossina austeni and Glossina brevipalpis in Kwazulu Natal – South Africa," (www.avia-gis.com), with the aid of satellite imagery. The staff of Avia-GIS asked if I would be interested in trying to expand the NAMP model and if it was possible to get approval from the team that developed the NAMP model for a collaboration of both resources and archived data. If I had known then, what I know now, I would have the declined the request without another thought. Given the possible downstream benefits of having a potential system that assisted the industry, trade and economic wealth of Australia, it was hoped that with the assistance of Austrex, Avia GIS, and the team working on NAMP, that all three could collaborate on expanding the NAMP model. Unfortunately the ability to share information became too much of a political hot potato, as data previously collected and the government personnel involved in the collection of this information did not have the financial resources or the policy in place, to follow through with this concept.

Since it seemed that collaborating with the existing model was not going to be possible, Avia – GIS and Austrex sought to put an application into the Belgium government for funding of two projects using European acquired satellite imagery. The basis of the funding being that it helped create a market for such acquired satellite imagery. The first project was a study, looking at the environmental impact of rangeland management. The study area to focus on the Consolidated Pastoral Company (CPC) – Newcastle Waters, Dungowan, and east Kimberley stations of Auvergne, Newry, and Argyle Downs and Carlton Hill. The major focal point of this study will be to try and quantify the human impact on rangeland management by means of satellite imagery.

The second project submitted for funding was the development of data products from remote sensing that might be useful with respect to the understanding of the bluetongue disease and vector dynamics in Australia.

On the 1st of December both proposals were granted funding from the Belgium government and will proceed in March 2004.

While I believe this to be a significant achievement, it's disappointing to think that collaboration between the parties was not possible, and that having to go it alone so to speak, increases the risk of reinventing the wheel! By that I mean, why have two systems of similar capacity, when the resources, both time and money, could have been spent evolving an existing model to achieve, potentially even greater results.

Other Models

Rift Valley Fever (RVF)

This disease is spread by mosquitoes and has an enormous impact economically and socially because not only does it kill livestock that are economically important, but also it can be fatal to humans. In particular the agricultural economies of east Africa have been periodically devastated since 1950 and most recently in 1997/1998. Scientists from the Goddard Space Flight Center and the US Department of Defense have found a correlation between periods of prolonged high rainfall associated with El Nino/Southern Oscillation or as the Americans refer to it ENSO, (Tucker, 2002).

With a combination of warmer than normal sea surface temperatures (SST), associated with El Nino in the Pacific, and above normal SST in the western equatorial waters of the Indian Ocean, historical data has shown that this normally lead to periods of prolonged high rainfall periods in East Africa which are favourable conditions for an outbreak of mosquito borne diseases.

Using indices such as rainfall, temperature, soil moisture, and NDVI, the team was able to identify periods and areas that were potentially conducive to RVF. Once the potential areas are identified, planning such as vaccinations and vector control can be undertaken as a means of prevention rather than cure.

Using near real time satellite imagery showing the changing patterns in the NDVI and monitoring of the sea surface temperatures, maps showing anomalies in these indices are published on the web, http://www.geis.ha.osd.mil, and assist public health agencies with field sampling and cuts the cost of surveillance.

This type of methodology has also been used for the study of malaria forecasting in the area of southern India and Bangladesh, where SST and sea surface tide heights (SSTH) coupled with NDVI and ENSO data are used to forecast potential malaria outbreaks (Tucker, 2002). The economic loss both in terms of a country's human life and the drain it puts on the economy through loss of productivity in the workforce, cripples some countries e.g. Bangladesh, India and Myanmar where during particular seasonal conditions this disease is a high risk.

Other Systems Observed on the Nuffield Study

Production Estimates and Crop Assessment Division (PECAD)

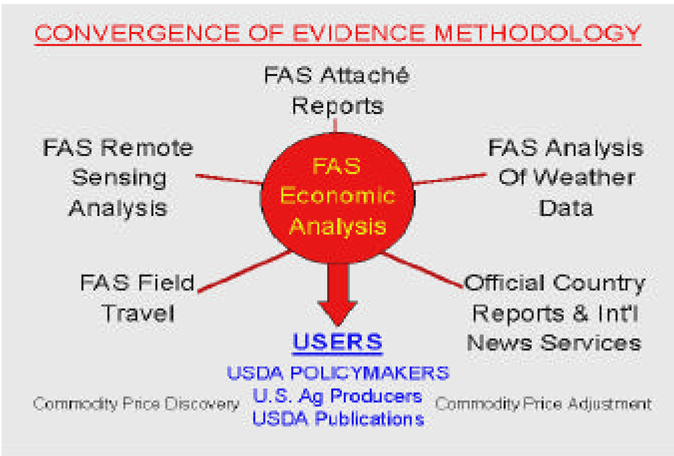
http://www.fas.usda.gov/pecad/

George Korte, who was the author of a book called, "The GIS Book," and whom I met with in Washington, (I read his booking in a library in England, and at the back of the book he left his number – so I gave him a call!), he gave me a contact in the USDA Foreign Agricultural Service (FAS), Bob Tetrault. This gentleman worked with the Production Estimates and Crop Assessment Division, PECAD. My primary objective for this study was to try and find a model that could forecast arbovirus diseases, or a model that could be adapted to achieve this outcome, but the PECAD system that I observed and spent the day with in Washington was by far the greatest experience of my study.

The official mission statement for this system is, *"To produce the most objective and accurate assessment of the global agricultural production outlook and the conditions affecting food security in the world"*.

After spending a very short period of time with Bob Tetrault, one thing became very clear. The United States has the ability to monitor and forecast global commodity production. Not only that, but every thirty days, all this information is recalibrated following the analysis of the updated data. Earlier in this report I mentioned that information is what makes the world go around, the following is a very good example of substantiating that point. PECAD is a tool that is so sensitive in some cases, by the information it generates that its disclosure must be delayed or controlled, so as to prevent speculation or manipulation of commodity prices on stock exchanges. The effect from this type of information abuse, has the ability to destabilize agriculturally based economies, not to mention the ethics and code of practice for trading on the stock exchange.

Diagram 1: PECAD – How it Works!



(USDA/FAS, 2002)

PECAD produces this information through the use of CADRE which is an acronym for a geospatial database management system DBMS, that stores daily weather data from over 10,000 weather collection points (this includes all US military installations) and imagery derived data, such as interactive and automated extractions, vegetation vigor data from imagery such as NDVI, and then it catalogs the results from crop and soil moisture models. However sometimes it is necessary to do some "ground-truthing" using local personnel to visually confirm data produced by satellite.

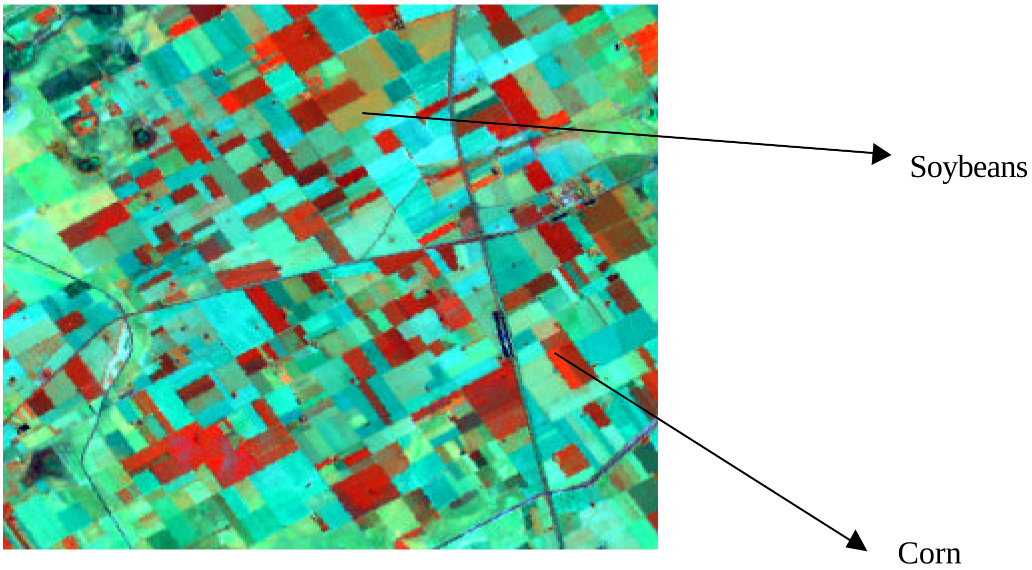
People may wonder why if PECAD has all this high tech equipment that they would need to "ground-truth" the information received? Put simply, satellites and computer models, no matter how good they are, don't always give the exact answer, hence there will always be a need for human intervention.

Other Uses of PECAD

Agricultural Monitoring and Food Security

By being able to monitor the rest of the world's production, the US is positioned to adjust its domestic policy (export subsidies), and pricing, so as to take full advantage of the world market prices. Bob Tetrault spoke of an example whereby the US Government investigators were using the spy satellite, (IKONOS), to confirm that farmers who were accepting export subsidy grants for producing soybeans had in fact planted soybeans and not some other crop. I think the term he used was "double dipping the cookie jar"! The IKONOS satellite has a resolution of 1 x 1 m^2 which when used in conjunction with a vegetation index, has the ability to distinguish different crops – hence I expect that there have been a few red faced farmers trying to explain why there is a crop of corn in the paddock as opposed to the soybean subsidy that they had received!

Diagram 2: Imagery Showing Different Crops



FAS/USDA (2002)

Foreign Aid Assessment - Disaster Monitoring and Relief

One of the disturbing points that our group heard in Belgium when speaking to the different organizations surrounding the European Union Agricultural unit, was that historically the US seemed to be most generous in giving agricultural aid grants/gifts during times when commodity prices were lowest. While it is understandable that the US does not want to forego any loss in export income, it does smack of double standards when the operative word in this issue is “aid”. However using this system the US is able to monitor countries whose crop or crops form a significant portion of the country’s export earnings, can foresee an impending need for assistance, can allocate resources accordingly, should policy permit. My personal opinion on this particular aspect of PECAD, is that it can leave a particularly nasty taste in ones mouth, if one was to take a purists point of view on using the demise of one country, to profit take in another! But having said that, trade has never been about being nice – it’s about making money!

Having the ability to access the world's weather database on an hourly basis also assists with issues such as disaster management and preventative action by different services to minimize losses both economically, and more importantly loss of life. Flood counter-measures; thaw monitoring, tornado/hurricane monitoring etc. all help minimize loss to communities that lie in the path or are within the downstream areas of the catchment.

Miscellaneous Systems Observed

Ambulance Efficiency

While sitting on the train on the way into Washington I started talking to a pair of off-duty ambulance staff. When I told them what I was in town to study they started to tell me about the new system they had installed in their vehicle.

By using a GIS and GPS tracking system, linked to the city's traffic network, their dispatch and recovery time back to the hospital had been reduced quite significantly. This was achieved by having the GIS/GPS tracking system indicating to the driver on a computerized display, the shortest route to the emergency site and then back to the nearest hospital. To ensure this was possible when the ambulance approached a set of traffic lights within a quarter of a mile, the system would link into the computerized traffic system, and change the traffic lights so as to provide passage, as they approached. They could not quantify the efficiencies that this system had achieved, but did comment that this was a fantastic development for them.

US Navy Repairs and Maintenance

George Korte told me about his company's (INFO TECH), latest contract that involved repairs and maintenance for the US Navy. Being such a large and vast organization and the fact that a lot of efficiencies were being lost in the system as a result of this, his company was contracted to identify and install tracking chips, on or within the equipment, and then log its data into a database. In doing this the appropriate technician, with the correct spare part or tools could arrive at the correct site and perform the appropriate task. On completion of this task the technician also had a list of other relevant tasks that he could perform on site or could be allocated to the next job/task closest to him. The whole aspect of the system is to streamline it, and in doing so, reduces the cost. This if George was correct, ran into the hundreds of millions of dollars every year.

"Pinpoint" Farm Management Software

On Newcastle Waters in the NT, they were using a GIS software package called "Pinpoint". I say were using because the management has decided to discontinue its use. Not because it wasn't any good, but because it was very user unfriendly, and the backup service was not very good, and in the end it became too time consuming to maintain for the output it produced. Which if you read George Korte's book, "The GIS Book", some of the very big No No's are;

- Lack of management's support
- Single user operators
- Poor backup service
- Constant updating etc.

Yet from where I stood and what I saw this system had to offer, (it did have some short comings), I thought it was good. Its capabilities were that it showed a map and in a set of overlays, the property as a whole, waters, roads, fences, stock numbers per paddock, whole property inventory – such as stores, individual equipment, fencing plant, drugs and chemicals etc.

For each paddock it could list the stock types, the last time the paddock was mustered and what had been done to the stock, as it also followed the Cattle Care system as well. Its limitations appeared to be that it could not understand that a paddock could not be 100% mustered clean. It could not understand that apart from deaths and rations the number should be perfect, so footnotes had to be added manually to account for this. The task of updating was normally left to a single person who generally did not actively take part in the daily routine of the property so any adjustment to the data had to wait until the relevant person came past the office or answered the radio – and that could be days! Also the fact that one person was in charge of this system, when they left, it left a hole in the system which meant further training for somebody else and more downtime. I could understand completely why this system was abandoned, but it is a shame that more had not been done with it.

Conclusions

Satellite imagery is proving to be a very powerful tool in agriculture. However as good as this technology is it is worthless without good management that comes from human intervention. Putting it bluntly, there is no substitute for good management – everything I have discussed in this report has been a referral to the use of a tool for management. It won't give the user all the answers.

I enjoyed reading somewhere about the time there was a competition between the Russian space agency and NASA about giving the astronauts a pen to use in space, because a normal pen does not work in space. NASA spent in excess of a million dollars developing a pen that would work in frigid conditions, extreme heat and still function in the weightless environment of space. The Russian's gave each of their astronauts a pencil! The point I'm making here is, don't become a technocrat if there is no benefit. A person who has farmed the same piece of land for 10 years will know how the country performs.

Imagery is not something that individual farmers should rush out to acquire for their own enterprises. For individuals on farms, scenes for small farming operations would require 1m or 10m spatial resolutions, and would be very expensive, and for an informed decision, archived imagery and several follow up imagery would also need to be purchased, adding further cost. The cost obviously reflecting the type of information required from the image. i.e. Number of bands, scene size, amount of history required etc.

Large corporate agribusinesses like Australian Agriculture, the land holdings of the old Stanbroke Pastoral Company and Consolidated Pastoral Company could utilize this type of system because of their land mass groupings and the size of their enterprises allow them to use wider scenes i.e. (20/30m or 80m) of raw data to look at things like landscape management practices and impact evaluations such as the effect of long term stocking densities. It comes back to being able to see the forest instead of the trees, and so there are economies of size/scale here that affect the amount of benefit gained from this technology.

It would be my suggestion to view the provincial imagery or district imagery as a single farmer/grazier to interpret prevailing conditions and use their own ground-truthing on farm to compare the two scenarios and then formulate a decision after that assessment.

The use of GIS and satellite imagery to forecast disease outbreaks has great potential, but I see it as being something that will be limited by the interpretation of what is considered an acceptable level of precaution or risk. The Chinese government's health department will not accept that the NAMP model is accurate enough to ensure that the cattle in the north of Australia are free from Bluetongue, or that the level of activity during the cooler drier months, warrant any reconsideration of the Bluetongue protocol. Any model will have limitations, purely and simply because nobody has yet been able to understand the blueprint of nature – it has a nasty habit of making a liar out of the person who thinks they have the perfect model, and yet we build models to forecast diseases and disasters that require a level of acceptance of risk. But the people have trouble agreeing on what is an acceptable level of risk, so better models are built, and the cycle continues. Without a comprehensive analytical system that can draw upon all of the variables involved, "forecasting" will remain an elusive and possibly an unrealistic goal, but one has to start somewhere!

In concluding it must be said that to ignore the technology that is available today or to be consumed and driven by it, instead of using and managing it, is to put limitations on one's potential.

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