

# **EDUCATING NATURAL RESOURCE PROFESSIONALS FOR THE 21<sup>ST</sup> CENTURY**

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## **Introduction**

Australia has a long tradition of educating professionals to work in agriculture. Farquhar (1966) in his review of agricultural education in Australia found that Australian courses differed from those overseas in being strongly oriented towards agricultural science, whereas North American courses had a much wider array of electives and prepared graduates for a wider range of functions. Since the Farquhar review in the early sixties, agricultural science courses at major Australian Universities have diversified and now offer a broad range of specialties, but still generally with a strong orientation to science for agriculture.

In the early seventies new natural resource management courses start to emerge, partly as a response to the narrow specialization's of existing agricultural and forestry courses. The new courses, initially at the then Canberra College of Advanced Education, the University of New England and later at Griffith University all sought to develop a broader resource management program. They all had a basis in ecology but with opportunities to include economics of natural resources and to a lesser extent rural sociology and community engagement, the forerunner to the present idea of a triple bottom line. These new programs looked to integrate the various sciences and other disciplines at a landscape scale rather than focus on narrow specialties.

## **The Traditional Agricultural Science Courses**

Agricultural science courses in Australia have been built around understanding the relationships between soil, water, plants and animals. These courses have been built upon what are now called the enabling disciplines of chemistry, physics and some mathematics. They have had elements of economics, rural sociology and even agricultural engineering, this providing a very broad biological education that has enabled graduates to make careers in a wide range of disciplines.

This education has been very successful in developing professionals who are well equipped for research careers in the various disciplines that make up agricultural science. Other graduates from these programs went into regional delivery roles where they delivered the knowledge from the science base to farmers.

The end client in this professional relationship was the individual farmer, and agricultural graduates worked with farmers or with groups of farmers to maximize farm production and profitability. The traditional agricultural science courses have done well for Australia, pushing productive enterprises into many parts of Australia. They have built wealth for some individuals and communities and helped settle the hinterland.

But this education has also failed our country in many ways. We have destroyed the capacity to provide ecosystem services, we have failed to understand the water balance and have induced massive problems of soil erosion, salinity and acidity on our landscape (Anon 2000). Our destruction of vegetation to provide sub-economic farms has been a disaster. Our exploitation and waste of groundwater resources like the Great Artesian Basin has been a disgrace. We have destroyed riparian vegetation and degraded the health of the waterways on which we and our ecosystems depend. We have allowed the engineering profession to dam rivers and apply water in inappropriate ways in inappropriate places, without them having a clue as to what they were doing.

The reductionism that characterizes our applied sciences has caused these problems. We have solved problems at the paddock level, but have created worse ones at the landscape scale. We have failed to integrate our disciplinary knowledge at the appropriate landscape scale (Cullen 1999).

Many academics will argue that our present agricultural and forestry education brings together a variety of sciences and technologies to address the problems of agriculture. While there is a considerable breadth to such education, much of it is poorly integrated, and it is largely at the inappropriate paddock scale.

More of the same is not going to repair this damage. We need a fundamental rethink of our education programs if we are to produce natural resource graduates equipped for the challenges of the 21<sup>st</sup> Century.

In my view agriculture, forestry and the emerging natural resource management are applications of ecology. Ecology is the science of interrelationships in nature. Ecology must not be seen as a catch-cry for anything outdoors, or a marketing label for any field biological study. It is the integrating biological science that works out how the bits come together and interact. It is the integrating science that lets us see the big picture.

## **Challenges of Natural Resource Management**

The Federal State of the Environment Report (2002) documents the failures of much of our present natural resource management. Federal and State Governments have just committed \$1.4 billion of taxpayers money to try and address salinity and water quality issues.

European farming practices replaced the native vegetation with crops and pastures that have shallower roots and different growth patterns. Water is no longer used at the same rate, and the unused portion "leaks" below the root zone where it leads to rising groundwater. Rising water tables mobilise stored salts and bring them towards the surface. It also leads to discharge of saline groundwater to streams. The scale of these regional groundwater systems might range from the paddock to hundreds of kilometres. The time scale over which dryland salinity establishes itself, spreads and has its effects can be long, ranging from tens up to several hundred years, but once established it can be very difficult or impossible to contain or reverse.

Our agricultural activities have caused these problems, and our agricultural science has been ineffective in dealing with them. Effective understanding of salinity requires geo-hydrological skills commonly lacking in agriculture graduates who can deal with land and

water at the paddock rather than the regional scale. Farmer concerns focussed our efforts on living with the symptoms rather than addressing the causes.

The big issues facing natural resource management as we enter the 21<sup>st</sup> century are:

- Inappropriate land use that leads to leakage of water, nutrients and salt, causing massive downstream impacts.
- The need to move farmers from a self image of commodity producers to managers of natural resources.
- Productive primary industries that don't require subsidy by other farmers and the community by tolerating pollution.
- How do we assess and pay for ecosystem services?
- How does society support the ecosystem services they provide? Payments, markets, duty of care or regulation?
- How to allocate water between competing uses and what is the role of the market?
- How to measure the health of landscapes and waterways?
- How do we measure and restore the loss of biodiversity we have caused?
- Ineffective Government structures at State and Federal level that are unable to provide for cost-effective investment in the public good.
- How do technical people develop and deliver the knowledge that is needed to landholders, community groups and the agencies that need it?
- Development of comprehensive environmental management systems that deal with off site impacts as well as food safety.

The pressures on agriculture to be “clean and green” are not only impacting on genetic and chemical inputs to farming, but are requiring closer attention to externalities and the environmental subsidy they represent. Environmental management and quality control systems are starting to address some of these issues at the farm level; some of them have to be addressed at the regional community level if they are to be effective.

### **Getting the Scale Right**

Catchments appear to be the most effective scale in which to consider many of these natural resource management issues. They are certainly more appropriate than the paddock or farm scale. Catchments are appropriate for the water issues, and probably for many of the ecosystem services. They are workable for weeds, less so for disease and feral animals. Biodiversity needs to be addressed at the still larger bio-region scale. It is a difficulty for governments since State and local government boundaries tend to have no heed for catchment boundaries.

Our agricultural training has not equipped graduates with the system thinking skills to address natural resources problems at the appropriate scales. We need to understand the impact of farming systems at the catchment scale. We need to be able to undertake Environmental Impact Assessments of the effects of clearing native vegetation, and of other vegetation changes. What is such clearing doing to regional water balances and to biodiversity. We need to appreciate that the stocking rate we use affects water quality directly, through the retention of sediment and organic matter in longer vegetation. Grazing of riparian strips has serious impacts on the health of rivers, as has the planting of willow trees. Our graduates need to have some of the skills of regional planning and design; we need to equip them with tools and approaches that work at multi-scales.

When we start looking at natural resource management at the catchment scale we start to get a better understanding of the ecosystem services (Costanza *et al* 1997) that we depend upon. The fundamental questions at the catchment and landscape scale include:

- What are the relative rates of soil formation and soil loss for different land uses?
- What is the sediment load we are applying to downstream rivers?
- What is the role of particular vegetation in preventing or slowing soil loss?
- How important is riparian vegetation in protecting stream banks and filtering material entering a stream?
- What are the nutrient stores and sinks in the landscape?
- What is the regional water balance and what might happen if we alter it?
- Are we likely to induce waterlogging, salinity or flooding by our actions?
- Where are the main areas of important biodiversity and how can they be maintained (Morton *et al* 2002)?

I suggest we have rarely asked these questions, because they are meaningless at the paddock or even the farm scale.

Even more difficult are the challenges of time scales. We appreciate the variability of the Australian environment and the need for long runs of data. But we have failed to put in place the long-term monitoring and experimental situations that might have guided us. With the sort of time lags between action and symptoms in salinity of between 30-60 years it is challenging to manage long term data sets.

### **Working with Communities**

It has become apparent that many of the natural resource problems we face are beyond the capacity of individual landholders to manage, and they are beyond the capacity of Governments to do much. Community – Government partnerships are seen as a promising way forward in this impasse, although this approach has some limitations.

Certainly community groups such as landcare have helped communities identify their major problems, and move beyond denial of them. They have provided an excellent learning framework for the communities and have been a vehicle for substantial Government investment through the Natural Heritage Trust. Whether this investment has done much more that inform the community awaits later evaluation, but is now appreciated that the scale and coordination of these efforts were probably inappropriate.

The present Federal investment vehicles, the National Action Plan for Salinity and Water Quality, and the Natural Heritage Trust Mk 2 are based on the assumption that community based catchment planning and delivery is essential (PMSEIC, 1999). The elements of the NAP are as follows:

- Strengthen catchment plans by better technical input
- Ensure catchment plans address national & state interests as well as local concerns through flow, salinity, nutrient and biodiversity targets
- Accreditation of Plans
- Block funding to deliver clear targets & timelines
- Focussed on 21 seriously damaged catchments.

It is clear that funds may be used for a variety of purposes, including the purchase water, retire land or to provide annuities. It will be a challenge for communities to use funds for such purposes.

Natural resource professionals are now having to work with communities to help them understand complex ecological relationships, and to sort out appropriate interventions to manage the landscape. They need skills in education to help these communities develop more appropriate conceptual models of how the landscape actually functions. They need the conflict resolution skills to assist communities debate the upstream-downstream tensions that are inevitable in catchment management. Professionals in the future will need the skills to design landscapes where forestry, agriculture and native vegetation are located in appropriate places within the landscape. These land uses must provide a mosaic that enables the catchment to meet the national targets for the exports of contaminants and the maintenance of biodiversity now being set, as well as maintain an appropriate hydrological balance.

### **Delivering the Knowledge**

I start here with two assumptions.

- People make better investment decisions when they operate in a rich information environment,
- Landholders have a conceptual model of how their landscape functions, and engaging with new knowledge may lead to a richer more comprehensive conceptual model. This is in fact the learning process.

The professional support for agriculture comes from two sources. Agricultural science, operating in its traditional disciplinary silos addresses critical questions and creates new knowledge. The more general professional role of agriculture is the integrating science that operates at the farm and hopefully the landscape scale to integrate the knowledge assets coming from research and synthesize this knowledge in a way that is useful to landholders, government agencies and their advisers.

There are many challenges in getting useful outcomes from our public investment in knowledge generation and in community planning and delivery mechanisms. The technical challenge of assembling and delivering the appropriate technical information in ways that it can be useful for regional communities is one obvious challenge. Do graduates have the skills to synthesize existing knowledge and to communicate it? Do they have capacity to build trust with a cynical and distrustful community? Do they have the skills to work with indigenous communities on these issues?

Delivering knowledge is fundamental to the innovation process. The collapse of the state agency extension networks, and replacement with private providers of knowledge and community facilitators has been a significant change. The widespread assumption that

researchers should do their own technology transfer has been ineffective. They often lack the skills, motivation or opportunities for this task.

The knowledge exchange function is so important to the management of Australia's natural resources that it needs professional attention rather than expecting research scientists to do it as an add on extra. I see knowledge exchange as a two way process where scientists contribute knowledge, but also listen and help draw out the users understanding of the system. The concept of broker is to bring together for mutual advantage, rather than just selling some solution.

In the CRC for Freshwater Ecology there is a team of people called knowledge brokers who have a strong technical base and strong communication skills. They are synthesisers and packagers of knowledge rather than creators of new knowledge. They are motivated by focussing existing knowledge to solve a problem rather than selling their favourite research tool, model or their next set of experiments.

### **Collaborative Science**

Many of the larger problems now facing society, including those in natural resource management are not as amenable to solution through disciplinary research, and require the intellectual contributions of several disciplines if progress is to be made

This new mode of knowledge production builds on the traditional discipline oriented model of research and its normal quality control system of peer review. The emerging model has the following special characteristics (Gibbons *et al* 1994).

- Applied—This new mode of research is driven by the need to find useful answers to complicated 'real' problems.
- Trans-disciplinary—The new model does not depend on various disciplinary specialists working in disciplinary isolation with the occasional interconnection. It relies on frequent interaction and stimulation across the disciplinary boundary.
- Transient—The new model is often transient as teams are developed to address a particular issue and disbanded at the end of the task. It is not organised in the traditional university structure that assumes an ongoing existence.
- Quality control—Traditional peer review is still central to the new model, but quality is also judged through the usefulness of the research findings.
- Leadership—is shared in terms of the substance of the scientific input, with different individuals 'leading' the group at different stages of its development. Process leadership is also valued in its own right, and effective groups do need someone taking the 'facilitation' role.

The power of a simple, diagrammatic conceptual model of the system being investigated must not be underestimated. All researchers have conceptual models, but often do not make them explicit. If these models can be shared and negotiated issues like the meaning of terms, scale, critical drivers and so on are argued and resolved rather than remaining as hidden barriers to communication. This process allows people to challenge their own assumptions and the baggage they bring to any new problems. Robust argument lets people test alternative views, clarify the appropriate scale with which to view the problem and be comfortable in changing their position or assumptions.

The process of developing a conceptual model put the model building at centre stage in the research process. The model becomes a simple statement of the collective understanding of how the system works and is in fact the first stage in articulating hypotheses for later testing. The model is not about putting all possible pathways and interactions into a comprehensive overview; it is a synthesis of views about sub-systems brought to the process by disciplinary specialists. It demands that these views be brought together at a common scale. It is a working model that can be further developed as insights grow through the process. The process makes the participants various assumptions obvious, and allows them to be debated (Cullen *et al* 1999).

The implementation of a new mode for research pushed many researchers outside of the traditional approach to research and often beyond the comfort zones of individuals. Generating conceptual models is time intensive, without there being any guarantee of funding, which challenged the priorities of researchers in a busy and competitive environment. Most researchers found the interactions and knowledge generated were worth the costs. Even so, many involved in the process at times felt alienated, misled, uninformed, or otherwise 'bruised'—as their ideas were scrutinised, their comfort zones stretched and their egos challenged—as the intellectual and interpersonal demands of the process placed pressure upon them. Consequently, efficient, transparent and sympathetic process facilitation was essential.

This new mode of knowledge generation poses some challenges to Universities in teaching people to work across, and to manage the intellectual interfaces that we have previously largely treated as solid walls. The disciplinary structure of the Universities produces isolated specialists who knew almost everything about small bits of the whole system, but have limited capacity to put this jigsaw together. The isolation of the various biological sciences from each other and from the physical sciences meant there is no hope of developing a predictive understanding at the landscape scale.

### **Why is it so?**

If you accept my proposition that agricultural education is no longer meeting our national needs, we need to examine how our planning in Universities has gone so wrong.

McColl, in his 1991 review of agricultural education (Dept of Employment, Education and Training 1991) identified the failures of Universities to plan strategically in this area. While Universities are required now to have mission statements and to have strategic and quality plans, mostly these are done at the broad institutional level and seem to have limited connection as to what happens at the faculty level. McColl suggested some reasons for these failings;

- Diversion of resources to facilitate amalgamation of institutions
- Uncertainty of future institutional structures
- Limited growth in undergraduate numbers
- Age structure and tenure of academic staff making redirection difficult

The one mechanism that is common at the faculty level is the course advisory committee. McColl found these committees to be often dominated by academic staff. He found little evidence of genuine market research or attempts to assess community needs at the broad level.

University staffs spend a lot of time in meetings that purport to be planning. They are generally bounded with a strong assumption that any changes must be done within existing resources. A real decline in available resources, or a wish to market existing courses to a wider range of students often drives them. Much of the planning is at the wrong level within the Institution and does not examine the possibility of redirecting resources to focus on key strengths, despite the widespread rhetoric that this is the strategy.

This behaviour is driven by Government funding formulae for Universities, and the internal budget allocation mechanism that largely mimic that of the Federal Government. Resources flow to where students are enrolled, so its is hardly surprising that Departments will want to badge units in the most attractive ways, and that they would seek to do all the teaching in a program within the Department rather than use service teaching from other departments. Of concern also is the propensity to market a course in some specialised area where little specialised expertise exists but as a vehicle to market existing offerings.

Planning activity in many Universities is based on trying to maintain academic groupings and maximise the groups advantage from the funding formulae within which they operate. There is limited connection in many cases with the professions they purport to serve. Far from providing leadership in the area of agriculture and broader natural resource management, many University Departments are lagging far behind. Far from being leading examples of learning organisations, many Universities seem deeply mired in past decisions with little evident capacity to adapt.

### **The Professions of Agriculture and Natural Resource Management (NRM)**

Agriculture must drive the triple bottom line of rural Australia. Agriculture must contribute to the environmental, economic and social wellbeing of rural landscapes and rural communities. This is essential for the well being of rural Australians, but is also being insisted upon by urban Australians who seek food and fibre from rural Australia, produced in a sustainable manner.

The profession of agriculture must integrate these three elements at the landscape scale. Agricultural professionals need to be able to design rural landscapes that are in long-term hydrologic balance, with exports of soil, nutrients, salt and agricultural chemicals within agreed National targets. This may require a mix of vegetation, including trees, crops and pastures that is consistent with the soil and the landscape capability of particular regions. NRM professionals will be engaged in the setting and monitoring of targets, as well as in designing the rural landscapes that will let them be achieved.

There needs to be markets for the various products so that landholders and the rural communities that depend upon them can live in reasonable economic security. To be able to sell onto the Australian market, farmers will need to be working within an Environmental Management System that assures the agreed targets are being met through best management practice. Governments and communities will need to pay for the environmental services they demand from landholders. Regulators will need to ensure that the wastes from any farm do not destroy the livelihood of downstream farmers or the environment. The consumers should pay the full costs of production, not be subsidized by accepting environmental degradation.

Rural communities will be sustained by Landcare groups and their derivatives that enable communities to develop learning and support structures so they get to understand their environments and the challenges they face, as well as explore possible ways forward in a supportive environment. NRM professionals will be key supporters of such communities, helping frame problems and bringing knowledge to the groups. Townspeople will be welcome members of such groups, building linkages between landholders engaged in various agricultural and NRM activities, and other economic interests including tourism.

Agriculture needs its “general practitioners” who take the emerging knowledge from the various sciences that serve agriculture and integrate it at the paddock, farm and landscape scale to achieve the triple bottom line outcomes we seek. These generalists are more than just extension workers, delivering the new knowledge; they apply that knowledge in the particular context. They will have a broad education in the biological sciences, as well as understanding of soils, water and economics and sociology. They are synthesizers and integrators of knowledge.

Agriculture also needs its specialized research scientists who work in particular disciplines to generate new knowledge in the disciplinary context. Much of this new knowledge is emerging from mainstream science in biotechnology and information technology with agriculture as one of the important applications. The generalist will also help define and frame the problems that need to be addressed within the disciplinary context, as well as be the integrator that helps develop new and improved agricultural systems. Agriculture will also need science from areas that are not so fashionable, and may have to develop those sciences. Soils and pest management are examples of sciences that may need to be tied closely to the profession of agriculture.

## **Summary and Conclusions**

Science produces much of the knowledge that underpins the production we expect from agriculture and the wider ecosystem services we expect from natural resources. The graduates in any profession are critical drivers of the innovation process; they know there are better ways of only we are smart enough to find them.

The world of natural resource management is changing rapidly and those who seek to provide graduates to work in it need to understand these changes and ensure graduates have the appropriate skills. Despite the successes of agricultural science, we have failed our country by failing to consider the impacts of farming activities at the landscape scale.

Agricultural science courses must continue to provide the variety of sciences that underpin agricultural production in a sustainable way. It may be that the natural resource management graduate will be the integrator of this knowledge and the person who delivers it to communities at the farm and the landscape scale. This will need such graduates to have enhanced understanding of both agriculture and forestry if they are to act as landscape scale “general practitioners”.

The three main areas that must be addressed are:

- To ensure graduates have the skills to think and work at the landscape scale and have a strong systems thinking framework.

- To ensure graduates are trained to be synthesisers of knowledge as well as generators of new knowledge, and have the skills to exchange knowledge with a variety of clients.
- To, ensure graduates can work in collaborative teams to address the multi-dimensional problems faced by rural Australia.

## References

Anon (2000). Dryland Salinity, National Land and Water Resources Audit. Canberra.

Australian State of the Environment Committee. 2001. Australia State of the Environment 2001, Independent Report to the Commonwealth Minister for the Environment and Heritage. CSIRO Publishing on behalf of the Department of the Environment and Heritage, Canberra.

Costanza, Robert; d'Arge, Ralph; de Groot, Rudolf; Farber, Stephen; Grasso, Monica; Hannon, Bruce; Limburg, Karin; Naeem, Shahid; O'Neill, Robert V.; Paruelo, Jose; Raskin, Robert G.; Sutton, Paul; van den Belt, Marjan. (1997) The value of the world's ecosystem services and natural capital. *Nature* 387 253-260

Cullen, P. (1999) Water, Politics and Power - Can we Integrate Natural Resource Management in Rural Australia. pp 24-32. in Robertson, A.I. & R.J. Watts (ed) Preserving Rural Landscapes: Issues and Solutions. CSIRO Publ. Melbourne.

Cullen, P W., Norris R. H., Resh V. H., Reynoldson T. B., Rosenberg D., and Barbour M. T. (1999). Collaboration in Scientific Research: A Critical Need for Freshwater Ecology. *Freshwater Biology* 42 131-142.

Dept of Employment, Education and Training. Dept of Primary Industries and Energy (1991) Report of the Review of Agricultural and Related Education. Aust. Government Publishing Service. Canberra.

Farquhar, R.N. (1966) Agricultural Education in Australia. Aust. Council for Educational Research. Melbourne. 322pp.

Gibbons, M., Limoges C., Nowotny H., Schwartzman S., Scott P. and Trow M. (1994) *The New Production of Knowledge*. Sage Publications. London.

Morton, S., Bourne G., Cristofani P., Cullen P., Possingham H. and Young M. (2002) *Sustaining our Natural Resources and Biodiversity*. An independent report to the Prime Minister's Science, Engineering and Innovation Council. CSIRO and Environment Australia. Canberra.

Prime Minister's Science, Engineering and Innovation Council 1999. Dryland salinity and its impact on rural industries and the landscape. Occasional Paper Number 1. Department of Industry, Science and Resources. Canberra.