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Insights and Applications

A Critical Evaluation of Interventions to Progress Transdisciplinary Research

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Transdisciplinary research is widely being promoted for its potential to effectively address complex issues, such as ecosystem management in a changing climate. Working across disciplines and with broader society can benefit greatly from continuous evaluation to improve transdisciplinary practices. However, methods for such continuous self-reflection are scarce, with little evidence of the application of social science concepts, theory, or methods. This article presents a case study of how researchers from different disciplinary backgrounds have familiarized themselves with the key social science concepts of “structure” and “agency” to reflect on the integrative research efforts of a research center in southwestern Australia. They identified influential “structures” as the geographical separation of the center’s research groups, contrasting research cultures, and little previous engagement with the social sciences. Evidence of “agency” comprised various interventions to promote collaboration. Intriguingly, these interventions rendered some challenging paradoxes.

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The complexity and uncertainty characterizing environmental issues such as climate change require the use of integrative research. This is hardly a new message—the need for integration is widely acknowledged and proclaimed. Integrative research includes the involvement of various academic disciplines, policy and society in defining research problems, participation in the research activities, and collaborative monitoring and evaluation. These joint, so-called “transdisciplinary” activities are noted as critical (Bhaskar et al. 2010; Reyers et al. 2010). Various efforts have been made to provide conceptual frameworks, handbooks or recommendations, and evaluation methods (Pohl 2005; Tress et al. 2007; Hirsch Hadorn et al. 2008; Roux et al. 2010). The question is, why is it still so hard to achieve integration? Clearly there are still significant theoretical and practical problems that need to be overcome.

Where does one start this task of integration in the context of a newly established research center of multiple but chiefly natural science disciplines, a center with as its mandate to explore problems of forest health in a changing climate, and in a political and policy environment in which, for the majority, this issue was not a priority? In this article we concentrate on how we addressed a key component of integration, namely, the collaboration between academic disciplines that is needed to resolve forest health issues in the context of climate change. We are cognizant that this is only one component in a much broader process of integration, and as such we also highlight the potentially paradoxical consequences of our findings for the broader task of linking up natural resources science with society.

The purpose of this article is thus a critical self-evaluation, both for ourselves and for the many others involved in researching and managing complex, wicked environmental problems where transdisciplinary research can provide essential insights and potential solutions.

Peer-reviewed publications based on critical self-reflections made during the process of working toward an integrated mode are rare, particularly in situations where the conditions for starting collaborative research were far from ideal. Therefore, these self-reflections, as well as the framework we used to reflect, are the subject of this article.

Interdisciplinary research goes further than multidisciplinary research, with cooperation leading to the formulation of common methods and theory. Transdisciplinary research, likewise, cuts across disciplines, and also involves nonacademics (Max-Neef 2005; Tress et al. 2005; Petts et al. 2008; Hirsch Hadorn et al. 2008; Castán Broto et al. 2009). It requires interactions between science, policy, and society that are transparent, acknowledge complexity, appreciate different types of knowledge, and achieve integration as a precondition for solving real-life problems (Rydin 2007; Roux et al. 2010).

Importantly, our research center would not have existed without the pressure that members of the public put on politicians to act to prevent tree decline. It is because of this history that we wanted to learn more as a group about transdisciplinarity. We wanted to go beyond giving public presentations about ecological restoration and providing mere ad hoc responses to questions from a concerned public. We also realized that collaboration between natural and social scientists

was a necessary condition for achieving a greater integration and for interacting effectively with interested stakeholders.

Some authors attribute the difficulties of disciplinary cooperation to diverse quality criteria, which require different methodologies that cannot be easily integrated (Evely et al. 2010). Engaging the social sciences and understanding the social context of implementation, such as the social and political values and the complex normative process of laws, policies, and planning, have been pinpointed as particularly relevant but undervalued as a condition for the production of socially relevant outcomes (Reyers et al. 2010).

Although much of this article is about collaboration between academic disciplines, because this is what we focused attention on to begin with, we simultaneously considered how the kinds of collaboration that proved effective in the academic realm might perform in wider collaborations. We explain in this article how there was not always automatically a positive relationship between more effective “internal collaboration” and a broader collaboration with other relevant stakeholders.

The self-critical insights reported in this article were facilitated by Archer’s (1995, 2010) sociological concept of the *morphogenetic sequence*. Archer’s framework provided a guide for describing, analyzing, and intervening in transdisciplinary research activities and enabled change over time to be analyzed. The term “morphogenesis” comes from developmental biology, referring to the process by which an organism develops its form and structure. The morphogenetic sequence shows how relatively stable, structural factors such as rules (i.e., “structure”) can influence the ability of individuals to intervene and change a situation (i.e., “agency”) (Archer 1995; 2010).

The aim of this article is to critically evaluate which interventions enabled collaboration to progress and what structural elements remained persistent (and unresponsive to integrative research), requiring different interventions. From its initiation, our research center in Australia’s southwest, the State Centre of Excellence for Climate Change, Woodland and Forest Health (CoE) (<http://www.foresthealth.com.au>), had transdisciplinary teamwork as one of its ambitions to address forest degradation in the context of rapid environmental change.

Research Setting and Evaluative Framework

Australia’s southwest is of concern to ecologists, given its global biodiversity hotspot status. Changes in temperature and rainfall and increased frequency and intensity of heat waves and droughts will affect the forests and woodlands of this region directly—altering species interactions, fire regimes, and hydrology (Laurance et al. 2011). In the forests of the southwest, dieback of dominant trees wandoo (*Eucalyptus wandoo*) and tuart (*Eucalyptus gomphocephala*) has received attention from community groups. Indeed, public pressure has put both species on the Western Australia (WA) State Government’s agenda, which subsequently supported formation of two research groups to address the declining health of these species and their associated ecosystems. These groups then morphed into the CoE, formed in 2008, with research funding from the WA government. The CoE has four research programs, focusing on (1) remote sensing and climatology, (2) plant pathology, ecophysiology, entomology, and forestry, (3) ecological restoration and landscape ecology, and (4) policies and action for woodland and forest restoration.

Archer's work (1995; 2010) provided the evaluative framework we applied to the research center's activities. This framework includes:

- a. The *structural conditions* under which a certain activity is undertaken are the rules and resources that constrain or enable social action (Giddens 1984). Rules may be formal and informal. Examples of structure relevant to this study include the disciplinary organization of universities, the standards and norms that define what is scientific rigor, and the related institutionalized reward systems.
- b. *Social interactions* are undertaken in response to these structural conditions with the aim of facilitating change. Social interactions relevant to this study are the interventions implemented to enhance integration.
- c. *Structural elaboration* refers to the changes in structural conditions that may or may not occur as a result of the interplay of social interactions and structural conditions (Archer 1995; 2010).

The three stages of Archer's morphogenetic sequence guided our evaluation and interventions. The first stage involved collecting documents detailing the establishment of the CoE and obtaining oral histories. The second stage involved interventions (Archer's "social interactions") aimed at achieving interaction across disciplines. In the third stage of the research, the authors reflected on any changes in the structural conditions ("structural elaboration") that had occurred through face-to-face meetings and contributions to this article. Introducing Archer's (1995; 2010) sociological concepts at CoE meetings added another language to the largely natural science research vocabulary and methods that had dominated previous meetings and to which most social scientists had adapted (Rodger et al. 2010).

Structural Conditions

After community groups had successfully placed wandoo and tuart decline on the WA State Government agenda in the 1990s, a Tuart Health Research Group was established at Murdoch University in 2003. Also in 2003, the WA Minister for the Environment formed the second research group focused on tree decline—the Wandoo Recovery Group—including researchers and community members. Murdoch University and the University of WA submitted a joint bid for funding for continuation of the research to the WA government in 2005. The final agreement between all parties was signed in 2010.

Four structural elements of the CoE influencing how transdisciplinarity was undertaken by the new center carried over from the preexisting research groups: (1) spatial (and disciplinary) separation of researchers; (2) active community involvement that led to the establishment of the center; (3) absence of social research; and (4) shared natural science research practices and traditions. Two other elements related to the new CoE were also influential—(5) discipline-oriented performance measures and (6) a limited time horizon of funding for the CoE. Identification of these elements was influenced by known barriers to transdisciplinarity from the literature and from discussions among the authors.

1. *Spatial (and disciplinary) separation of researchers.* Before joining forces, the two research groups studied tree decline in different species, with different emphases due to researchers' specialisations and personal preferences, but also due to the different ecologies of tuart and wandoo. Both groups adopted descriptive as well

as experimental approaches, with experiments being more field-based for tuart and more greenhouse-based for wandoo.

Having researchers located at two spatially separated universities and with different research orientations led to various practical problems, such as the extended length of time it took to finalize contracts, resulting in different starting times for research staff and, hence, lost opportunities to jointly formulate the research questions. Also, being on different campuses reduced the likelihood of researchers meeting informally, enabling facilitation of further discussions regarding research questions and joint projects.

2. *Active community involvement in forming the two original research groups.* The two original research groups consisted of policy and community representatives. Both were part of the successful funding bid for the CoE. Once the CoE was formed, a Science and Participants' Committee was established to replicate this strong community engagement, although meeting attendance by community members since the center's inception has been poor.
3. *Absence of social science research from these two groups.* In developing the bid for the CoE, the WA government requested inclusion of social science, a disciplinary area not included in the original research groups or the proposal. Social science was identified as important for "educating the public" and closing the perceived gap between science and action. This "translate and transfer" view of social science in integrative research was an initial structural condition of the CoE.

The idea was that having social scientists undertaking this task would mean the natural scientists could devote their time to their research and writing journal articles, rather than communicating and liaising with other stakeholders, such as managers and policymakers. Early discussions among CoE researchers, however, led to the recognition that there was a specific social science dimension to questions surrounding climate change and forest health, justifying the social sciences as a substantive research enterprise irrespective of needs to "translate" knowledge into practice. Moreover, we noted that social scientists could articulate key differences between conceptual, methodological, and theoretical paradigms upheld in the natural and social sciences, and could initiate interventions such as the ones described in this article.

4. *Predominance of natural science research practices, traditions, and quality criteria.* The two preexisting groups shared similar norms and rules regarding the practice of science. Criteria such as validity, quantifiability, objectivity, reliability, and generalizability were regarded by both groups as important indicators of the quality of their research work. Such criteria may differ from those found in the social sciences, such as credibility, transferability, dependability, and confirmability (Lincoln and Guba 2003). As a structural condition, we identified the juxtaposition of, on the one hand, a frequent focus on contextual factors in the social sciences and, on the other, attempts to rule out contextual factors for the sake of replicability in the natural sciences.
5. *Discipline-oriented performance measures required by the WA government.* The mechanisms for rewarding academic work are still mostly organized along disciplinary lines (Evely et al. 2010), and can be impediments to cross-disciplinary collaboration. For example, one of the outcomes described for the CoE was the technically specific "number of trees planted" and "trees saved" in each year, potentially an easy-to-measure indicator. Specific outcomes or processes depending on the interactions and learning processes were not included as performance measures.

6. *A limited time horizon of funding for the research center.* Research centers, other than the traditional monodisciplinary faculties at universities, are often dependent on external, unstable sources of funding. Although longer term funding is partly dependent on the success of researchers in convincing funding bodies of the societal or environmental relevance of their research work, which might be enhanced by a transdisciplinary approach, there is also an important role of factors that may not be as easily influenced, such as the state of an economy and political interest and will.

The limited time horizon of the funding for this center meant that a relatively large part of the available time was spent on setting up and will probably be spent on winding down. Faced with the temporality of their jobs, some researchers started looking for other jobs when other researchers (having started at a later point in time) were still in the middle of their projects. This made it difficult to continue building trust and relationships, between the researchers and with other stakeholders. From a relatively early moment onward, no clear messages could be given as to the longer term presence of the CoE, which is another important structural condition that shaped the chances of collaborative work in this center.

Social Interaction

The interventions undertaken to address the structural impediments to collaboration included a range of meeting types and approaches, a weblog, joint field trips, joint publications, efforts to collectively select field research sites, and renegotiating the key performance indicators.

A number of meeting opportunities were fostered, including monthly meetings of CoE researchers and bimonthly “inspirational exchanges.” The larger monthly meetings initially focused on administration but were deliberately changed, as an intervention, after 6 months or so to focus more on the substance of the research. For example, 1 year after commencement of the CoE each meeting included at least one researcher talking about his or her forest health research. The inspirational exchanges between CoE researchers assisted mutual understanding across the different paradigmatic and methodological approaches available for researching forest health and climate change (cf. Patterson and Williams 1998). The exchanges comprised individual researchers leading an informal discussion about their research. Strober’s (2006) study of academic seminars as a means of fostering conversations across disciplines influenced the choice of this intervention. As the number attending the inspirational exchanges grew, however, they transformed into lectures, reducing opportunities for informal discussions.

A one-day workshop involving forest managers and CoE scientists was held to identify and develop common research interests and encourage the development of research questions addressing societal problems. A “transdisciplinary day” was held to discuss the principles and possibilities of transdisciplinary research. Interestingly, for much of this day, teams self-selected to work on joint papers. Writing together forced researchers to address paradigmatic differences between disciplines. A weblog (www.blogonforesthealth.com) was established to share research highlights, broader reflections on current political climate change discussions, research plan introductions, and field observations. Writing short postings in accessible language was difficult for the scientist-bloggers, presumably because writing personal reflections was

an unfamiliar communication genre. Gradually more nonscientist involvement seemed to have made it easier for the CoE researchers to blog, although continued encouragement was required.

Joint field trips with a broad range of people created opportunities to discuss research. The occasions when CoE researchers helped each other with fieldwork (e.g., seed collection, checking fauna traps, monitoring seedling performance with volunteers) provided opportunities to question observations, discuss new ideas, and learn about each other's interests and language.

Despite numerous attempts to collectively select a shared set of field sites, this was not achieved. Efforts were made to agree on selection criteria, field trips to potentially suitable sites were made, and remote-sensing data were analyzed to identify suitable sites. Partly, issues of scale hindered these efforts. While ecophysiology's starting point is often the individual tree (in its context), remote sensing begins at the broader, landscape scale. This inability to resolve the scales of research and mutually acceptable field sites soon evolved into a situation where researchers individually selected sites to answer their research questions and address their own requirements.

Structural Elaboration

How did these interventions bring about changes in the initial structural conditions? Importantly, we acknowledge that a great part of the activities focused on collaboration between the disciplines, rather than activities to encourage broader collaboration, which would be a more logical follow-up to the community-based origins of the initial research groups, and a more radical interpretation of our transdisciplinary ambitions. We discuss in the following how we have interpreted the influences of the interventions on the structural conditions and why we focused more on some conditions than others.

1. *Spatial (and organizational) separation.* Although the spatial distance between researchers located at the two universities remained, ways were found to overcome this, for example, by rotating the meeting locations. Joint fieldwork provided ample opportunities for collaboration resulting in joint projects and publications and was one of the strongest influences in changing this structural condition. Fieldwork involving local communities and/or policymakers guided research directions and stimulated collaboration.
2. *Active community involvement in forming the two original research groups.* Most of the people initially involved in the two original research groups have not become more permanent participants in the research process. There is the unanswered question of whether the establishment of the CoE displaced some of the influence held by the two original research groups and their greater level of participation. The one-day workshop engaged managers with the CoE scientists, but broader engagement continued to be an issue for the CoE.

Community involvement was not totally absent, however, with opportunities for public participation pursued at an individual project level. Early interactions between researchers and local communities and/or policymakers, often in relation to a specific problem in a specific place, sometimes provided a platform for the design of a subsequent research project. Nevertheless, this did not translate into community involvement in the center's core activities, for example, in the Science and Participants' Committee.

3. *Absence of social research within the two groups.* The CoE has been dominated by physical and natural scientists (e.g., six of the seven postdoctoral researchers). Meetings have continued to use the language of natural science and have mainly focused on the ecological dimensions of the research, thus doing little to ameliorate this structural condition (Moore et al. 2009). Many of the scientists have, however, developed a clearer understanding of the role of the social sciences and no longer view social scientists primarily as messengers between their objective science and society. Joint field trips and joint papers in particular provided a platform to explicitly address the different paradigms. Through the writing of this article the authors, including ecologists and sociologists, have gained an insight into some key sociological concepts like structure and agency and their interactions, and how these concepts have aided in critically evaluating our own process.
4. *Dominant positivist natural science research practices, traditions, and quality criteria.* The interactions within the CoE did not change the existing quality criteria for research in the different disciplines. Engaging with each other in the ways already described did, however, increase our mutual understanding regarding the differences. This in itself opened doors for collaboration, and although we are still a step away from transdisciplinarity in the sense of joint theory and methodology development with a broader set of stakeholders beyond scientists, we started efforts to formulate joint projects and publish together, which was a quality indicator for all members of the CoE.
5. *Discipline-oriented performance measures required by the WA government.* In terms of the discipline-oriented performance measures negotiations with the WA government were underway at the time of writing. Fixed, quantifiable standards were formulated when the research center was established. We wanted to change these standards to better reflect changing expectations of outcomes as interactions occur, both regarding changed perceptions of what might be desirable in the context of climatic changes and regarding newly agreed outcomes resulting from dialogue between disciplines and with a wider range of stakeholders. It takes time for the different disciplines and communities to understand each other, to get to a point where opportunities for adding value to each others' research focus can be identified, and to develop respect for each other's culture (Pohl 2005). Project objectives and performance measurements should therefore be adjustable as collaboration progresses.
6. *A limited time horizon of funding for the research center.* Although long-term continuity is perhaps the most important condition for the development of transdisciplinary teamwork, this was also the most critically absent factor for our center. This is an ongoing problem for research centers established to tackle complex societal problems where transdisciplinarity may offer the only hope of success. They often emerge from political imperatives, making it challenging to maintain this imperative and with it the associated much-needed funding.

Discussion

Among the identified interventions, joint fieldwork and joint publications and projects were identified as the strongest in overcoming the main barriers to integrative research. An explanation for their effectiveness was that they required the greatest commitment from researchers to move beyond their disciplinary comfort zones.

Having to produce joint outcomes or decisions meant that researchers had to genuinely understand each other. In the case of fieldwork, we could discover and explain how different meanings were given to observations or, for example, why certain sampling and measurement decisions were being made. Through fieldwork, different meanings attached to concrete observations could more easily be shared between researchers and policy or community members.

Pursuing joint publications as a recommendation is more problematic, however, because it is paradoxical on two counts. The first part of the publishing paradox is that making the effort to produce joint publications contributed the most to achieving interdisciplinary aspirations. This is juxtaposed against the academic requirement to publish being thwarted by multi-, inter-, or transdisciplinarity because joint publications take more time and are harder to publish in highly cited (mostly monodisciplinary) journals (Kueffer et al. 2007). Greater acceptance of transdisciplinary papers in journals that traditionally publish single-discipline papers would help break down this barrier. An analysis of the benefits and tensions involved in joint publishing, and also the implications for journals, is an interesting topic for future research.

An important point of attention and contention in relation to this paradox is how the importance of publishing as a structural performance indicator relates to the achievement of practical outcomes. In our center there was often a tension between the aim to “score” in terms of numbers of peer-reviewed publications and time spent on interaction with stakeholders. By targeting publishing as a familiar, and therefore comfortable, path to better interdisciplinary dialogue, outcomes such as activating and facilitating sharing of knowledge with active community members may have obtained relatively less of our attention.

The second part of the publishing paradox is the ideal of transdisciplinary writing and publishing, including both academic and nonacademic (societal) authors. In this CoE the reality was more problematic, proving to be highly context dependent. For example, one of the researchers in our CoE, based on a previous job and good relationships within the Department for Environment and Conservation, published with officials from within that department. In other situations, lengthy approval procedures, especially when a research paper includes points of contention involving a government department, might prove prohibitive for authorship by an employee of that department. For a community member an academic paper might not be an outcome to which they aspire but rather might divert attention from the real outcomes that they expect from a “good” research project or program, such as ecological interventions in a forest in decline.

This vexed question of community involvement in writing was largely resolved in one CoE writing project, which produced a journal paper reflecting on the contribution of intensive fieldwork with volunteers to environmental restoration (Buizer et al. 2012). We organized a discussion session prior to writing the paper, followed by a “book club” session in which we discussed the draft paper and its results. Participants found the text rather “jargony,” a difficult problem to solve because of the language and conceptual reasoning required by the journal. It might be more desirable in these situations to allocate time to jointly formulating a separate outcome to avoid this problem. This is not, however, what academics are expected to do or rewarded for doing.

The other five interventions, which were all characterized by information exchange but did not have concrete products such as field observations or papers, had less clear benefits. They did, however, help to overcome some of the barriers,

or were a vehicle to establish other interventions, such as the transdisciplinary day, which facilitated planning of joint projects. By themselves they did not, however, require the same level of commitment to attempt to understand or even assimilate paradigms alternative to those of the researchers' own disciplines.

Joint fieldwork in particular facilitated establishing connections with communities, which is often considered a key requirement for moving from interdisciplinarity to transdisciplinarity. This highlights another paradox, because an unintended consequence of the establishment of the CoE has been decreased societal involvement. Over time the CoE seems to have displaced the community participation that was an integral part of the initial wandoo and tuart research groups. "Integration" should therefore not be viewed as a holy grail for better cooperation but should be critically evaluated in each context: Our case illustrates how the bringing together of actors and institutions into one center may, in part, lead to segregation, rather than integration.

The managerial standards and language characterizing the governance of many of today's larger research enterprises, such as the CoE, probably made the meetings and activities of this large center less appealing to community members. A focus on fixed targets and other administrative "necessities" such as progress reports were a central feature of these managerial efforts. Changing the discipline-oriented performance measures and developing a new kind of adaptive evaluation and target setting are critical considerations for future transdisciplinary research efforts. Making meetings more substance oriented and focused on adaptive learning may also bring about greater involvement.

The poor attendance by community members at the Science and Participants' Committee seemed to be reproducing Funtowicz and Ravetz's (1993) "science at a distance from society." Joint fieldwork at a project level at specific locations had a strong positive role. It helped with jointly defining problems and moving toward cooperation between disciplines and communities. But other than at the project level, more engagement by community members in setting the direction of research programs and interpreting and using the results remained an unmet challenge.

Climate change research relies on many disciplines and demands democratic participation because it concerns questions about what, where, and how to intervene in people's environments. The analysis provided in this article, using Archer's framework, is highly pertinent to other research programs that similarly must be built on a previous dearth of integrative research, where solutions are required to complex societal problems and require societal judgments as part of their solutions. The framework has practical utility for analysts, particularly when combined with participatory research, and as a means of guiding and subsequently evaluating interventions aimed at enhancing transdisciplinarity. Critical pluralism—adopting an open, questioning attitude to others' theories and methods and just as importantly to our own—is central to the success of these transdisciplinary efforts (Patterson and Williams 1998; Moore et al. 2009). We recommend such analyses, highlighting the ambivalences and potential pitfalls of integration as much as the potential and achieved gains. Mere generic pleas for more integration or more transdisciplinarity may conceal that the road to get there is often a bumpy one.

Directions for the future have also been suggested by this reflection. Most important is making time for researchers from various backgrounds, and for interested policy and community members, to work together in designing, conducting, and analyzing research projects. Joint field trips are an essential ingredient, and joint

publications can help in working together between disciplines. Time spent on the latter, however, must be weighed against other outcomes such as intensified interactions with (policy) communities to genuinely “co-create” and “co-implement” a research program.

Such interactions may not directly produce the outcomes traditionally required by funding bodies and university structures, but might eventually bring about a much more fundamental shift in how public money is spent on research. There might be a greater emphasis on practical outcomes and a reduced emphasis on peer-reviewed publications. Also, as academics, all of us must engage in the often difficult but essential debates about what is knowledge and how to work with, between, and among differing worldviews and methodologies. The findings from this work suggest that the harder the struggle, the greater are the returns.

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