Considered data arrangements for effective and holistic catchment management

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Abstract

Traditional water monitoring programs have focused upon individual parameter monitoring, which includes, monitoring physical chemistry or biological indexes such as macroinvertebrates or fish, in isolated programs. This monitoring is generally analysed separately and used as a surrogate for overall river health. It is becoming increasingly necessary to understand more about our catchments to determine the effects of our actions. By storing the various monitoring programs data in one database the accessibility of the data is increased. The by-product of such a system is that, whilst the data can be still used in isolation for the various programs, it can now also be accessed readily and used collectively in strategic management, by creating specific catchment indicators based on a variety of datasets. There are a variety of commercially available data management tools which store and manage data: there are none which have been created specifically for the natural resource management field. Environmental organisations collect a broad array of information all of which have different methods of reporting and confidences levels. The importance of community satisfaction towards the health of the river and the water quality parameters along that stretch of river are intrinsically linked and of equal importance, yet the scientific rigour to collect each dataset is markedly different. Wimmera EcoGeoGraphica (WEGG) gives resources managers the ability to access a variety of information on a particular theme or subject quickly, while retaining the initial purpose and confidence level of each dataset.

Keywords

Information management, database management, natural resource management, monitoring, strategic management

Introduction

Environmental organisations such as Catchment Management Authorities perform a wide and varied array of activities, from river and riparian management to managing market based solutions and community engagement. Project officers employed to manage these projects are usually specialised in these fields and whilst they may have an understanding of how their projects fit within their particular departments, it is less likely that they will have an overall understanding of how their projects align with other projects from different parts of the organisation or the overall natural resource management field. It is also challenging for these project officers to understand and evaluate the net efforts from the range of projects undertaken by such organisations.

In more specific terms, the collection, storage and analysis of data is a time consumptive task whether project officers have knowledge of the subject matter or not. Often only trends which have been analysed in the past or where data is easily accessible, usually from only one or two data sets, are used. Questions, such as, "Where in the Catchment have fish biomass and abundances been stable with salinities above 5,000 μS/cm on average during the past two years?", become too complex a task for quick analysis, as they require not only multiple data sets, but also the geographic relationship between them. While questions like those above are traditionally time consuming tasks, the ability to take this data and compare it with management activities such as the kilometres of riparian fencing established in the past year add a completely new dimension to an already complex query.

In addition to these issues, employment expectations in Australia are slowly changing. Australian Bureau of Statistics figures show that in 2006, 11.6% of the Australian workforce had changed their job in the last 12 months, with 33% aged between 20 and 34 (ABS, 2006). Such a high staff turnover means when a project officer leaves, 'knowledge' leaves with them. With such figures indicating that high staff turnover is now a

national trend rather than a symptom of an individual organisation's ability to satisfy and retain its employees, retaining knowledge learnt collectively by project officers in a whole of organisation accessible environment is critical to Wimmera CMA's future.

To address the above issues while not increasing data management resource requirements, Wimmera CMA set about creating a database that could store, link and retrieve a wide range of river health information and present the results of management queries in words, numbers, images, maps, and graphs. Wimmera EcoGeoGraphica or WEGG is the result.

Knowledge, managing change

The management of knowledge is paramount to future success in an industry such as natural resource management. Whilst a wide breadth of knowledge exists at all sorts of levels, it is usually housed in a range of differing locations and formats, by a variety of people, who are not aware of the value their individual information presents when used in conjunction with that of others'.

Although a large degree of information already exists, the industry is still relatively new, therefore the level of discovery is high. Information often exists at a range of differing levels, continually being built upon through a variety of projects, processes and time.

Catchment Management Authorities in Victoria and throughout Australia are charged with achieving sustaining and improving catchments for future generations. One of the greatest challenges is to be able to monitor and assess programs and projects which are designed to improve long-term health of a system. The indicators which are used to initiate these programs/projects may only show a response over long periods of time and therefore while they need to be monitored it is assumed that there will be no significant changes. Programs/projects usually have sub-indicators which are indicators that will show a general trend in improvement if the program/project is successful. It is therefore important to monitor these indicators and sub-indicators concurrently to gauge a program's/project's success (DNRE, 2002).

Catchment health indicators

Victoria has performed monitoring under the Index of Stream Condition (ISC) framework on a 5 yearly cycle in both 1999 and 2004 in an attempt to ascertain the condition of catchments. This broad level monitoring gives an indication of the health of the streams within the river basins of Victoria and is proposed as a long-term monitoring initiative. What the ISC does not do however, is link the on-ground works that have occurred within the catchment to potentially alter the stream condition between monitoring events.

ISC has been a success in developing a statewide framework for monitoring stream health, its main limitation is that it is based around a 5 yearly monitoring framework. Managers of the catchments, waterways and landscapes, need more accurate and timely knowledge to assess catchment improvement performance. With funding cycles rotating on a revolving yearly cycle, the need to assess the effectiveness of individual projects is paramount. WEGG allows the management of data such that the development of indicators may function on a more frequent time scale utilising a variety of captured data.

Monitoring is a time consuming and costly endeavour which requires constant management to maintain useful and accurate data and, with time, datasets. Significant time is spent searching through old datasets for information required for projects without any certainty of how accurate the information is. Often the same information is searched for at a later time for another program, effectively doubling time resource expenditure. By putting data into one collective database the searching for data becomes a simpler process. This collective database then enables managers to take new management techniques or practices and apply them to old data. An example of a new view placed upon old data is Riparian vegetation and fencing information. Traditionally, the fenced kilometres and trees planted were all that was collected. With a little more effort, the protected streamside area, riparian zone as well as the area of specific ecological vegetation class' protected can be collected and ultimately utilised as measures for the assessment of change.

The Department of Sustainability and Environment (DSE) in Victoria holds a vast amount of water data in the Victorian Water Resources Data Warehouse (www.vicwaterdata.net). The warehouse currently holds a vast array of information relating to streamflow and water quality as well as a limited amount of groundwater information. The warehouse doesn't have the ability to store additional catchment information which is

specifically related to resource managers active work programs such as erosion works on waterways or individual research around specific areas of our catchments. Regionalising the data collected is an essential framework for focusing attention, summarising patterns, aggregating information, and developing indicators, as well as allocating priorities and resources (Thackway & Cresswell, 1995).

To ensure positive progress is achieved we should stop re-inventing the wheel with projects by continually doing literature reviews just to bring ourselves up to speed. We need to move forward whilst keeping an eye on the past, our successes and our failures. This can only be achieved through a strong understanding of previous catchment achievements, either those relating to monitoring, research or works undertaken.

Taking the next step

Realising the need for strategic data management, the Wimmera CMA indicated the development of a database which would solve its data management dilemma. The basic specifications of this database dictated that it needed to be able to hold and report on the following:

- Physical chemistry;
- Macroinvertebrate communities;
- Streamflow;
- Site photographs;
- Spatial information; and
- Waterwatch and Saltwatch data.

This initial step in the databases development was a relatively simple task as data can be input using specific identifiers for datasets and a date/time stamp. The true managing power of the new database was the development of linking different datasets to similar subjects while retaining their original form, and to use these links to report data at a variety of levels so as to allow for comparison. at a variety of management levels.

Strategic catchment management and site specific information

It is important that all data that is collected retains its original integrity. WEGG allows for this by having a series of layers where data can be stored (These layers are classified as themes, sub-themes, subjects and instances). The data requester can then determine what themes they require and the tiered information required below.

This tiered system allows for specific data to be stored whilst retaining its integrity and giving the user of the information, the ability to use the same information at a broader level. A simplistic example of how this system works is looking at an individual data set which is used by multiple users. Figure 1 shows the data supplied at one site, while Table 1 illustrates the level of detail that four different users may require from the same data.

CATCHMENT (Theme)
→ River (Sub-Theme)
→ Site (Subject)
→ Parameter - Fish, Salinity, Dissolved Oxygen (DO), Riparian Vegetation, Photo

Figure 1. Tiered level for information gained at one site

Table 1. Type of user and what level of detail they require

Level of Data	Strategic Manager	Public	Scientist/Consultant	Resource Manager
Catchment	√			
River		√		√
Site				√
Fish			√	√
Salinity		√	√	√
Dissolved Oxygen			√	
Riparian Vegetation				√
Photo		√		√

For example:

- The **Strategic Manager** may only be interested in the overall trends of the catchment. At this levels catchment scale conditions or change is required to secure funding or to prioritise overall outcomes for the organisation.
- The **Public** covers a broad level of interest in data. Some may be interested in the general health of a river they live by, others may be interested in the specific salinity level at certain pool which they are swimming in or pumping water from.
- The **Scientist/Consultant** may be undertaking a review of fish populations and size distribution in relationship with Dissolved Oxygen and Salinity. This review means that the Scientist requires accurate and in-depth data at specific sites to produce reports with a high confidence level.
- The **Resource Manager** while usually having knowledge of certain environmental components is required to be a generalist in terms of natural resource management. The need to understand a variety of information quickly means that the data at a river level would speed up this process. This means that they then can concentrate on the trends at specific sites and react to issues which arise within a short timeframe.

Most monitoring programs are independently operated (i.e. have there own code systems and specified outcomes) and have not been designed with larger scale assessments in mind. However, in this monitoring system each site (subject) can be linked to a river reach (sub-theme) which is linked to a river system (theme). The river reach can also have an association to a Waterway Management Unit (subject) which is linked to the Wimmera Catchment (sub-theme), linked to Catchments (theme) (Figure 1). These associations can be defined by various means, in the case of the above example the river system is geographically enclosed by the management unit. The benefit of these multi-level linkages and associations is a seemingly endless amount of data that can be accessed dependent upon the level of complexity you require.

An example of how the associations are utilised within WEGG is presented in representing the Wimmera CMA's `Wimmera Waterway Health Strategy 2006-2011' (2006), which sets river health targets for the waterways of the Wimmera region. The strategy breaks the catchment into 19 independent waterway management units and within each of these specifies targets for individual river reaches. Each management unit has a number of reaches and a variety of information from monitoring can be derived from WEGG at levels from individual sites, reaches or management unit type scales.

One of the key design features within WEGG is that all data has the potential to be aggregated upwards. If a very specific question was asked of a monitoring program it is more than likely that the dataset for that program is able to be utilised to some degree. An example would be where specific monitoring was being carried out to ascertain the impacts of a specific environmental flow on a fish population. The monitoring program would be designed to answer specifically this question but it could also possibly help to indicate the portion of the overall fish population.

Capacity for the linking of information

Many databases are able to link one data set to another (called an association within WEGG) to show that the two have a relationship with one another. WEGG has taken this one step further in that it allows the relationships to be established both ways. An example is that WEGG can associate a river reach with a management unit. We are then able to associate individual biodiversity monitoring sites to the reach. The platypus and fish of each of the monitoring programs specific sites can then be associated with fauna caught within the entire catchment. The benefit comes with the various questions that could be asked of the information when stored in this manner. We could answer;

- How many platypus were caught in a specific site within the management unit.?
- Were there any fish caught within the specific river reach?
- How many monitoring sites exist within the catchment?
- How many fish monitoring sites exist within the catchment?

and many more without having to know specifics about monitoring projects, catchments, or management units

What makes WEGG somewhat unique is that it can do this on multiple levels and keep these relationships permanently without having to update the links if new information emerges. For example, if a new site was

added to a reach, the links above that reach would automatically be generated for that new site without having to manually create the links for the new site. In addition, WEGG has the capacity to remember these links so that we only need to make the association once and the system updates the associations with each new piece of data that is added. Traditional systems require this updated linking with each new piece of information generated.

Selling the story

Selling the story is just as important as the work around improving the condition of the asset. If you cannot convince those with the dollars that, firstly, there is an issue and secondly, you have the capacity to do something about it, you have no chance of gaining the necessary resources to implement key management actions. WEGG offers Wimmera CMA the ability to quickly supply information about the condition and trend of specific issues through the linking of many individual monitoring programs to create catchment indicators within the catchment at a glance. Through the presentation of such indicators, investors are easily able to then see how the project fits within the larger organisational program and also what effect a specific project may ultimately have on catchment health.

Information quality

A major issue surrounding information management is the ability to quantify data quality. Quantifying the quality of input data is a key to the ultimate performance of both the database and also the organisations ability to make decisions with data of a quality appropriate to the risk of error. It would be irresponsible to commit to a highly technical and expensive project using data collected from school groups; or conversely collecting water quality data with a high sensitivity solely to look at general catchment trends is an over use of scarce resources. Data input mechanisms within WEGG allow for the database administrator to determine each piece of data's quality either individually or collectively. The determination may be made by the standard of measurement adopted, the individual or group collecting the information. If individual pieces of data from a greater collection are considered to be of concern, they can be flagged accordingly. The importance of such an ability is when data is being requested, the user can request a minimum level of data quality for their specific query dependent upon the risk involved in an incorrect determination of their question.

What sort of information can be stored?

The initial design request of WEGG was for it to store an array of environmental data that traditional water monitoring databases could not readily or successfully handle. As the project developed, it was realised that the type of data which could be stored within the newly proposed WEGG database framework was limitless. This effectively meant because of the wide variety that natural resource mangers collect the database framework was limitless. All the main file forms can be stored; photo's, maps, sound files, movie files, documents (reports in any electronic form) and importantly any type of metadata, from salinity results to Index of Stream Condition scores. Anything that is related to the catchment management is able to be stored with the ability to quickly add new fields as the organisation demands. The main benefit being that all of this information can be stored for later recall in areas appropriate to all who may wish to utilise it in the future. The ability to store all this information in the one database, which forms relationships, means the user can quickly interrogate the data. Questions such as; "show me all of the photos relating to this particular reach"; or, "identify all of the sites on River X where water quality was xx in August in 2000-2006", become a quick search function rather than a time consuming search of endless photo subfolders or multiple spreadsheets.

Integrating WEGG in the field (PDA's)

A big development for the gathering of relevant information for the organisation is realising that our project officers have been collecting large amounts of information for long periods without them realising the importance of it for the wider organisation. Project officers have been out inspecting sites for grant applications without providing the information that they have collectively learnt to the greater organisation. Elsewhere in the field, the officers have been learning things like whether a particular reach is protected by fencing, or if there are weeds of significance in the area. They have been acting on it through their own knowledge but as an organisation we haven't really collected this information on a wholesale basis to help with our strategic planning for the future. The relatively cheap nature of portable Personal Digital Assistants (PDA's) with integrated GPS will allow these same field officers to record this information for future uploading to WEGG.

New PDA data collection systems for Asset Health Analysis, Property Enhancement Grants and Environmental Water Reserve Event monitoring have recently been initiated. In addition to the benefits in the provision of information to strategic planning for catchment management, the programs are already showing fantastic savings for field officers in that they are able to spend more time in the field than back in the office entering information into individual databases that are used for funding purposes. Time savings alone are in the order of 75% with officers discovering that they no longer need to spend time in the office inputting information from hardcopy sheets that have been entered in the field. In addition, the PDA's are able to store valuable information that further improves the effectiveness of officers in the field by providing them with information they would generally need to be back in the office for, with items such as appropriate ecological vegetation classing and species planting lists.

Integrating community knowledge

A major plan for the future is the development of smaller and more portable 'sister' type databases that can be given to interested individuals and smaller organisations/clubs within the region for their use. In this way, bird observers, fishing clubs, field naturalists and other such organisations would be given this cut down version of the database (EGG rather than WEGG) for their own use. The idea for the use of such systems will be that the database given to them will work two-fold:

- First, it will provide them with a simple mechanism to keep records of their efforts;
- Second, it will allow for easy uploading of their information into WEGG which in turn will give the authority the opportunity to utilise information from other sources within the catchment as it chooses.

Wimmera CMA can then decide which datasets should be utilised dependent upon the level of risk that may be associated with the decision that they are trying to make.

This second point is one which Wimmera CMA believes will really make the link between what CMA's are supposed to be about (community engagement) and what they are actually doing complete. That is, a CMA is empowered to represent and listen to the community as well as the environment, and by looking at the data of these individuals and organisations collectively along with data it has collected, this sort of planning and assessment may be realised.

The future

Information collected in natural resource management is constantly developing and along with this, the expectation for more considered approaches to management dictate that more and more data is required prior to the making of decisions. A database must be able to keep up with the ever improving ideas and methodologies of resource managers and WEGG is the foundation for such as system.

This database has been designed with an open structure to allow for improvements and 'add-ons' as required without having to redesigned the whole system. The creation and effective use of such a data management system will enable natural resource managers to concentrate on continued management and improvement of our natural environment using new and innovative strategies rather than spending large amounts of time searching for and validating data.

It will help to ensure that projects are not duplicated in subsequent years with the rotation of new staff and that the industry will utilise those findings of the past, wether they be specific to research, on-ground works or monitoring.

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