

Lessons from Interdisciplinary and Policy-oriented Research, and Postgraduate Training, at the Centre for Resource and Environmental Studies, The Australian National University, 1973–2004

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It is often claimed that awareness of natural resources depletion and environmental degradation are recent issues in Australia, and that the now widespread call for integrated knowledge, as part of the solution to these problems, is a recent phenomena. Bonyhady (2000) shows that these concerns date from the earliest years of European occupation. The use of the River Murray water received considerable attention in the debates over the Australian Constitution in the 1890's. The essays in Barrett (1925) evidence sophisticated understanding and policy proposals that are still valid. The forerunner of Kosciuszko National Park was established in 1944 to protect water resources, while measures for catchment management were included in the 1949 and 1957 legislation that created the Snowy Mountains Hydro-Electric Scheme at a time when soil conservation was a matter of active debate (Mobbs and Crabb, 2002). Current debates over the 'new' idea of a duty of care in fact resurrect an older tradition (Bradsen 2000). The modern idea of sustainability, often seen as a product of the 1990s, similarly has deep historical roots, in classical economics and elsewhere, and began to be clearly stated as a policy imperative from the late 1960s and early 1970s. These are but a few examples.

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This paper tracks integrative and policy-oriented research and postgraduate training at a university centre between 1973 and 2004, and is written at a time of ongoing interest and activity, and distils observations and lessons from this of relevance to the rising levels of interest and activity in interdisciplinary R&D.

ORGANISING INTEGRATION: THE ESTABLISHMENT AND MANDATE OF CRES

From the 1970s university undergraduate curricula began to include ‘environmental studies’ and ‘environmental science’, reflecting growing concern in public and policy circles. In 1960 the Liberal Party proposed a Faculty of Agricultural Science Studies at the newly amalgamated Australian National University and Canberra University College. An ANU response appeared in 1967, recommending a Centre (or School) of Natural Resources, and CRES was established in 1973, on the basis of a Statement of Intent prepared by ANU in 1969:

‘The ANU sees a need in Australia to ensure that the natural resources of the country are at the same time husbanded, developed and conserved in the general interest and in a wise and informed way. There is an urgent and continuing need for the conservation and improvement in the quality of existing assets and for their regeneration; for their development, where appropriate, in the national benefit; and an evaluation in economic terms of the renewable resources of the country’ (quoted in Fenner, 1979).

We could do no better in informing a mission statement today. This statement was not a mandate for CRES, but rather a context for its research. Between 1969 and 1982, when a formal mandate was proposed, there is abundant evidence in Fenner (1979) and Harris (1994) for the philosophy that guided CRES’ work:

- development and environment should not be divorced (hence the title CRES);
- CRES should be concerned with policy issues relating to natural resources and environment to a much greater degree than most universities of the time (or even today); and
- because the effective solution of the problems of concern to CRES are complex and involve the relationship between the human and non-human worlds, research should be inter-disciplinary but rooted in strong training and understanding of disciplines

The 1982 mandate codified this evolving philosophy, repeating the emphasis on policy relevance, interdisciplinarity, and the nexus between natural resource use and environmental change. It also observed that:

‘CRES should concentrate on issues which tend to be too broad to be undertaken effectively by specialist sections of the university and which require the range of disciplines which CRES can command. In addition, the research should be excellent, published in both the standard academic mode, and made available to a wider public, focus on the development of concepts and methodologies rather than being based on the collection of primary data, identify key issues and programs of research but also carry out short-term projects as necessary, and staff should pursue the Centre’s programs rather than their individual research interests’.

The mandate did not mention postgraduate students.

The sentiments and prescriptions of the 1982 mandate not only grew from the ideas that set up CRES but also continued in the CRES Mission and Vision statements designed to guide activities from 1999–2004. The ‘hand of continuity’ noted by Mobbs and Crabb (2002) is clearly evident, but only from the 1999 document was training of the next generation explicitly part of the mandate.

The ANU context, and especially that of its research and post-graduate focused and statute-defined Institute of Advanced Studies of which CRES is a part, must be recognised. CRES is a small, interdisciplinary unit (varying between 11–15 core staff over the past decade) within an IAS dominated by much larger and mostly discipline-defined research schools. As the most research intensive university in the country, the focus of activities, and the manner of promotion and selection of staff, is different from some other universities. ‘Research excellence’—in a formal sense and oriented toward the international sphere—dominates, and therefore individual disciplinary standing is emphasised. Risky integrative ventures in new domains where established and (academically) respected literatures do not exist are not always easy in such an environment.

ORGANISATION AND DISCIPLINES

The 1982 mandate, and the first organisational structures of CRES were programmatic, with a strong sense of an internally planned set of activities that could be funded and staffed.² In the early years, three programs were formed: the Resource Program, the Applied Systems Program, and the Human Ecology Program. The 1978 Review of CRES criticized this structure and led to more interaction between the Programs. The Review also urged more short-term projects, which the then Director resisted because of the need, in his view, for research to be carried out ‘...within the framework of logical, connected and systematic programs of research, which are more than mere collections of projects’ (Fenner, 1979).

But the Programs did not survive. Some large projects were established (in the Hunter Valley and East Kimberley, for example) to explore the multifaceted nature of natural resource use and human well-being. Long-term ecosystem monitoring and analysis of dynamics and programmatic work on catchment hydrology and integrated catchment management have developed without formal programmatic structures; although much of the latter work is now institutionalised in iCAM (Integrated Catchment Assessment and Management), a joint arrangement between CRES in the IAS and the Faculty of Science in the Faculties.

2. Noting that the full funding and staffing complement originally planned for CRES has never been achieved.

The Programs were seen as divisive as they created separate groups. Projects are problem (or issue) focussed, and a lot of the current research of CRES is carried out by individuals or small sets of collaborating individuals rather than larger teams. This shift from Programs to projects and individuals is partly the result of Directorial preoccupations, the ever-present pressure to meet disciplinary strictures for professional development, and the growing proportion of CRES' budget that is externally sourced. When a large fraction of funds comes from outside—the figure now hovers around 50%—programs designed from inside are difficult to maintain. Although ongoing research themes can be maintained, such as forest ecosystems dynamics and conservation, spatial and temporal dynamics, environmental history and catchment management to name a few, they are fed by external project-based funds that provide operating money, some student scholarships, post-doctoral fellowships and equipment. Salary costs are mainly funded from the IAS' Block Grant, but discretionary expenditures must be separately sourced. This is the result of a deliberate policy, when faced by tightening budgets, to maintain academic staff positions and thus sufficient disciplinary spread and supervisory capacity rather than provide discretionary budgets for fewer staff.

So that CRES does not degenerate into a mere collection of projects, to echo Fenner (1979), the 1999–2004 Strategic Plan gives heightened emphasis to policy relevance and interdisciplinarity and to the larger sustainability domain rather than only specific environmental issues. The interviews of CRES staff by Mobbs and Crabb (2002) clearly show that policy relevance presents few problems, although connecting research and policy remains a challenge. The injunction to be interdisciplinary does presents challenges to staff and students, despite the long history of rhetoric and actual achievements. The broader focus of sustainability, even as a general domain within which to locate and contextualise more specific research, also remains problematic for some.

Interdisciplinarity is variously seen as unattainable, fashionable and therefore suspect, dangerous given that rewards in academia are tied to disciplines, or straightforward because it flows directly from the nature of the problem or issue being investigated. The idea that the problem sets both the range of disciplines and degree of their integration is attractive to many staff, but this of course can result in staff tackling problems that require few disciplines, based on voluntary behaviour in a world where the disciplines still hold sway and define the incentive structure within which careers are fashioned.

The disciplinary mix in CRES has varied through time with, in the early years, few social scientists other than economists and very few from the humanities. Among the natural sciences, the physical, earth, biological and mathematical sciences have been represented. Psychology, human ecology (possibly an 'interdiscipline'), economics and geography have all found a place.³ Environmental history was practiced until recently by one scholar on a part-time basis, but now also by a historian of science and a geomorphologist interested as much in environmental reconstruction as in environmental history. The recent broadening of the disciplinary base to include the humanities, in the form of history and anthropology, has seen the development of the

3. At the time of writing, the 15 core staff includes individuals with backgrounds in ecology, mathematics, economics, public policy, geomorphology, anthropology, history and hydrology.

‘ecological humanities’ in CRES, which emphasises culture and human values. Finally, policy and institutional analysis by one researcher (with a substantial cohort of PhD students) has had considerable impact inside and outside the Centre.

With few staff and many relevant disciplines, there have always been gaps.⁴ For example, CRES has never included a lawyer on staff, despite the law being key to natural resource and environmental management. While there were times when some missing disciplines would not have been warmly welcomed in CRES, their absence now is simply a reflection of budgetary constraints. In such cases, linkages with other disciplines have been achieved through collaboration with other research organisations and individuals, and such linkages have been common at all stages of CRES’ history.

The number of CRES staff in each discipline has always been small, and in some cases limited to a single individual. This is problematic when postgraduate demand outstrips the supervisory capacity of an individual. It is also a limit because one institutional analyst, for example, cannot either cover the whole field or represent its heterogeneity. It also limits severely the flexibility to respond to pressing policy issues or to take on externally driven commissioned research. Visitors fill some of the gaps but long-term visitors cannot be expected to fully act as staff members and short-term visitors have a tightly prescribed purpose. In times of contraction (eg. the mid-late 1990s), losing or discontinuing one position has often equalled the losing of a disciplinary area.

POSTGRADUATE EDUCATION

Although until recently education and training of students has not been explicitly part of the CRES mandate, a longstanding view in CRES is that universities must be involved in those activities and that students bring a vibrancy and often heterodoxy to a research establishment. They also dramatically expand the amount of research carried out, and have been at the forefront of CRES’ interdisciplinarity.

During CRES’ first decade a coursework Masters was delivered. More recently, a few research Masters students have been educated, but by far the bulk of postgraduates have been PhD candidates, varying in numbers between 9 (in 1987) and 55 (in 2004).

Until 2002 when the IAS was brought into the ARC and DEST funding schemes, there were no financial incentives to ANU for the education of PhD students. CRES nonetheless had a respectable number of PhD students (nearly 40 following a change of Director and thus policy from the late 1980s), although this actually cost the Centre money from its block funding. This supervisory load, although high on IAS standards, was viewed as a worthwhile activity and there was little resistance from staff. However, in 1997 the number was deliberately reduced because of the strain being placed on resources and the lack of internal structures within the ANU to encourage or reward postgraduate training.

4. For a rough iteration of the formal disciplines relevant to informing and/or development policy responses to sustainability, see Dovers (2003).

That situation has now changed, and CRES has again lifted its student numbers. This has not required any great effort, and the demand from highly qualified prospective students still well exceeds both the supervisory resources (some staff actively supervise over ten students) and the availability of suitable scholarships. The ‘average’ CRES PhD student is not the fresh Honours graduate that is the main target of the standard APA scholarship process, but more likely an older individual with professional experience and often an interest in integration.

One of CRES’ chief legacies is its students (Mobbs and Crabb, 2002), most of whom have been actively involved in the intellectual life of the Centre and then have gone on to positions of influence elsewhere. Completion and employment rates are very high, and destinations in government, the private sector and non-University research organisations exceed academic careers for CRES graduates.

On average, about 25% of PhD research projects can be thought of as deeply interdisciplinary in the sense that various disciplinary perspectives are altered during their integration. Another 25% are multidisciplinary, combining differing perspectives such as economics and social network analysis. The remainder are largely disciplinary, some of which make forays into other fields of study to contextualize the research or to gather supplementary techniques or data. This mix varies over time, but is considered appropriate.

Student discussions in recent years have revealed a range of attitudes to interdisciplinary research. Some students have come to CRES deliberately to do interdisciplinary research. Others have been changed by the experience of being at CRES, have adopted a strong policy focus, and are alert to other disciplines to a degree unlikely to be achieved in a disciplinary unit. Others remain within the confines of their discipline and take little notice of the intellectual life of the rest of CRES. A few are threatened by the constant ‘chatter’ about interdisciplinarity and policy orientation.

With the entry of the IAS into the DEST funding schemes, an incentive to enrol more PhD students has driven numbers up to 55 in 2004, aided by an increase in the number of staff able to supervise. The often individualistic nature of research driven by external funding and by the simultaneous desire to maintain both policy focus and interdisciplinarity has been responded to with discussions and workshops to limit the danger of strong individualism, and these forums have provided opportunities for student participation.

Fenner (1979) identified a problem faced by CRES when he observed that co-operative work cannot be forced from above. Discussion and debate therefore must be commonplace so that an ‘air of interdisciplinarity’ is always about, and staff can develop collaborations knowing that their endeavours will be supported. For students whose tenure is only 3–4 years, the slowness of this collegial process can be frustrating. Some see the need for more explicit training in interdisciplinarity and sustainability. Others wish to be left alone.

There is a case for formal training of this kind and for a little more of a 'guiding hand' from above. The danger is that many disciplinary students would not thereby be attracted to CRES and, given the importance of student load and completions to the finances of the Centre, as well as the value of more disciplinary PhDs, this could be disastrous. So the debate is slow and the changes incremental.

Challenges to interdisciplinary postgraduate research can be noted. Finding the appropriate disciplinary as well as interdisciplinary skills for inclusion on supervisory panels can be difficult. This is even more of an issue as the incentive structure created by Commonwealth funding formulas disfavours cooperation across universities and even within them. While in many parts of the university system students attempting interdisciplinary work will lack formal supervision in key relevant areas, and even have only a single, disciplinary supervisor, this is an inadequate situation. ANU students must have a panel of three supervisors, and CRES students commonly have significantly more than this, with co-supervisors or advisers providing support in methods, multiple bodies of theory, or in applications. A continuing challenge is the shortage of appropriate examiners for interdisciplinary theses—some CRES staff are in constant demand as examiners, and in turn there is a limited supply of examiners for our own theses. Many fine disciplinarians, even when only one of three external examiners, can be entirely incapable of comprehending and assessing interdisciplinary work.

STAFF RESPONSIBILITIES

In a place like CRES, there is a responsibility on staff to learn more about other disciplines, comprehend the broader sustainability domain, and to understand the public policy process. A deliberate effort has been taken recently to broaden understanding of disciplines, accepting that interdisciplinarity requires such understanding as well as a problem that needs more than a single discipline. A book is therefore being written largely by CRES staff and students about foundational concepts of many, but not all, relevant disciplines. The chapters have received detailed peer review and have been intensively workshopped by CRES staff and students, and others, to provide both feedback to the authors and a deeper understanding of the disciplines. While not universally acclaimed, this process has helped many look beyond their own horizons. The book is aimed at junior undergraduates and so an educational purpose is envisaged.

The lack of understating among many disciplinarians in CRES (and elsewhere) of the process of public policy formulation may seem paradoxical given the long-standing focus on policy. It seems that many studies in CRES have aided policy formulation without this understanding, especially in soil, catchment, forest and biodiversity management and in the Indigenous domain. But it is likely that greater impact could be had if policy formulation were better understood, a comment that applies to other similar groups in universities and to CSIRO. Currently, there is no explicit process in CRES to bring this about.

Because the academy is seen to have at least in part denied 'the social world' (Bourdieu, 1993), that is, ignored the power relations between academics, politics and funding, and because the social contract between knowledge producers and the state has shifted

toward results that are immediately useful and/or money-making (Nelkin, 1996), CRES is well placed. But this requires that staff and students of CRES take up the challenge of deeper interaction and policy relevance. There is of course a further reason for a continuing evolution of CRES, and that is the increasing seriousness of environmental change and natural resource depletion, along with a growing public demand for solutions.

Academics in Australia, and elsewhere, are under greater scrutiny from many quarters and their autonomy is no longer regarded as a right. Academic freedom is now viewed as an indulgence, even as a political threat, or more modestly as a licence to pursue arcane research at public expense. This has never been CRES' mode, but CRES is caught up in changing societal views of universities. This is the time for CRES to more deeply engage with its mandate and to understand the context of power and opinion that will shape its future.

DOING INTEGRATION: CHOICES

CRES staff and students choose research questions that derive either from the needs of users or from their perceptions of what might be useful. Apart from a small amount of consulting, most of which connects closely with ongoing research themes, research in CRES produces both useful new knowledge and inputs to disciplinary, and interdisciplinary development. This is an astonishing success story, given that the financial pressures over the years could easily have turned CRES into a consultancy firm which just happened to have students. The staff of CRES have always been clear-headed about their major purpose and have thereby kept consulting under control by doing only a limited amount and of an appropriate kind. The neo-liberal and managerialist transformation of (not only) the R&D sector in Australia has created a peculiar environment for the undertaking of independent, policy-oriented and interdisciplinary research, and CRES has been both purposeful and perhaps fortunate in being able to avoid the marketisation of research that is affecting so many research organisations. Policy-oriented research in this environment has the risk of capture within immediate political agendas, whereas more strategic development of interdisciplinary theory and method may have no 'client' in the market place.

A topical example of this dilemma currently is the commercial focus of the CRC system, where public good or exploratory or even strategic research have little place. The standard research funding system of the ARC has never been good at coping with interdisciplinary proposals, and although R&D corporations and other partners are increasingly interested in such work the research funding environment is nonetheless still largely more suited to disciplinary endeavours or to commercially attractive technological development.

The research questions are guided by the purpose of CRES, by policy relevance, by the need to be useful (which is not necessarily the same as policy relevance), and by the likelihood of a substantial academic contribution. Where theoretical developments need to be made—for example in the mathematics of digital elevation models, the parameterisation of hydrologic models or understanding institutional change—they are

made but always within the context of application rather than being driven by curiosity. In highly diverse ways, CRES has always been empirical or realist rather than primarily theoretical.

ORGANISATION REVISITED

We have already described the modes of integration that have existed in CRES: the individual as an interdisciplinarian, small groups some of which in the early years were formalized, ongoing themes, project teams that dispersed when the task was finished, and in one instance the whole of CRES engaged in the Hunter Valley project established in 1981. The success of these formal and informal structures varied, as much related to personalities as structures. Individuals can be successful integrators, whether through their own works or by editing collections of essays. The small groups, some formalized, were able to create an identity which has persisted in the case of iCAM. But in a place the size of CRES, formal groups produce divisions, and limit the amount of new collaborations and integrative activities. A hard-learned aversion to unwieldy ‘mega-projects’ that target real or perceived policy fashions runs deep in the Centre, although this approach appears popular elsewhere.

Project teams continue to be a successful model, forming, dispersing and re-forming as research questions—whether these are theoretical, methodological or applied—emerge or as collaborative or funding opportunities arise. The individuals maintain their disciplinary (or in some cases interdisciplinary focus) but learn further integration as they cycle through projects. But to some degree this is an idealized description of what happens. For short-term staff members, the opportunity to collaborate widely or for long is limited. Students work mostly alone for obvious reasons—the PhD is an inevitably individual enterprise. Early career researchers face particular risks in undertaking integrative work when they could consolidate their careers more safely by remaining discipline focused.

The Hunter Project deserves some attention as an example of design from the top. Everyone was to be involved, working as a multidisciplinary team with integration as the eventual goal. The project is not regarded as a successful example of interdisciplinary research (Mobbs and Crabb, 2002), although the approach is perhaps better judged as a product of its time and part of a progression through multi- to inter-disciplinarity. The integration did not work because of differing opinions about preferred frameworks, and because integration was left until late in the project. There were inevitable personality differences, individualism in work done, and no clear way for generalising the integrative method to other places. There was also no committed user to provide an external stimulus. That said, many outcomes were very useful (for an overview, see Jakeman et al 1987).

This is not an uncommon experience. Time is needed to build teams, understand epistemological differences, for leadership to evolve, and to define the research problem. In particular, interdisciplinary interaction must be present from the problem definition and research design phases, not added along the way or at the end.

Other large-scale projects did more. The Hong Kong Project was the first large-scale application of the ideas of human ecology to a whole city (Boyden et al, 1981). It is highly regarded and widely cited, although now people are belatedly reinventing this sort of analysis without reference to what are its still-innovative conceptual foundations. Of a different kind, the Fundamental Questions Program (FQP) (see Boyden et al 1990 for the foundational product) contributed well structured and deeply integrated insight, about people and the biosphere.

So large (by CRES' standards) projects can work, but need at least the following elements:

- One or more integrators who see the project through and provide the central organisational and intellectual basis;
- Solid but flexible management, rather than the laissez faire approach often adopted;
- A 'real' problem that generates excitement and motivates the contributors, ideally involving theoretical, methodological and applied aspects;
- Adequate resources to ensure proper completion;
- Publications that target the interdisciplinary research community to pass on the experiences, the user community, and disciplinary peers so that individual researchers do not become invisible to their major peer group; and
- A physical setting conducive to group work and routine interaction; something that CRES does not have.

The same list applies to smaller projects, although in practice the scale of resources, management and time required may be smaller. One clear insight from the CRES experience is that instant gratification through interdisciplinarity is unlikely, but rather that problem definition, human capacity building and theoretical and methodological development may follow a process of many years before widely appreciated applications appear, although multiple and useful outcomes are produced en route. Over CRES' history, an example is the thread running from early human ecology work through the FQP and other late 1980s to early 1990s work on sustainability to the Ecological Economics Program and subsequent activities, or from earlier water resources and hydrological work to recent developments in integrated assessment. Path dependency matters, and integrative capacity cannot be suddenly invented without precedent or source. That path dependency may run through the one organisation, or through and across many organisations.

FRAMEWORKS

Integration of work done in the original CRES groups (Applied Systems, Natural Resources, and Human Ecology) was expected to be achieved by systems analysis as a shared framework. This strategy had limited success, apparently because of differing opinions of a system perspective and indeed over the utility of such a perspective.

This experience has continued, and can be seen in widely differing approaches to integration in various disciplines and interdisciplinary clusters. As a result, a number of frameworks for interdisciplinary research have been used in CRES:

1. *Systems*—a focus on connectivity between the components of a phenomenon or problem, either qualitatively or quantitatively. This approach is widely used in engineering but has a bad name among many social scientists and humanists because of its connection to cybernetics. This generated debate which is often not about systems analysis but is about its normative form. Systems perspectives to varying degrees underpins a range of recent and current work at CRES.
2. *Human Ecology* deals with the interplay between human social systems and biological systems, especially between resource and energy use, the bioproductivity of ecosystems, and the quality of human life. This can be considered an example of Systems Analysis. The most celebrated example in CRES is the Hong Kong study.
3. *Ecological Economics* takes into account natural systems, human psychology and history, and investigates the interdependence of natural and economic systems. Its proponents identify the lack of consideration of these to be a fatal flaw in neoclassical economics. This area is possibly the largest and most rapidly growing of the explicit ‘interdisciplines’ focusing on sustainability,⁵ but is seen by some economists as a normative pursuit and too ‘green’, particularly as practiced in Australia. CRES had a formal but loose Ecological Economics Program from 1994–2000 (eg. Common 1995; Dovers et al 2003).
4. *Environmental and resource economics* has been pursued at CRES in several phases and is currently a (relatively) major area (eg. Grafton et al 2003). It is focused on resource, environment and sustainability issues, and to some degree on institutions and governance, but is more closely allied to standard neo-classical economics than ecological economics. Nonetheless, theoretical reorientation to account for sustainability within economics is a theme of work at CRES (eg. Pezzey and Toman 2002).
5. *Environmental history* explores the various ways in which people and the non-human world have interacted and related through time. As practiced in CRES, environmental history contributes to modern priorities of natural resource and environmental management (eg. Dovers 2000; Robin 2001). It has done so to explain better how current situations have occurred, how particular policies came about and which ones worked, and why some current changes in the landscape cannot be causally related only to recent changes because they have origins decades ago. A growing interest in this field, and now the subject of research in CRES, is the idea of tracking policy learning among policy makers, researchers and communities.
6. *Policy and institutional analysis* has provided a vehicle for engaging different disciplines required to explain or develop elements of a particular policy problem. More significantly, this framework has allowed the exploration of the underlying attributes of policy and institutional problems in sustainability (Dovers, 2001; Connor and Dovers 2004), including temporal and spatial scales, pervasive uncertainty, systemic causes, property rights and responsibilities, and lack of

5. For a discussion of a number of interdisciplines, see Barnett et al (2003)

defined policy. This framework has also been used to examine the link between knowledge and policy, and when combined with environmental history, focuses on policy learning and adaptive behaviour.

7. *Integrated water resources assessment and management.* Integrated assessment attempts to integrate ecological, social and economic phenomena within a flexible modelling framework that can both qualitative and quantitative insights and data. By modelling, this approach provides outputs of the ‘what if’ kind; that is, if a dam is built on a river what are the likely outcomes ecologically, socially and economically (Jakeman and Letcher, 2003; see also White et al 2003). More recently, empirical approaches using the techniques of earth science, isotope analysis and environmental history have added to the dimensions of catchment assessment and management (Wasson, 2002).
8. *Spatio-temporal analysis* of natural systems is mostly directed to understanding the non-human world, however the spatial and temporal fit between these and human decisions and institutions are a small but important part of CRES’ activities. The mathematical and statistical innovations of this framework have drawn international acclaim, especially in the construction of digital elevation models and the space-time variability of climate (Houser et al 2004). Links to global models of climate and therefore ‘predictions’ of climate change have been made, along with analyses of agricultural planning, biodiversity assessment, and integrated catchment modelling. This framework has seen substantial theoretical, methodological and applied developments, demonstrating that contributions to a broad range of knowledge are possible in a place such as CRES which has an applied and policy focus.
9. *Landscape ecology* is a prominent and highly productive domain at CRES, expanding the ‘plot’ and ‘species’ focus of much ecology and conservation biology to include multiple species and habitats, climate and landscape-scale processes (eg. Lindenmayer and Franklin 2002). This has also provided an enhanced biophysical perspective from which to incorporate policy, institutional and participatory dimensions into biodiversity research.
10. *Ecological Humanities.* This is the most recent framework to be added to CRES’ repertoire, and has its roots in environmental philosophy, anthropology and history. It focuses on the cultural dimension of behaviour and decision making, and has a strong cross-cultural component that explores the differing world views of indigenous and non-indigenous Australians, and other cultures.⁶ The opportunity provided by this framework to draw into it a larger number of humanists are exciting, and substantial progress has been made. But the humanities are notoriously immune from considerations of the natural world, with some notable exceptions.

It is the experience with so many and varied—and valid—integrative frameworks that continues to both inform ongoing development of these frameworks themselves, but also the exploration of the more systemic difficulties in interdisciplinary integration. It is highly unlikely that there will never be a ‘science of sustainability’, despite the

6. This new area will be developed and communicated from 2004 in part through the e-journal Australian Humanities Review, see www.lib.latrobe.edu.au/AHR.

hubristic claims or intent of some research groups, and although significant advances have been made in many areas, the distances between disciplines (and other knowledge systems) often remain significant. This is not simply an issue for research providers like CRES, but for relevant research funding bodies as well. Land & Water Australia has been far more proactive in defining and supporting integrative research than other bodies in Australia, and individuals at CRES have been closely involved with the development of LWA's Social and Institutional Research Program, and with the present LWA integration initiative (Mobbs and Dovers 1999; Dovers and Roughley 1999; Dovers 2002).

The present project of developing a book that explains to students the different disciplinary perspectives on the environment is one ongoing activity. Another is deeper exploration of interdisciplinarity around key attributes of sustainability problems, for example scale (Dovers 2004). Other key attributes, of which disciplines have fundamentally different constructions, are emerging foci at the Centre, for example uncertainty.

CLOSING COMMENT

These emerging areas represent what might be seen as a new phase in developing the art and craft of interdisciplinarity. After decades of general theoretical and practical 'experiments' in interdisciplinarity, it is now time to be clearer about what the term means, and to delve deeper into what the fundamental differences between disciplines really are, how they matter to gaining purchase on sustainability problems, and how we can connect if not reconcile them. Doing that is crucially important, but at the same time CRES (and other research units) needs to maintain disciplinary excellence and productivity, earn external research income, nurture its human resources, attract and professionally train a large number of postgraduates, and usefully engage with the policy community.

On its own, with current resources and with existing linkages, CRES can progress all these tasks to some degree, but the interdisciplinary and integrative imperative would be better served by a larger and more cohesive effort involving many groups and centres towards a more evolved theory and practice of integrative R&D. In particular, better communication between separate interdisciplinary groups and between the emerging range of 'interdisciplines' (eg. environmental history, integrated assessment, ecological economics, ecological humanities) is needed, lest these ironically become silos. Such collaboration in a long term and uncertain R&D domain is not encouraged by the imperatives and incentives of the modern competitive research environment, but if this LWA symposium and what results from it help even only a little, then it will have been very worthwhile.

REFERENCES

- Barrett, J. (ed). (1925). Save Australia: A Plea for the Right Use of Our Flora and Fauna. Macmillan, Melbourne.
- Barnett, J., Ellemor, H. and Dovers, S. (2003). Interdisciplinarity and sustainability. In: Dovers et al, New Dimension in Ecological Economics.
- Bonyhady, T. (2000). The Colonial Earth. Melbourne: Meigunyah Press.
- Bourdieu, P (1993) The Field of Cultural Production. Columbia University Press New York.
- Boyden, S., Dovers, R.R., Shirlow, M. (1990). Our Biosphere Under Threat: ecological realities and Australia's opportunities. Oxford Univ Press, Melbourne.
- Boyden, S., Millar, S., Newcombe, K.J. and O'Neill, B. (1981). The Ecology of a City and its People: the case of Hong Kong. ANU Press, Canberra.
- Bradsen, J. Soil conservation: history, law and learning. In: Dovers, S. (ed). Environmental History and Policy: Still Settling Australia. Oxford Univ Press, Melbourne.
- Common, M. (1995). Sustainability and policy: limits to economics. Melbourne, Cambridge Univ Press.
- Connor, R. and Dovers, S. (2004). Institutional Change for Sustainable Development. Edward Elgar, Cheltenham.
- Dovers, S.R. (2001). Institutions for Sustainability. Tela Series, Issue 7. Australian Conservation Foundation, Melbourne.
- Dovers, S. (2002). The integration imperative in natural resource management: issues and options for Land & Water Australia. Unpublished scoping paper, CRES, ANU, Canberra.
- Dovers, S. (2004). Embedded scale: interdisciplinary and institutional issues. Epistemology and Scale, Millennium Ecosystem Assessment Conference, Alexandria, 17–20 March.
- Dovers, S. and Roughley, A. (1999). Development of a prospectus for an R&D program on social and institutional arrangements in natural resource management. Report to Land & Water Resources R&D Corporation, CRES, ANU, Canberra.
- Dovers, S., Stern, D. and Young, M. (2003). New Dimensions in Ecological Economics: Integrated Approaches to People and Nature. Edward Elgar, Cheltenham.
- Fenner, F. (1979). The Centre for Resource and Environmental Studies: 1973–1979: a personal assessment of its history, objectives and accomplishment. CRES, Canberra.
- Grafton, R.Q., Adamowicz, W., Dupont, D., Nelson, H., Hill, R.J. and Renzetti, S. (2003). The Economics of the Environment and Natural Resources. Blackwell, Oxford.
- Harris, S. (1994). Social Science and Environmental Studies. Unpublished paper given at Celebrations marking the 21st birthday of CRES.
- Houser, P., Hutchinson, M.F., Viterbo, P., Douville, H.J. and Running, S.W. (2004). Terrestrial data assimilation. In: Kabat, P. et al. (eds). Vegetation, Water, Humans and the Climate: a New Perspective on an Interactive System. Springer-Verlag, New York.
- Jakeman, A.J., Parker, P.K., Formby, J. and Day, D.G. (1987). Resource Development and Environmental Issues: Opportunities and Constraints in the Hunter Region. Canberra, CRES.

- Jakeman, A.J. and Letcher, R.A. (2003). Integrated assessment and modelling: features, principles and examples for catchment management. Environmental Modelling and Software. 18: 491–51.
- Lindenmayer, D.B. and Franklin, J.F. (2002). Conserving Forest Biodiversity: a Comprehensive Multiscaled Approach. Island Press, Washington.
- Mobbs, C. and Crabb, P. (2002). Building Strengths in Interdisciplinary Research on Resource and Environmental Issues: An Appraisal of CRES Experience 1973–2000. Unpublished paper available at www.cres.anu.edu.au.
- Mobbs, C. and Dovers, M. (eds). (1999). Social, economic, legal, policy and institutional R&D for natural resource management: issues and directions for LWRDC. Occasional paper 01/99. Land and Water Resources Research and Development Corporation, Canberra.
- Nelkin, D. (1996). The science wars: responses to a marriage failed. Social Text, 46–47:93–100.
- Pezzey, J.C.V. and Toman, M.A. (2002). Progress and problems in the economics of sustainability. In: Tietenberg, T. and Folmer, H. (eds). International Yearbook of Environmental and Resource Economics 2003/3. Edward Elgar, Cheltenham.
- Robin, L. (2001). Birds and environmental management in Australia, 1901–2001. Australian Journal of Environmental Management. 8: 105–113.
- Wasson, R.J. (2002) What approach to the modelling of catchment scale erosion and sediment transport should be adopted. In: W. Summer and D.E. Walling (eds.) Modelling erosion, sediment transport and sediment yield. UNESCO Technical Documents in Hydrology No. 60 pp. 1–11, UNESCO, Paris.
- White, I., Falkland, A., Perez, P., Dray, A., Jones, P., Metutera, T., and Metai, E. (2003). An integrated approach to groundwater management and conflict reduction in low coral islands. In: Proceedings of the 1st International conference on hydrology and Water Resources in Asia Pacific Region, APHW2003, Kyoto Japan, 13–15 March 2003. K. Takara and T. Kojima (Eds). pp 503–508. The Asian Pacific Association of Hydrology and Water Resources, Tokyo Japan.