Beyond Reductionism

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This is a book about the work of scientists in the era of the Anthropocene, where human beings appear to have become a driving force in the evolution of the planet. It is a diverse collection of empirical, methodological and theoretical chapters concerned with the practice of interdisciplinary social-ecological systems research. The aim of the contributors is to give the reader an appreciation of the range and complexity of the challenges faced by researchers, research institutions and wider communities trying to make sense of the causes and consequences of the this new era of global environmental change.

The tragedy of the Anthropocene, of the large-scale anthropogenic habitat destruction and planet-wide impacts of anthropogenic climate change, is not that science has failed humanity but rather that it has served humanity all too well, making possible in just a few hundred years volumes and scales of human activity far exceeding anything ever seen before. Coming to terms with that success was the aim of the 1969 Alpbach Symposium, from which this book draws its name, where contributors including Friedrich Hayek and Ludwig von Bertalanffy asked themselves: what theory, practices and standards are required to move beyond reductionism? Like those from 1969, the answers presented in this collection are hugely diverse, ranging from the work of PhD students concerned with research methods and institutional obstacles, to mid-career scholars presenting their innovative 'beyond reductionism' research methods, to emeritus professors looking back over what has been achieved in the past thirty years and suggesting where things might go from here.

This text aims to help a growing community of passionate thinkers and actors better understand themselves and their work.

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Beyond Reductionism

A passion for interdisciplinarity

Edited by Katharine N. Farrell, Tommaso Luzzati and Sybille van den Hove

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This book is dedicated to the memory of Paul Cilliers (1956–2011), who was Professor of Complexity and Philosophy at the University of Stellenbosch in South Africa and founder of its Centre for Studies in Complexity. Without his courage and conviction to think differently about life and his willingness to share this with those around him, this book would never have come to fruition.

Contents

Contributors

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Mario Giampietro holds an ICREA Research Professorship at the Autonomous University of Barcelona (UAB), where he is affiliated with the Institute of Environmental Science and Technology (ICTA) and is one of the founders of the Liphe4 research network. He works on integrated assessment of sustainability. Using concepts derived from complex systems theory (multi-purpose

grammars, impredicative loop analysis, Sudoku effects), he developed an innovative scientific approach to the study of ecological economics – Multi-Scale Integrated Analysis of Societal and Ecosystem Metabolism (MuSIASEM) – that can be used to integrate different, incommensurable narratives, used in different quantitative analyses. His books include *The Biofuel Delusion*, written with Kozo Mayumi, and *Multi-scale Integrated Analysis of Agroecosystems*.

C.S. Holling is an ecologist by training and creator of the ecology-based discourse on resilience, which first led to a revolution within systems ecology in the 1970s and eventually formed the basis for the current discourse on resilience of social-ecological systems. He is Emeritus Professor of Zoology at the University of Florida and the founding editor of the journal *Ecology and Society*, and has served as director of the Institute for Animal Resource Ecology in Vancouver, British Columbia, which he helped to establish, and of the International Institute of Applied Systems Analysis (IIASA) in Vienna. He is the author of several classic systems ecology papers, including 'Functional response of predators to prey density and its role in mimicry and population regulation' and 'Resilience and stability of ecological systems'. His books include the edited collections *Adaptive Environmental Assessment and Management* and *Panarchy*, edited with Lance Gunderson.

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Brian Walker is retired Chief of Australia's CSIRO Wildlife and Ecology department. He is now a Research Fellow in CSIRO with its Sustainable Ecosystems group, has a part-time appointment in the Stockholm Resilience Centre and is Chair of the Resilience Alliance (www.resalliance.org). He was born in Zimbabwe, had his tertiary education in South Africa and Canada, was a Charles Bullard Fellow at Harvard, lectured at the University of Zimbabwe and was Professor of Botany and Director of the Centre for Resource Ecology at the University of Witwatersrand in Johannesburg before moving to Australia in 1985.

Abbreviations

ADHD	attention deficit hyperactivity disorder
BPD	borderline personality disorder
CBA	cost–benefit analysis
CDM	clean development mechanism
CEM	collective ecological management
CPR	common property resource
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
DE	domestic extraction
DSM-V	*Diagnostic and Statistical Manual of Mental Disorders*, Fifth Edition
EFA	energy flow accounting
EPE	ecological political economy
EROI	energy return on energy input
FAO	Food and Agriculture Organization
GDP	gross domestic product
GDR	(former) German Democratic Republic
GIAHS	Globally Important Agriculture Heritage Systems
GM	genetically modified
GMO	genetically modified organism
GRAINN	genomics, robotics, artificial intelligence, nanotechnology and neuroscience
HANPP	human appropriation of net primary production
HDI	Human Development Index
IIASA	International Institute of Applied Systems Analysis
IARE	Institute of Animal Resource Ecology
ICTA	Institut de Ciència i Tecnologia Ambientals (Barcelona)
ILA	impredicative loop analysis
ILO	International Labour Organization
IPCC	Intergovernmental Panel on Climate Change
IRC	institutions-as-rationality-context
ISEE	International Society for Ecological Economics
IT	information technology

IUCN	International Union for Conservation of Nature
LH	left hemisphere (of the brain)
MA	Millennium Ecosystem Assessment
MCE	multi-criteria evaluation
MDGs	Millennium Development Goals
MEFA	material and energy flow accounting
MFA	material flow accounting
MuSIASEM	Multi-Scale Integrated Analysis of Societal and Ecosystem Metabolism
NGO	non-governmental organization
NIA	national income account
NPP	net primary production
OECD	Organisation for Economic Co-operation and Development
PPP	purchasing power parity
PTB	physical trade balance
PTSD	post-traumatic stress disorder
RA	Resilience Alliance
RH	right hemisphere (of the brain)
RMIU	rationality as maximizing individual utility
SES	social-ecological system(s)
SHEE	safety, health, environment, ethics
SRC	Stockholm Resilience Centre
TCE	tonnes of carbon equivalent
TOE	tonnes of oil equivalent
WMD	weapon of mass destruction
WTO	World Trade Organization
WWF	World Wildlife Fund/World Wide Fund for Nature

1 Introduction

Katharine N. Farrell, Tommaso Luzzati and Sybille van den Hove

Introduction

This diverse collection of empirical, methodological and theoretical chapters concerning the practice of interdisciplinary research is intended to give the reader a glimpse at the state of the art and the main challenges facing researchers, research institutions and communities that aspire to carry out and develop non-reductive, interdisciplinary investigations of social ecological systems. The topics addressed within its pages may be assigned labels such as social-ecological systems research, sustainability science or ecological economics – all of which, of course, somehow describe what the contributing authors aim to address, both here and elsewhere in their work. However, as the name of this collection, which we borrow from Koestler and Smythies (1969), would suggest, we prefer to think of this text and its contributions in a broader context, as part of the more general work of discovering what it means to be doing science well in the twenty-first century.

The human innovation 'methodological reductionism', which may be said to have seen its first comprehensive explication in René Descartes' *Discourse on Method* (1978 [1641]) and its early practical application in the factories of eighteenth-century England, has produced astounding changes in the economic productivity and the ecological impact of human societies across the planet over the past 300 years. When taken in historical context, the speed of these transformations is breathtaking: the Palaeolithic period (Early Stone Age) lasted around 1 million years; the Late Stone Age (comprising the Mesolithic and Neolithic periods) lasted several thousand years; while the era of industrialization, which Crutzen and Stoermer (2000) have dubbed the Anthropocene, has so far lasted a few hundred (Gowdy 1994). This magnificent speed of modern technical innovation can be understood as a testament to the powers of methodological reductionism – to the systematic and, to a large extent, successful endeavour to interrogate the physical world, piece by piece, disclosing the secrets of nature (Bacon 1875 [1623]). Ironically, the tragedy of the Anthropocene era is not the failure but rather the success of this reductionism.

Coming to terms with that success was the topic of the Alpbach Symposium, held in 1968, which brought together leading life sciences experts from a range

of different disciplines, including Arthur Koestler, Friedrich Hayek, Victor Frankel, Ludwig van Bertalanffy and many others (Koestler and Smythies 1969). What these men (and they were all men) argued in 1968 was (1) that moving beyond reductionism was necessary in order to describe the special characteristics of complex life related phenomena, and (2) that there were points of connection and overlap between the various life sciences disciplines, which could help to provide a map for how knowledge from these various disciplines could be combined without being reduced. Koestler and Smythies described their objective as 'the emancipation of the life sciences from the mechanistic concepts of nineteenth-century physics, and the resulting crudely reductionist philosophy' (ibid.: 2).

Forty years on, although there remains little argument regarding its merits, moving beyond reductionism still presents great challenges for the scientists, citizens, bureaucrats, technocrats and politicians of the twenty-first century. While we do not imagine that the contributions to this collection should or will single-handedly enable its readers to surmount these in a single leap, it is our hope that they may encourage those who may have become discouraged and inspire those who are wondering what might be waiting to happen.

The field of ecological economics, which can be understood as one of the homes for this collection, now just over twenty years old, has explicitly taken up the challenge of moving beyond reductionism as one of its core methodological tasks, as has been pointed out by in the prefaces by both Robert Costanza and Richard Norgaard, two of its founders, who have kindly offered their reflections on this topic as an overture to the chapters that follow. Operating, as it does, at the interface between the life sciences of ecology and economics, ecological economics is, by definition, concerned with the interplay between complex living systems. It is, by definition, oriented at a point of study that lies beyond reductionism. In this respect, the story of how ecological economic methods have developed over the past twenty years is a central part of the story of how new interdisciplinary scientific methods, ones that lie beyond reductionism, have developed over this period. Telling a part of that story is the basic aim of this book, and in order to do so we have invited contributions from a diverse selection of scholars, ranging from PhD students working to find their footing in the amorphous field of social-ecological/ecological economics research (Barry and Farrell; Santaoja *et al*.), to scholars in the middle of their careers, actively producing these new tools and approaches (Farrell *et al*.; Giampietro *et al*.; Salleh *et al*.; Vatn), to those most senior, who have helped to give this fields it features, who here look back over what has been achieved but also, perhaps more importantly, point out for us their visions of where thing might or should go from here (Martinez-Alier; Ravetz; Clark; Walker and Holling).

Structure of the text

The collection is divided into three parts delimit the main themes of the book: Part I, concerned with the idea of ecological economics; Part II, on life after reductionism; and Part III, titled 'Into the woods'.

Part I, 'The idea of "ecological economics": interdisciplinarity in theory, method and practice', is intended to give the reader a feeling for the general subject of interdisciplinary research concerning social-ecological systems and relationships, and to highlight the challenges that its practitioners can expect to face, and do face, on a daily basis in their work. It begins with a history text by Martinez-Alier that documents a variety of approaches to the study of social metabolism that have been employed by scholars since the start of the industrial era up until today. Farrell *et al*. then continue with the work of documenting the shape of this field or research, but with the explicit aim of developing a tentative ontology of social-ecological systems research, which they then use to explore ways in which it may be possible to standardize the design of interdisciplinary methodologies without reverting to reductionism. Next, Ravetz, again with a historical approach that walks up into the present, considers the predicament of controlling the quality of this type of interdisciplinary research, on the one hand reminds the reader precisely how and why such control is so important and on the other discusses the empirical grounds for imagining that it may be almost impossible to achieve, at least if the social practices of science are not changed substantially. Closing out Part I are the reflections of Clark on the challenges and promise of interdisciplinary studies. Clark wrote her first major work on the topic of developing interdisciplinary research methodologies (1989) in the 1980s, as she was expanding her studies of biology and environment out to incorporate the social complexity of human biology.

Part II, 'Life after reductionism: exemplary ecological economics beyond reductionism, in practice', is intended to provide the reader with a look into the world of applied interdisciplinary ecological economics investigations and analysis. Perhaps the most diverse part of the book, here the authors present concrete examples of how they are reaching beyond reductionism in their works. Starting Part II with a discussion of the practical challenges they encountered when beginning their collaborative work as supervisor and student, Barry and Farrell bring us from the close-up vantage of their personal experiences up and out to a formal political theory discussion concerning how the typical constitution of the modern university serves to inhibit and constrain the development of interdisciplinary work. Next, Salleh *et al*. illustrate, through reference to the development and ongoing contributions of the discourse on ecofeminism, how it is nonetheless possible to establish and conduct a discourse beyond reductionism, in their case focused on the embedded and embodied character of the human condition, within the limitations of modern scholarly inquiry. Closing out Part II, Giampietro *et al*. provide us with an elaboration and justification for a new analytical tool called MuSIASEM (Multi-Scale Integrated Analysis of Societal and Ecosystem Metabolism) that provides non-reductionist sets of indicators for measuring the combined social and environmental well-being of a community, which they have developed building on the work of Nicholas Georgescu-Roegen (1971) and on principles from biology, chemistry and physics.

Part III, 'Into the woods: mapping the challenges and the possibilities for continuing the development of methods that extend beyond reductionism', is

intended to give a hint as to how this field of research might be successfully developed in future. Here Santaoja *et al*., a group of PhD students who have conducted their doctoral studies as part of the social ecological research project GoverNat, document how they overcame the challenges they faced in concretizing their research within an international, interdisciplinary context and provide suggestions and advice to other students who may set out to follow this path. Moving on from the vantage point of the novice to that of emeritus, Walker and Holling, in an elaborated version of the keynote lectures that they gave at the Stockholm Resilience Conference in 2008, draw upon their decades of experience to provide a reflection on what has been accomplished so far and to suggest: (1) research agenda items and key topics that they believe now need to be studied, and (2) strategies for effectively organizing social-ecological systems research teams. Finally, taking up the task of organizing social-ecological systems research teams as an empirical object of study, Vatn closes the collection with an analysis of the institutional context within which this kind of research is carried out today and a series of recommendations, based on institutional theory, regarding how the applied work of interdisciplinary ecological economics could be made more effective.

This text draws together contributions from a huge range of scholars, working in fields stretching from resilience studies to ecofeminism, who are all engaging with the same theme but often coming from quite different directions. This gives the text a distinct voice and perhaps a sometimes jumbled feel. We hope that readers will find the sometimes bumpy ride stimulating and that they will be patient with the authors whose positions seem odd or unfamiliar, looking for the links between the chapters rather than their differences. Reaching back to the general system theory origins, which underlie many of the current ecological economics methods that lie beyond reductionism, this text aims to provide a scholarly, robust but fresh and innovative perspective on this important methodological problem. Theoretical insights and methodological challenges associated with the need to move beyond reductionism are central to ecological economics. However, they are often assumed, as opposed to argued and systematically discussed. By putting these critical issues squarely on the table for discussion, we aim to fill a pressing gap in the literature and to help a growing community of passionate thinkers and actors to better understand themselves and their work.

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Part II

Life after reductionism

Exemplary ecological economics beyond reductionism, in practice






6 Building a career in the epistemological no man's land

John Barry and Katharine N. Farrell

Introduction

At the 2007 Conference of the European Society for Ecological Economics, Professor Malte Faber's keynote speech was entitled 'How to be an ecological economist'. In that lecture (Faber 2008), Professor Faber, himself originally an 'ordinary' economist, reflected upon a career's worth of experiences with the personal and professional challenges that arise as one reaches beyond the reductive boundaries of an individual academic discipline in an effort to conduct ecological economics research. In keeping with the discussion that Faber and others of his and the preceding generation (see also Boulding 1991; Max-Neef 2005; Røpke 1999, 2002, 2004; Walker and Holling, Chapter 10 of this book) have opened up, our aim in this chapter is to explore what is required of both the scholars and the institutions involved in conducting research that is concerned with *interactions between economic and ecological systems* – work that requires one to stand across the two disciplines of ecology and economics, often with very little institutional support underneath.

While our subject is, in principle, a matter of ecological economics methodology, we believe that the challenges associated with building an academic career in ecological economics are also matters relevant for the study of twenty-first-century environmental governance (Barry 2007).[1] This is because we consider accurately perceiving and appropriately responding to ecological economic situations to be central to good environmental governance. That is to say, we see the balancing act required for developing ecological economics scholarly work as having an important place within environmental governance, not only in terms of providing information, interpretations and recommendations but also in terms of the scholars' participation in the collective work of developing expectations and aspirations regarding societies' relations with their environments. On this basis we take up our exploration of scholarly practice in what we call the epistemological and methodological no man's land of interdisciplinary sustainability research. We do so not only as scholars of method or with respect to our personal experiences but also as political scientists.

Although ecological economics is practised within and across a wide variety of institutional settings, we focus here on the setting of university education and

research, in part because it is the setting with which we are most familiar and in part because we see the university system as a trend-setting institution.[2]

We begin by presenting some background on the specific topic of the political theory-oriented ecological economics PhD thesis that we prepared together, as student and supervisor, locating it within the larger domain of ecological economics through Giampietro and Mayumi's discussion of the requisite abilities for ecological economics. On the basis of this discussion we develop some minimum standards that we believe must be met if one aims to conduct the kind of fundamentally integrative ecological economic research and analysis that Max-Neef (2005) has tagged as 'strong interdisciplinarity', where not only data and results but also theory and explanations are built up between the traditional disciplinary domains. On the basis of this discussion we identify two quid pro quos, conditions that needed to be met or confronted if the work was to proceed at all: self-reflection and complex comprehension. In the next two sections we then consider some of the specific challenges that we encountered as we set out to conduct this kind of strongly interdisciplinary (ibid.) work within a traditional university setting. While our account is of our own experiences, we are exploring them here not only from a personal but also from a social science perspective, posing the question: what institutional settings and social practices may be required of universities if they are expected to support this kind of academic work?

Finally, on the basis of both our personal and our professional assessments we develop some practical recommendations regarding how ecological economics education and research might be better supported within university settings.

From our perspective as scholars of political science, working on issues that we classify as ecological political economy (EPE), we discuss and analyse what it means for a political scientist to think and work across disciplinary boundaries within the current globally dominant Western-style university system where the ruling constitutive research, learning and incentive structures (and also significant aspects of the culture of social sciences more generally) largely work against, rather than in support of, interdisciplinary (and multi-authored) research.

While our account may at times seem a little self-indulgent, our aim here is not to present ourselves as woebegone misfits or heroic outsiders. Rather, we wish to present a scholarly argument illustrating that inasmuch as environmental governance requires that the institutions governing human societies need to change, this need does not stop at the doors of the academy. That is to say, we propose that overcoming the substantial institutional and personal challenges that continue to face researchers concerned with ecological economics questions demands not only individual effort and creativity but also collective action and political commitment to institutional and cultural change within the *academy*.

Our focus on the institutional setting of university education and research takes up this domain of study as one among many that together comprise the complex system of global environmental governance. We maintain that, on the one hand, the move beyond reductive disciplinary boundaries is a necessary step that must be taken in order to conduct ecological economics research, while, on

the other hand, existing European-style university structures (which are the globally dominant structures for research organization) present substantial institutional obstacles and methodological challenges to taking this step.

Our argument presumes that social institutions, including the institution of university education and research, are impacted by and impact upon ecological economic situations and dynamics (Norgaard 1988; Özkaynak *et al*. 2002; Farrell 2007) and that the configuration of these institutions may be more or less useful for sustainable development (Dryzek 1987; Dietz *et al*. 2003; Olsson *et al*. 2006; Ostrom 2005; Young 2002; Biermann *et al*. 2007).

We are setting out to contribute to a discourse addressed by several other contributors to this book, concerning the empirical question of how revisions to the institutions of university education and research might contribute not only to the production of better science but also to the execution of better environmental governance. Our arguments are intended to give suggestions regarding what might constitute good environmental governance of university education and research, and they are informed by our experience within and our expert opinions regarding the current structure of this system. We see this work as an active and engaged part of the collective task of developing understanding and taking action to address ecological economic challenges.

Practically speaking, we consider here how scholarly work within university systems might be reorganized to be more useful for addressing ecological economic issues. In doing so, we touch upon issues that are intimately related to questions that are taboo within 'the academy' regarding the relationship between power and knowledge (in a Foucauldian sense) and the sanctity of facts. Here we are speaking not only as scholars but also as workers – as individuals employed within the *academy*. In this respect, in addition to being an assessment of an empirical political science problematique – let us call it the ecological political economy of environmental science – our comments will, from time to time, also take on a more normative, moral and even at times ethical tone.

Contextualizing ecological political economy

Our overall approach to the thesis discussed in this chapter was engagement with the following dilemma: in spite of substantial evidence indicating that there are good reasons to make radical changes in international systems of economic production and consumption, there has been, and there continues to be, a surprising inability exhibited in global human society (as a whole) to develop effective strategies for halting and reversing the recent (meaning during the past 300 years) trend of human-caused, largely economically driven, ecological system destruction. Here we propose that one possible contributing factor may be a lack of sufficient and suitable epistemological (interrogative) and integrative analytical (picture-building) capacity within the international system of university science.

As we began our journey together as student and supervisor, one of the first things we did was to distil the research question of the thesis down to one sentence:

> Having identified the tension between scientific and political understandings of environmental problems to be one of the obstacles facing societies of human beings aspiring to achieve sustainable development, I am working to develop new democratic theory that can help to resolve these tensions, in an effort to support the development of more sustainable human societies.

Although we did not know it at the time, this question struck to the very heart of ecological economics, raising issues regarding how the purpose of economic activity is determined and regarding the epistemology of ecological economics problems and the methodologies used to explore them. The point of departure for our work was puzzlement over the persistent use of monetary proxy values to represent the economic worth of ecological goods and services in economic analysis, despite a general scientific consensus that these values could not possibly be correct (Constanza *et al*. 1997; Norgaard *et al*. 1998; Daly 1998). One of the central tasks of the thesis work was to develop an alternative to the use of monetary valuation in environmental management decision-making. This eventually took the form of new environmental governance political theory, which we see as a contribution to the discourse on EPE (Gale and M'Gonigle 2000), and the groundwork for that new theory was laid by developing a systematic critique of the pragmatic defence of monetary valuation (Farrell 2007, 2009 [2005]). Since almost no one, not even Costanza *et al*. (1997), defends the practice of monetary valuation on purely theoretical grounds, it became clear to us that the persistence of this practice must somehow be related to its defence on pragmatic grounds, wherein it is maintained that monetary valuations of priceless ecosystem goods and services, while technically incorrect, are nonetheless useful:

> The figure [arrived at by Costanza *et al*. 1997] of 33 trillion dollars screams at us to save what natural capital is left. There are evident physical consequences of excessive human expansion that scream the same message without need of explicit valuation. But for those who only hear dollars, let us scream now and then in dollars! It is a crude and inaccurate measure, but I think it is more than just 'a bad underestimate of infinity'. For decision making, valuing natural services at infinity is not a great advance over valuing them at zero.
>
> (Daly 1998: 22–23)

Exploring the respective ecological economics and environmental politics literatures concerning monetary and non-monetary environmental valuation, we developed a heuristic framework for what we came to call ecological political economy (Figure 6.1), which we understand to comprise three inextricable domains of interdependence, all equally fundamental for understanding and articulating the economic worth of ecological phenomena (now commonly referred to as ecosystems services).[3]

In order to develop an EPE critique of the pragmatic defence of monetary valuation, we set out to understand a series of questions situated within several different disciplinary frames. With respect to ecology we asked: what are the most

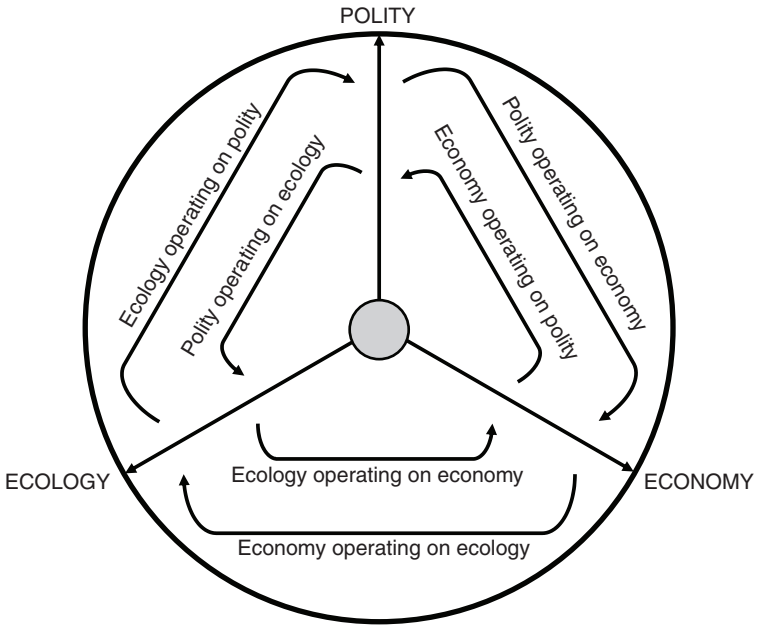

Figure 6.1 An picture of ecological political economy (source: adapted from Farrell 2009 [2005]: 19).

Note
Credit is due here to Juan Sanchez-García, whose informal lecture on the future of ecological economics given during the 2003 Tenerife ESEE conference inspired this visualization.

basic necessary conditions for being alive, working from the basis that construing the economic contribution made by ecosystems cannot be done without construing what and how that contributing is constituted? This led us into study of open systems thermodynamics, General System Theory, systems ecology and biology. With respect to economy, we asked: what is it about estimated, stand-in monetary values that makes them unsuitable as input data for economic analysis and decision-making? This led us into study of basic micro- and macroeconomics, decision theory, impact assessment and post-normal science. And with respect to polity, we set out to understand how and why this pragmatic defence of an obviously incorrect practice continues to enjoy such wide acceptance. This led us into study of political and social theory, cognitive science and anthropology. Finally, as we worked our way through these three questions we found ourselves confronted with a fourth: what role does the perspective of the scientist play in framing these politically influential arguments that are eventually presented as science? For example, the failure of monetary valuation to serve the purpose for which it is intended – to improve the ecological economic quality of environmental policy decision-making – can be understood as a detriment to the common good, because the promised contribution to development of good environmental policy serves a common interest of the entire community of human beings.

Politics and institutions: the fourth requisite ability of ecological economics

Within the broader domain of ecological economics, the research that we carried out can be understood to address what Giampietro and Mayumi have referred to as the fourth requisite ability of ecological economics. Quoting from a flyer announcing the 1987 Barcelona meeting, which was one of the first gatherings of the group of scholars who eventually established the International Society for Ecological Economics (ISEE),[4] Giampietro and Mayumi remind us that the original motivation for establishing this field was fundamentally interdisciplinary: 'Without an ecological foundation, economic policy is blind and unsustainable; without an economic foundation, ecological policy is impractical; that's why the leaders in these fields and many others have joined ISEE' (2001: 2). In an effort to interpret what this means for practice, they propose four requisite 'abilities' necessary for conducting ecological economic inquiry. The first three are as follows:

> [1] [t]he ability to understand and scientifically represent ecological processes…;
> [2] [t]he ability to understand and scientifically represent socioeconomic processes…;
> [3] [t]he ability to integrate the two systems of scientific representations in a way that makes possible to improve both understanding and representing the predicament of sustainability in a holistic way.
>
> (Giampietro and Mayumi 2001: 2)

The fourth is the ability to describe, understand and engage with the processes through which humans *translate* understandings of the predicament of sustainability into collective action.

While command of the first three abilities certainly requires interdisciplinary science, command of the fourth requires an extension of the ecological economic analysis in two new directions: first, into the realm of institutional and constitutional theory; and second, into a reflexive stance where the role of the ecological economic researcher, *within the governance processes that they are themselves describing*, is explicitly problematized. That is to say, we take here the position that political theory-oriented ecological economists (such as we are) must explicitly study and consider both the objective political forums where collective action on ecological economic questions is authorized and the impacts associated with their own place within the wider collective system of ecological economic activities of the societies of which they are part.

In so far as this is the case, new strategies for training and supporting the work of scholars who attempt the interdisciplinary ecological economics balancing act are urgently required, not because any one scholar or specific field of work deserves to be 'taken care of', but on scientific grounds, because it is only through careful attention to phenomena that are balanced between the disciplines

that core objects of ecological economic interest can be observed, described and understood (i.e. known) (Clark 1989; Vatn, Chapter 11 of this book; Faber 2008; Max-Neef 2005).

A fine line between reporting on experience and developing political theory

We are very aware that there is a fine line between presenting a simple account of personal reflections on our shared experiences and a formal attempt to grapple with the theoretical political science and ecological political economy methodology implications that we, as experts, glean from these experiences. However, we believe that the distinction can and should be made when discussing ecological economics methodology, bearing in mind that, regardless of the topic being studied, it is not possible to fully disentangle personal, professional and political perspectives from one another.

We have adopted this reflexive approach because we are interested in better understanding how the configuration of knowledge production institutions within a given society supports (or fails to support) that society's endeavours to describe, understand and engage with the processes through which humans (including ecological economists) translate understanding of the predicament of sustainability into collective action – Giampietro and Mayumi's (2001) fourth requisite ability of ecological economics. Since it is one of the primary knowledge production institutions of global human society, in spite of the fact that it is our place of work, it seems quite obvious to us that the structure of the *academy*, and particularly of the international university system that is its model, must be a focal point of interest for any such inquiry.

Working on this question compels us to reflect upon our own position within the academy, not only on personal and professional basis, as is ordinarily the case, but also on theoretical and methodological grounds. This is because the specific case of 'conditions necessary for conducting robust transdisciplinary ecological economics research' is embedded within the larger set of 'conditions necessary for the humane and ecologically viable operation of the global economic system'.

Complex comprehension of complex problems

Understanding and evaluating any ecological economics problem entails describing, if only at a most basic level, the structure and dynamics of the ecological system(s) within which the relevant economic processes are embedded. It also entails, again, even if only at a most basic level, describing the structure and dynamics of the human system(s) within which these same economic processes are embedded. It is simply not possible to clearly engage a basic ecological economics question through reliance upon any one single disciplinary frame and it is often the case that more than just these two are required. Investigation of such topics requires interdisciplinarity not only with respect to cooperation in analysis

but also with respect to the fundamental conceptualizations of the research (Max-Neef 2005; Faber 2008) and one's intellectual orientation towards the chosen research question or questions.

With its centre of gravity firmly fixed in the domain of interdisciplinarity, ecological economics rests in an epistemological and methodological no man's land. A fortiori, it is impossible for one discipline to provide a 'solution' to an ecological economics problem or question. We would go so far as to suggest that a 'problem–solution' approach is itself deeply problematic when considering ecological economics generally, and certainly with respect to the kinds of ecological political economy questions that concern us here. As Røpke (2002: 11) puts it, the original transdisciplinarity vision for the ecological economics venture calls, at its root, for work that goes 'beyond one discipline just [subsuming] another discipline under its own perspective'.

In this chapter we are working from the basis that the inability of the *academy* to make space for the epistemologically complex work of ecological economics is not merely a parochial concern for affected scientists wishing to secure a comfortable position within the university establishment. Following Clark (Chapter 5 of this book) and Giampietro and Mayumi (2001), we see this also, if not primarily, as a collective social problem, certainly for the global academic community and perhaps even for humanity as a whole, in so far as we accept that it is precisely such epistemologically complex research that is required if scientists are to understand and effectively engage with the most pressing ecological economics problems of the early twenty-first century, creating conditions conducive to conducting that research must be understood as a collective social project. Having navigated our way together through a stretch of this no man's land, we have chosen to approach the topic here by critically reflecting upon our shared experience as student and supervisor. In reviewing how our expectations and practices needed to be revised along the way, we hope to be able to offer some small insights into what is required of the scholars who venture into this new domain and of the academic institutions that constitute their professional work environments.

In our experience, we found that producing an ecological political economy PhD thesis that could still pass muster within the discipline of political theory required a great deal from us both. While determination, camaraderie and creativity helped to compensate for a lack of institutional understanding and support for our approach, we are convinced that the strain on individuals is too great and the chances of success are too slim to leave the future of this type of epistemologically complex research up to the good fortune and personal sacrifice of individual students and supervisors. If this is an area of research that needs to grow (and we believe that it does), then it is an area of research that deserves to have at its disposal the basic institutional supports that are traditionally available for disciplinary research: access to departmental infrastructures; provisions for training and development of students and staff; formal incorporation within university calendars, symposia and research programmes; etc.

Stepping into no man's land

In the preceding section of this chapter we have taken it as given that ecological economics does not fit neatly within the existing university education and research structures. In order to proceed further with our argument, we need to unpack that proposition a bit and consider: what is it that makes ecological economics so hard to map onto any single one of the traditional academic disciplines? Can this be changed? Should this be changed? And what is it about the academy that makes it so hard to fit ecological economics within its structure?

It is not difficult to understand why ecological economics does not neatly slot into the already well-established disciplinary silos of the university. This has to do, inter alia, with the range of issues, including cross-cutting issues such as scale dependency of social and physical dynamics; the great variety of types of investigative data (qualitative and quantitative, generated from within different disciplines, concerning various materials and life forms and compiled according to a variety of data collection and formatting standards); the diversity of methodological approaches; and the complexity of interactions between scientific, empirical, policy and normative dimensions of the ecological economics research problematique. Simply put, ecological economics, as we discovered in the course of preparing together an ecological economics dissertation, can cover, within a single sentence, paragraph or conversation, everything from the ultimate meaning of 'life' for human and non-human entities to the logistics of how to carry out an interview or phrase a key statement within an environmental impact assessment.

Scholars wishing to pursue ecological economics research face the intellectual challenge of making sense out of the potentially overwhelming range of subjects, topics, issues, schools of thought, debates, etc. that ecological economics sees as its 'subject area' (if such a term is even appropriate). In our case we grappled with questions about the epistemological framing of risk; about how to test ecological economics hypotheses; and the ideological and normative (often hidden or occluded) power of the very language (and grammar – understood as the rules of language use) we use to describe phenomena and prescribe engagement with them; about how we, as social scientists, might best approach natural scientists and engineers in order to engage in interdisciplinary collaborations; concerning what political and economic institutional structures might best support the move from ecological economics theory into practice (and back again!); to what degree the accuracy and legitimacy of ecological economics assessment are interrelated; where the results of our work should be published if our aim is to contribute to the project of ecological economics; where if our aim is to contribute to advancement of our careers; where if it is both, and what we should do when the two conflict; and so on. With so many options and so many relations in play, decisions regarding where any given ecological economics project belongs within the university are by no means easy to make.

While a certain amount of what might be called 'intellectual dyspraxia' seems to be necessary for effective engagement with any strong interdisciplinary

research question, the range and spectrum of ecological economics subjects means that answering even the most basic questions of *what* to research and *how* to research it can be overwhelming. Losing one's way and losing heart and enthusiasm in this no man's land seems to be part of the process of finding one's way (Faber 2008; Santaoja *et al*., Chapter 9 of this book). Discovering the new, uncharted areas that we encountered while researching and supervising this ecological economics PhD felt to us, at times, like pioneering exploration: exciting, frustrating, risky and enjoyable, sometimes all at the same time. The novelty of ecological economics as a research subject meant that the PhD we created together was the very first of its type at our university. As a result of this, there was no pre-existing research within the faculty, nor were there appropriate supervisory mechanisms in place for supporting the interdisciplinarity of the work of the thesis. And even as good-willed and enthusiastic partners in this project (supervisor and student), we ourselves were still coming to the topic from very different epistemological and disciplinary positions: on the one hand, from a disciplined political studies background with a specialization in green political theory and experience with official and non-governmental politics, and on the other, from a mixed academic background that included biochemistry, political science and environmental engineering, combined with a professional career that included experiences ranging from environmental activism to regulatory compliance control carried out in collaboration with production line managers and accountants in private enterprises.

In the face of these various personal, institutional and academic challenges, working together on this PhD thesis was a bit like exploring a strange new landscape in which we regularly disagreed over what to call or name all the new features and objects that we were discovering. This called for substantial goodwill on the part of both teacher and student, which we were fortunate to have in abundance because we both care passionately about the thesis topic. However, we can imagine that things might have turned out quite differently if we had had only our expertise and our institutional positioning to draw upon as resources. This leaves us to wonder how many promising ecological economics theses have never been written simply because the favourable conditions needed to make them possible were not present. What new and valuable understanding do we lack today as a result?

Work that is meant to be meaningful

While the normative character of any work intended to address environmental issues is a theme in its own right (see Becker and Jahn 1999; Forsyth 2003; Martinez-Alier 2002; Diaw and Kusumanto 2005), we found ourselves facing special demands specifically associated with our wish to produce work that is meaningful for contemporary environmental governance debates. Of course, we presume that most scholarly work is intended to speak to some social discourse, and so the dilemma is not ours alone. What we are getting at here is a will to produce meaningful research in a manner that is more akin to Marx's famous

dictum: 'The philosophers have only interpreted the world in various ways, the point however is to change it' (Marx 1978 [1845]).[5] For scholars concerned with addressing real-world problems like the deterioration of our planet's environmental life support systems, the task at hand is not only to understand the world but also to *change* it. With the thesis work we carried out, we sought to go beyond simply describing and interpreting how environmental governance 'is' to prescribing how it 'ought to be'. But we also added to our agenda the dimension (not unique to ecological economics, but certainly one of its defining features) of moving beyond prescribing change to suggesting how to implement that change.

There are not only ethical but also empirical implications associated with this kind of normativity. Insights are *meant* to be made available for practice, but their implementation and further development in practice are relevant not only for political action but also for further scholarly assessment of the appropriateness of recommendations. Since the work is always going to be serving one or another political perspective, in order to remain ethical, research projects concerned with EPE should, from the outset, clearly answer questions regarding for whom and to what political end the work is being conducted. However, meeting this ethical demand is not without its risks. With fear of 'engaged research' that has 'heterodox' and challenging political, ethical and economic consequences, when such work is placed before academic peers it is often negatively branded as being ideologically motivated and partial. In failing to be 'objective', such work is demeaning one of the unique selling points of the university, its status as a site of impartial, objective knowledge production.[6]

Our own experience as a case study

In the European-style university system, which is designed to reward and support discipline-specific research and results, carrying out the epistemological bridge work that lies at the heart of ecological economics inquiry also requires bridging the institutional structures that support these various pertinent epistemological domains. However, the gravitational pull of dominant paradigms and accepted or 'normal' patterns of knowledge production in traditional university settings is strong. In our case we found that working at the boundaries between disciplines required both strong personal commitment to the work and a willingness to face the risk of being ostracized, both socially and financially. Put another way: in order to develop the dissertation *Making Good Decisions Well* (Farrell 2009 [2005]), we had to exert a great deal of effort in order to place ourselves in a highly exposed and insecure position within the academy. For an established scholar, this is risky; for a student it is, at best, a gamble.

While there are now a few major ecological economics centres associated with universities,[7] and an increasing number of environmental studies departments that include ecological economics in their curricula, many ecological economists working within university settings still live a sort of double academic life, having a discipline-specific institutional home in economics or ecology, or sometimes geography, anthropology or science and technology policy studies,

and conducting their ecological economics work alongside bread-and-butter disciplinary work that relates more specifically to their institutional home. To a degree, this arrangement is perfectly reasonable. Since ecological economics is more than just one single discipline, it makes little sense to try to limit the work to a single field of its own (Norgaard 1989; Martinez-Alier 1999). Nonetheless, the situation highlights the fact that there remain clear institutional barriers to establishing this kind of work within the *academy* (see Max-Neef 2005; Clark 1989; Clark in Chapter 5 of this book). Upon venturing into this no man's land, one becomes, at least for some time, disciplinarily homeless (Max-Neef 2005).

We encountered this homelessness ourselves and it seems to us, in hindsight, that it was largely due to the structure of the arguments that we were building. Within *Making Good Decisions Well* (Farrell 2009 [2005]) there are core arguments that have been built using pieces of political science and ecological economics theory, which employ principles from far-from-equilibrium thermodynamics, categorizations drawn from cognitive science, and logical elements of argumentation drawn from evolutionary theory and philosophy. In order to gather together all these various threads together into one coherent fabric, we consulted with a great variety of experts, teachers and critics. Fortunately for us, the experts whom we approached (both inside and outside of our university) were willing to talk with us and to give critical and instructive comments on our work. However, because we came to them as homeless people they did so out of goodwill, not because our request fell within their formal responsibilities. Perhaps they felt that our work might be relevant or interesting for them, but it was certainly not among their duties to reply to our enquiries. That is to say, they had to make an extra effort, above and beyond their ordinary work, to provide their comments. Of course, these colleagues might have found our questions to be a source of new ideas (we would like to think so, in any case), but their decisions to engage with us were decisions to take on extra unpaid work and to go against the grain of the academic system.

Lest we be accused of condemning the academy as an institution unfit for the purposes of ecological economics, we hasten to point out that the very birth and growth of the field is itself a testament to the capacity of the modern academy to produce new forms of knowledge. But it is also a testament to the endurance, courage and commitment of those who dared to be different and who were willing and able to become intellectual pioneers. We do not mean to suggest that this is an all-or-nothing situation, where everything must change or nothing can be accomplished. Instead, we are looking to invoke and employ the spirit of continuing self-refinement that has always been part of the academic endeavour. The current organization of the academy, with its epistemological no man's lands and disciplinary diamond mines, is not inevitable. Indeed, even the currently dominant disciplinary character of the university system has not always been the case. The very name *university* has its origins in the idea that these institutions should be centres for the development of universal knowledge, and nearly as soon as there came to be formal institutionalization of what we might today define as disciplines – coming largely with the industrialization and specialization of

science in the nineteenth century – calls for interdisciplinary collaboration began. For example, an appeal for interdisciplinary studies can be found in Cardinal Newman's (1999 [1854]) classic text *The Idea of a University*, where, long before the overspecialization and hermetic separating of different knowledges that we encounter today, it was nonetheless possible for him to note:

> I have said that all branches of knowledge are connected together, because the subject-matter of knowledge is intimately united in itself, as being the acts and the work of the Creator. Hence it is that the Sciences, into which our knowledge may be said to be cast, have multiplied bearings one on another, and an internal sympathy, and admit, or rather demand, comparison and adjustment. They complete, correct, balance each other. This consideration, if well-founded, must be taken into account, not only as regards the attainment of truth, which is their common end, but as regards the influence which they exercise upon those whose education consists in the study of them. I have said already, that to give undue prominence to one is to be unjust to another; to neglect or supersede these is to divert those from their proper object. It is to unsettle the boundary lines between science and science, to disturb their action, to destroy the harmony which binds them together. Such a proceeding will have a corresponding effect when introduced into a place of education. There is no science but tells a different tale, when viewed as a portion of a whole, from what it is likely to suggest when taken by itself, without the safeguard, as I may call it, of others.
>
> (ibid.: 92)

And even as early as Kant we find discussion of potential problems associated with poorly executed interdisciplinarity: 'We do not enlarge but disfigure the sciences when we lose sight of their respective limits and allow them to run into one another' (2005 [1787]: 15).

That is to say, the questions we raise here concerning life in the no man's land of ecological economics are questions that seem to us to have always stood before the academy and the scientists who comprise it. In conducting this critical ontology of ourselves, as Foucault (1984: 47) describes it, we are returning to one of the earliest tasks of the modern scholar: considering what it means to enlighten.

Mapping the edges of no man's land

Working with the concept of post-normal science introduced by Funtowicz and Ravetz (1990a, 1991, 1992, 1993, 1994), we have been able to develop a 'rough working field guide' to the epistemological and methodological no man's land into which our research question led us. Post-normal science has given us both a terminology and a grammar that made it possible for us to communicate and understand each other more effectively. Being able to locate our political theory

questions (regarding the balance of rights and duties of citizenship, work as a social practice and the power of knowledge in environmental politics) and our ecological economics questions (regarding the role of entropy in economic processes, the biophysical constraints associated with the material basis of economic activity and the biological character of the human subject) within the post-normal science frame helped us to develop a workable common language for discussing these key elements of the thesis. In addition, the sheer existence of this discourse and the high quality of much of the work contributing to it gave us courage and confidence. In our experience the importance of having access to this kind of information, of knowing that there was rigorous, high-quality scholarly work under way that concerned itself with our no man's land and our sometimes shaky epistemological and methodological bridges, should not be underestimated. When moving into a new and novel area of work, especially as a PhD student seeking to establish one's reputation and credentials, it is reassuring to discover that others (perhaps not many, but some, and some who are respected) have already scoped out the territory a bit and identified it as being worthy of further investigation.

Of particular interest for our study were the implications associated with the normative proposition that ecological economics research should find appropriate ways to incorporate public debate into the process of scientific assessment (Funtowicz and Ravetz 1990, 1994; Funtowicz and O'Connor 1999). This proposition reflects a tendency within ecological economics research that seems to us to be intimately related to Giampietro and Mayumi's fourth requisite ability, typified by what Funtowicz and Ravetz (1994) call its 'issue-driven' approach to science. Whereas under a curiosity-driven approach the topics of research for modern science were determined largely by scientists following their own curiosity and inspiration, the advent of large-scale industrialization in the late nineteenth century saw a shift towards a mission-driven approach, with research agendas being set largely by the aims of commercial enterprises and the demands of the world's militaries. And eventually, linked to the time when new environmental impact assessment issues came to the fore in the 1960s with reports like Rachel Carson's *Silent Spring* (1963), and later that of the World Commission on Environment and Development, *Our Common Future* (Brundtland 1987), we can now talk about issue-driven science, like ecological economics. Here the research agenda is set collaboratively, by scientists and non-scientist, based on common concerns, and the execution of good-quality scientific method moves from being based on the routinized application of a set of fixed technical procedures to being marked by flexible but still rigorous co-production of knowledge by an epistemologically pluralist (Healy 2003) community of laypersons, technical experts and holders of various kinds of relevant scientific and non-scientific knowledge.

Within the issue-driven frame of ecological economics one can see the ancient 'public mission', as it were, of science and knowledge work (re)emerging. We tend to forget that despite the relatively recent era of patentable and profitable intellectual property rights, of mandatory science–industry collaboration (driven

by both formal government policy and financial need) and militarily supported technology development, and the ever-increasing focus on improving one's own academic standing through targeting publications to maximize one's impact factor profile, the work of science has always had an implicit 'public mission' to improve the world. Seen in this light, one of the opportunities coming along with the ecological problems of the twenty-first century is the chance to recover the public servant role of a science that has, in the course of massive science-supported industrialization, become in many ways no longer humanity's servant but its master (Marcuse 1991 [1964]; Max-Neef 2005; Farrell 2008). Here the socially engaged inter- and transdisciplinarity of ecological economics can be understood as a situation in which scholars are stepping back into the driver's seat of scientific knowledge production, self-consciously seeking to produce knowledge that can serve the specific social and political purposes associated with achieving ecological viable, economically productive and politically just systems of collective human action.

From the inside out: some reflections on our own experiences

Having laid out the ecological political economy theory context within which we propose to embed our discussion, in this subsection we present some admittedly subjective but, we think, nonetheless relevant reflections on how we have seen these issues arising in our own work, from the inside out, so to speak.

Student perspective: Katharine N. Farrell

FINDING ONE'S PLACE

In many respects one of the greatest challenges for me in conducting this research was that of finding my place. Being based in an interdisciplinary research institute (the Institute of Governance, Public Policy and Social Research, IGPPSR, was a partnership project between the university's schools of sociology, economics, politics and law), the idea that one could and should be operating across disciplines was accepted within my immediate environment. Looking back, I can imagine that without this sympathetic immediate environment the work would have been even more difficult, so this simple acceptance was certainly important. However, even with the shelter of interdisciplinary institutes like the IGPPSR, the overall university system still expects a scholar to have a home: people want to be able to assign a label; teams of researchers want a succinct description of what you propose to do; departments want people who can teach introductory courses. For an interdisciplinary scholar, acceptance beyond the bounds of such an institute, as a member of the wider community of the university, depends not only upon producing good science but also upon finding ways to consistently translate the interdisciplinary descriptions and analysis of one's work into one or another disciplinary language. This is an awkward position, tantamount to having to justify one's right to be.

While I was able to develop productive connections with my colleagues in the schools of politics, law, biology, philosophy, anthropology and economics (the main disciplines relevant for my work), establishing and maintaining these connections depended, in the first instance, at least as much on my interpersonal and social skills as it did on my capacities as a scholar. In addition, even where there was strong expression of interest from colleagues in these departments, a constant effort was required on my part just to maintain these relationships, since my presence was not a part of their ordinary departmental activities.

FINDING MENTORS

Unlike in many professions of the twentieth and twenty-first centuries, qualification as an academic is still today, much as it was centuries ago, very much a matter of apprenticeship; to find a master and to work for and with them, to watch them work and thereby develop a feel for the craft of research and science, is still the primary method of training. For this training method to work, mentoring is vital. One needs mentors to mimic, after which one can begin to model one's own style. However, when the chosen field of investigation is at the frontier of science and located in the no man's land of ecological political economy, it is not at all clear just who one's mentors should be.

In my case, as with most academics, my PhD thesis supervisor, a political theorist, with whom I am writing this chatper, was my primary mentor. But my research also included core scientific points of argument based within ecology, economics, cognitive sciences and philosophy. In these areas my supervisor, a political scientist, could not serve as my mentor. Setting out to find other established researchers with an understanding for these three additional core areas of study and an appreciation for my attempt to weave them all together was a research task in and of itself.

WORKING AT A FRONTIER WITH MULTIPLE MENTORS

A mentor is, in principle, someone who has been where you are heading, who can point out some of the pitfalls that might be lying ahead, who can critique and guide you in the development of techniques and methods, and who can encourage you that you are indeed heading in the right direction. However, when one is breaking new ground and moving into uncharted territory, the role of a mentor is slightly different. It becomes more like that of a wise friend who can suggest good principles but who can no better predict the future than can you. In the case of the research for this PhD thesis, which was concerned with the ecological political economy of disciplinary and interdisciplinary scientific research methods, my primary mentor was anchored within a discipline that informed the content and language of his guidance. His advice and examples had to be transposed *and* compiled with advice and examples from other mentors who also had their own intellectual homes in other, equally relevant but differently conceptualized, disciplines. Even if one is lucky enough to have a mentor

with experience in bridging disciplines, they too will inevitably have their own style and strategies for combining information and interpretations from across the disciplines. And finally, there is the challenge here of mixing together the messages not only intellectually but also emotionally and socially, as each mentoring relationship inevitably has its own style and character. In such a context it takes substantial effort and probably a bit of luck to avoid becoming a 'jack of all trades, master of none'. And it takes dedicated and forward-looking mentors who are able to see the risks that a student is facing, who are willing to venture a way into this no man's land themselves and who are willing to commit to the work; it is very easy for a student of many to become the responsibility of no one.

Teacher perspective: John Barry

Taking on an interdisciplinary PhD student within the context of a discipline-focused higher education organization, buttressed by one's own disciplinary training and mindful of the discipline-specific reward and promotion system, is an exercise in trust, perseverance and, at times, hope over experience, and at times an expectation that everything will turn out right in the end. When one's institution is set up in such a way that it is in spite of rather than because of this institutional context that one carries on the supervisory relationship, the quality of the working relationship between student and supervisor is even more important that in the standard PhD learning context.

The sense of being a pioneer in a new area, while exciting, also at times raises issues of vulnerability in relation to one's academic judgement and occasionally places one outside of one's areas of competence. However uncomfortable this may be (and one should not underestimate the benefits of frequently being outside one's intellectual 'comfort zone'), I have found that one of the most important and necessary qualities for interdisciplinary supervision is honesty within the supervisory relationship: admitting that one is not sure of what is the 'right' path for the thesis. At times this honesty demands a leap of faith to 'let go' of the natural desire to render and translate the student's work into the more familiar language and idioms of one's home discipline.

On balance, this work demands a certain degree of candour, regarding for example the practical limitations of creating one's own esoteric language. The student must be given enough room to really develop their ideas while still being given the tools to successfully position themselves within the still heavily discipline-oriented institutional structures within which they will have to build their academic career. In supervising an ecological economics PhD, the supervisor must be willing to learn new intellectual languages and explore and become familiar with new bodies of knowledge. It is not merely intellectual curiosity that is required of both student and supervisor – which after all should be the hallmark of all research; also needed is the ability to couple it with a capacity to 'join the dots' of what at first seem like distinct and separate issues, arguments, schools of thought, authors and debates. And a shared acceptance of the

'pioneering' and uniqueness of the research, accompanied by acknowledgement that this is challenging work, seems to be crucial to success.

One useful way to illustrate the special character of our shared experience is through reference to philosopher Alastair MacIntyre's well-known distinction between 'practices' and 'institutions'. For MacIntyre, 'practices' are forms of human collective and productive activity which have their own internal goods and standards by which they are judged. As he puts it (1981: 187), a practice is

> any coherent and complex form of socially established cooperative human activity through which goods internal to that form of activity are realized in the course of trying to achieve those standards of excellence which are appropriate to, and partly definitive of, that form of activity; with the result that human powers, and human conceptions of the ends and goods involved, are systematically extended.

Whereas institutions are human creations that have 'external goods' as their main motivation or standard by which they are judged – in the case of academia these standards include income, wealth, power, prestige or bureaucratic compliance – when viewed as a practice, supervision of a PhD has internal goods and virtues, such as co-producing new knowledge, training PhD students, enabling students to 'learn the craft' of academic work, and so on. MacIntyre alerts us to the danger that while institutions can support practices, they can also 'corrupt' them. In the context of supervising a pioneering PhD in ecological economics within a traditional university setting, we were in many respects left to work in isolation from our wider university institutional context. There were, for example, no regular ecological economics seminars and no other students or staff conducting ecological economics research.

Within this institutionally sparse setting, we found ourselves relying heavily on the quality of our 'practice' of teacher–student pedagogy, which became all the more important for guiding us in the development of the work, serving often as the main and at times our only referent for judging the quality of our work. When judgements about how to proceed, for example whether or not to pursue a certain line of inquiry, could not be based on external criteria because none of the academic institutions around us had positions on the questions that concerned us, we relied on good pedagogical practice to help us decide: are we treating each other with respect when we consider this question? Are we hearing? Are we acting with due regard for our respective roles as teacher and student? We cannot overemphasize how important a good working relationship and good interpersonal communication were for completing this PhD work successfully. We would even go so far as to call it absolutely central.

Challenges and recommendation

Both of us can testify to having often encountered one of Brutschin and Wiesmann's (2003) constitutive feelings of new and interdisciplinary research: that of

being outside of one's 'comfort zone', of having to understand and renegotiate familiar terms and issues, now seen in a new light or from a different disciplinary perspective. Brutschin and Wiesmann (ibid.: 2, emphasis added) note the challenges associated with this special feature of transdisciplinary research when they write, 'On the personal level, the social competence of researchers taking part in transdisciplinary projects must be very high, *in order to sustain disorientation and question one's own disciplinary paradigms*.' This sense of risk, disorientation and novelty, which is part and parcel of conducting innovative research, means that more support than the 'standard issue' is needed if the work is to remain clear and focused: more time is need for gaining one's orientation and renegotiating understandings, more patience from supervisors who may at times be as confused as their very confused students, more resources for verifying and elaborating new understandings, and more down time, to allow our human brains to return to the restful world of the mundane after our sorties into this domain of cognitive chaos. And here it is important to be clear that we do not just mean financial or funding support, although that is still often lacking for the kind of strong transdisciplinary work we are talking about here. Here we also mean mentoring support (for both students *and* supervisors) and community support, to ensure a convivial research environment where such work is valued as an innovative and important contribution to the advance of science, rather than just being seen as somehow a bit 'odd' or off the beaten track.

An ethico-political imperative

Instead of viewing our work as merely idiosyncratic, we see our position, as ecological political economy scholars concerned with the place of purpose in environmental sciences for policy, to be somewhat like that of someone who is critically investigating racism within a racist context: we are critically investigating sustainability within the context of unsustainability. There is a strong argument for the ethical obligation of a scholar in such circumstances to disseminate their findings widely within and beyond the confines of the institutional and disciplinary context within which they are located, including going beyond the academy to engage with citizens, the policy and political community, the media, and so on. Increasingly, good environmental sciences scholarship is viewed in terms of 'making a difference', but this is still largely understood to refer only to the confines of knowledge production itself, with a key measure of success being the degree to which scientific advice has been taken up in practice (Tian 2004; Costanza 2003). The general standard used to compare the relative success of different scholars is still related to the high premium placed on the production of knowledge as a commodity, both in terms of patents and in terms of the self-referential (within the academy) obsession with the 'impact factor' of journal articles (Ravetz 1971; Costanza *et al*. 2004; Rhoten and Parker 2004) – an indicator that primarily confirms only that a scholar is functioning within the academic system in the approved manner.

This raises an extremely important question not only for ecological economists but for any scholar concerned with the complex human–non-human nature

relationships of the twenty-first century: what is the role and what is the political/ethical obligation of a scholar researching pressing and urgent political subjects? Does the critical scholar of racism have a duty to get involved in anti-racist political activity, or do they, quite to the contrary, have a duty to remain outside the political debate, in order to protect the authority of their analysis? Does the scholar of sustainability have a duty to 'make a difference' by getting involved in political, media or other forms of activity outside their prescribed, assigned and 'normal' academic position? Is it really possible to do this kind of work without becoming embroiled in the associated politics, even if only as a silent accomplice upholding the status quo? Under such conditions, can one realistically expect to maintain a clear distinction between one's role as a researcher (or student or supervisor) and one's position as a citizen or potential political actor?

A duty of care imperative …

The wider cultural and societal context within which we were working as we developed this thesis was marked by growing scientific, media and political concern over what has come to be understood as a multifaceted 'ecological crisis', particularly a growing appreciation for the impacts and implications of anthropogenic climate change. Since the persistent-seeming inability of European-style democratic institutions to effectively engage with these challenges was the focus of the thesis, we found that our scholarly work was intimately related to a major popular political discourse taking place around us in real time. We shared between us a disposition for combining normative theoretical reflection with real-world application, and felt a need to consider and engage with this wider cultural context.

As we have already intimated, we believe that any study of ecological political economy carries with it a de facto normative component. In our case, as the thesis we were working on developed, what we would call a 'politico-ethical imperative' emerged as an additional, praxis-oriented aim of the work. This imperative – to try to help address the environmental governance problems that we identified in the course of writing the thesis – was based on a realization that there are substantial policy and 'real-world' implications associated with how environmental science and interdisciplinary research are carried out within the university systems of the world. Even though the product of our collaboration was a theoretical dissertation, we could not ignore the putative significance of our findings for the ever-more urgent tasks associated with making the transition to sustainable societies. This imperative called upon us to integrate our work with this wider cultural context, or at least to develop a clear argument concerning what might constitute meaningful links between the related political debates taking place in our 'ecological economic cultural context'.

Particularly towards the end of the thesis work, there was a strong sense that a constitutive dimension of the thesis was this movement from theory to practice, which saw us independently and collaboratively involved in organizing special seminars and workshops, giving policy advice to government authorities

and in some instances participating directly in political debates and formal electoral competitions. These activities, which were undertaken alongside the writing of this thesis, were nonetheless part of that work, the motivation for investing our time and effort being the translation of our insights into actions.

We see this push towards political action, within and beyond the university, as a characteristic of ecological political economy research. The special normative character of ecological economics specifically and environmental science more generally is reasonably obvious and has already been discussed at length by others (Becker and Jahn 1999; Funtowicz and Ravetz 1990, 1991, 1992, 1993, 1994; Costanza 1991). Basically, since environmental science is concerned with the quality of human environment relationships, each study chooses, whether implicitly or explicitly, a definition of environment and an ideal for what constitutes good-quality human relations with that environment, and is conducted in order to provide information that can improve the quality of human environment relations with respect to the stated (or implicit) ideal.

Similarly, when we propose to formally consider the politico-ethical obligations that we felt as researchers working on topics of pressing importance to the political communities in which we live, we raise the point not only as a personal account but also as a formal object of study relevant for developing a better understanding of how to achieve Giampietro and Mayumi's (2001) fourth requisite ability of ecological economics: to describe, understand and engage with the processes through which humans translate understandings of the predicament of sustainability into collective action. This imperative places a number of challenging questions onto the table for discussion: at what point (if at all) should a researcher go beyond the academic world of peer review publications, research reports and dissemination of results at conferences into the rather more disorderly world of politics, with its noisy ideological debates, sometimes indifferent and sometimes expert citizens, and sometimes ignorant, sometimes biased, sometimes highly informed and innovative policy-makers and politicians? How should the ecological economics researcher, for whom the impact of research is arguably as important as the results, engage with and disseminate their findings to a wider public? How should such a researcher respond to the inevitable politicization of their work, which is created to be used by political actors and policy-makers?

Duty, decisions and the fourth requisite ability of ecological economics

Traditionally, the call for academic discretion has been based on the presumption that a line between the politics and the science of a given issue could be drawn: that the two could be held, in practice (Weber 1947; Habermas 1980 [1971]) if not in principle, separate from one another; and we believe that this is often still the case. However, with respect to questions of ecological political economy, the purpose-setting systems of human societies are brought *within* the analytical frame. When we begin to study Giampietro and Mayumi's fourth

requisite ability, our decisions as scholars regarding how the purpose-setting systems of human societies are conceptualized are inevitably political (Funtowicz and Ravetz 1997; Luks 1999; Funtowicz and O'Connor 1999; Farrell 2008). Martinez-Alier puts the problem as follows:

> Governance requires the integration into policy (whether greenhouse [gas] policy or European agricultural policy or local urban policies) of scientific and lay opinions, sometimes contradictory among themselves, relevant for different scales and different levels of reality. Who then has the power to decide the procedure for such integrated analysis? Who has the power to simplify complexity, ruling some languages of valuation out of order?
>
> (2002: 271)

Furthermore, he puts the task of addressing this problem squarely in the lap of political theorists:

> [T]he impossibility of an economic rationality (either based on the market or on central planning) which takes into account ecological side effects and uncertainties, and the impossibility, also, of deciding human affairs according to purely ecological planning, lead towards the politicization of the economy … the economy and the ecology of humans are embedded in politics.
>
> (Martinez-Alier 1991: 134)

Since the thesis we developed together was concerned with understanding how and where scientific and other forms of knowledge inform decisions about human–environment relationships, from our perspective as scholars, interactions between citizenship and science were objects of study and analysis. However, at the same time these same questions stood before us as ethical and moral considerations: how and where should we take action to try to change conditions within our university, within our own academic disciplines of economics, political science and ecology, and within our immediate political contexts in Northern Ireland and Europe?

The place of the academy within an ecological economy

The exceptional character of our continuing struggle with the tension between scholarly rigour and duty to our various professional and political communities was particularly evident to us in our work with the concept of collective ecological management (CEM), which served as an organizing framework for the political theory of the thesis. The concept was initially formulated theoretically by one of us (Barry 1999) and then developed by the other (Farrell 2007, 2009 [2005]) in a way that brings out the duty of scholars of ecological management to move not only beyond the reductionism of single disciplines but also beyond the confines of the academy to engage with the realpolitik consequences of their work.

Originally formulated within green political theory as an overarching critique of ecocentrism, CEM focuses attention on the role of institutions (such as the state and the market) in human–environment relationships and presumes that humans will always somehow actively manage their relations with their environments. Within the thesis reported upon here, the concept was developed in a number of directions and we do not have the space to review them all. What is important to our current argument is that we share, in our interpretation and elaboration of the concept, a rejection of a naive view that one sometimes finds within certain strands of economics, environmental politics and ecological thinking: that there is a 'solution' to human–nature problems which, once achieved, implies that a certain 'harmony' will almost automatically persist. As green political theorists we anticipate that successful institutions of environmental governance will need to be not static but changeable, able to continue responding to the inevitable changes that are only to be expected from the continuing process of evolving human–non-human relationships. To put it another way, we do not see sustainability as a goal but as a way of travelling.

The concept of CEM characterizes ecological governance as a complex set of political practices that make use of market, state and sub-state institutions and those associated with community, as well as combinations of them' (Barry 1999: 158). We understand human impacts on (or we might even say within) ecological systems to be ordinary and inevitable, and ask the question, how well do current practices manage these inevitable impacts, with respect to the needs of the ecosystems and of the human societies? In this light the question is not so much whether or not collective ecological management is taking place but rather how good the current system of collective ecological management is. Such assessment depends of course in large part upon what (if anything) a society has determined to be its collective aims for managing its relationship with the ecological systems within which it is embedded. However, determining appropriate aims is not purely a question of intent, first, since a society can quite easily have intentional aims that are incompatible with the needs of the ecosystems with which it is associated, and second, because even a society without any explicit aims for managing its ecological impacts has, nonetheless, implicit policies regarding how those impacts are to be managed, which are set by the aims of its political economy. Determining what should be the aims of a society's collective ecological management is both a political judgement regarding what that society desires and an empirical question of what the associated ecosystems can sustain. And since determining these aims is not a task that will someday be accomplished but an enduring and recurring feature of the activity 'collective ecological management', part of what must be determined when considering how to create good-quality collective ecological management is the procedures that are to be used to determine collective ecological management aims.

Ecological economics, in one way or another, is intended to contribute to each of these three CEM tasks – construing what are appropriate economic aims, construing what are appropriate ecological aims and construing what are appropriate procedures for determining aims – but it is mainly the third that concerns

us as political theorists and scholars of ecological political economy. And our interest in this third task places us in the midst of a complex circle of causalities: as we continue to make recommendations about how the collective ecological management institutions within which we ourselves are operating might be changed, in order to improve their fitness for the purposes decided upon by a collective to which we belong and contribute, this places our own theoretical propositions within our frame of analytical observation (Funtowicz and Ravetz 1990; Funtowicz and O'Connor 1999).

The activities of CEM can be understood as the collaborative problematizing by human societies of their own role in the designing of their own futures and those of their environment(s):

> In a sense the collective ecological management strategy is on one level a democratic political procedure within which various ways of valuing the environment (and thus various relations and interests to and in the environment) can be raised, deliberated and incorporated into policy recommendations.
>
> (Barry 1999: 120)

The concept is introduced towards the close of Barry's (1999) book and remains somewhat under-theorized in that text. However, its broad conceptualization of self–other–environment relations fits well with the ecological economics presumption that human societies and their purpose setting systems are materially and ecologically embedded (Georgescu-Roegen 1971), and it provides us with a basis for developing political theory that responds to Martinez-Alier's observation that 'the economy and the ecology of humans are embedded in politics' (1991: 134). Rather than viewing the inevitable limitations of human perception (as manifest for example in our ignorance about the future or our limited knowledge of the present) as an insurmountable problem that must be tolerated but should be minimized (Habermas 1984, 1987), we see them as operational features of an ecologically embedded human cognition (see Berger and Luckmann 1991 [1967]; Dennett 1992; Douglas 1986; Foucault 2003 [1973]; Prigogine 1997; Wakefield 1990) that structure and regulate how we, as humans, perceive and engage with the ecological systems within which we are embedded (Luhmann 2004; Blühdorn 2000).

Because our understanding of our environment is always limited, humans are always deciding on how to relate to the environment without having full knowledge about the impacts of their behaviours (see Simon 1955, 1959). Instead of seeing conflicting conceptualizations of human–non-human nature relationships as reflecting differences of interest, or identity-based values, or an ethically diverse sets of opinions, we see them as different ways of perceiving and contributing to the resolving the shared problems of collective ecological management. For example, rather than viewing them as something that must be resolved, we view value conflicts as a part of the complex multifaceted character of the ecological management collective, not as something that must be eliminated but as something that should be taken into account when proposing CEM operating

procedures (Farrell 2007). Building on this interpretation, one of us (Farrell 2004) has proposed the democratic institutional innovation of epistemological representation, which was eventually elaborated, within the thesis, as part of a CEM framework, leading to proposals for design of new institutional configurations that could support epistemologically complex environmental governance.

The details of that proposal can be found in the thesis and associated paper (Farrell 2004, 2009 [2005]) and will not be discussed here. What is directly relevant to our present argument is the proposition underlying them: that where political decisions are substantively dependent upon scientific assessments, the technical choices that scientists make regarding what to include in their assessments – how to formulate their research questions, which of their results to report, where to report them, etc. – are also substantively political choices (Farrell 2008). In so far as they are, the work produced as a result of these choices deserves to be assessed not only for its scholarly rigour but also for its political legitimacy. We would even go so far as to say that it is the moral duty of the scientists working with these kinds of problems not only to work according to best scientific practice but also to behave as responsible citizens, attentive to the fact that they are acting within the political forum of collective ecological management.

For an example of what we mean here, let us take another look at the now common practice of using monetary value proxies to represent the economic worth of ecological phenomena (employed within both environmental economics and ecological economics). Although practically no one claims that these proxy values are correct (Costanza *et al*. 1997), they are widely used because they make it possible to slot environmental values directly into existing economic models and because they make it possible to produce what appear to be robust and convincing economic analyses of the costs of environmental degradation. That is to say, the products of monetary valuation (proxy units of value meant to represent the economic worth of ecological phenomena) have pragmatic and rhetorical value. Nicholas Stern's report *The Economics of Climate Change* (2006) and the more recent European Union-generated *Economics of Ecosystems and Biodiversity* report (Sukhdev 2008) are two prominent recent examples, but use of proxy monetary values is widespread, and reliance upon this type of data can be found in thousands of economics and policy papers, as well as within the reports of the Millennium Ecosystem Assessment (MA) and Intergovernmental Panel on Climate Change (IPCC). The choice to use monetary value proxies instead of developing new methods of ecological economic assessment that do not require monetary values is just that, a choice, and one that is not without consequences. Continued use of monetary proxies serves to reinforce a set of scientific assessment practices (and associated institutions) that make it difficult and risky to develop alternative approaches (Farrell 2007). While it is a decision taken in the course of carrying out one's ordinary work as, for example, an environmental economist, policy analyst or ecological economic systems modeller, the choice to use monetary proxies is a political and not only a scientific one.

Taken under conditions where one tends to see oneself not as a citizen but as an expert, such decisions reflect an extension of the domain of politics into the daily practice of science, presenting political theorists with an empirical challenge and ecological economists with an ethical one: what is an appropriate democratic duty of care with regard to the choices made about how to conduct policy-relevant ecological economics research projects – generally, with respect to the daily practice that constitutes this work, and specifically, with respect to the practice of creating and using monetary estimates as proxies for the economic worth of ecological phenomena?

In considering this problem we looked again to Barry's (1999) theory of collective ecological management, picking up on the concept of ecological stewardship, where he describes green citizenship as 'a praxis of citizens critically evaluating preferences and attempting to come to agreement on limits within which particular social–environmental relations may be pursued' (ibid.: 234). He proposes that these conditions call for an eco-aware ethics of use, offering a theoretical position that proceeds beyond the distinction between anthropocentrism and non-anthropocentrism. Instead, under Barry's use ethic, humans may be understood to hold custodial interests towards non-human nature, interests that can be manifested through ethical but nonetheless anthropocentric behaviours. This ethic favours a human to non-human nature relationship that is '[mutualist] symbiotic rather than parasitic'. Humans are understood to have a responsibility of 'ecological stewardship' (ibid.: 64), which he suggests may be operationalized through collective ecological management.

This use ethic can be understood as a sort of duty of care, and exercising such a duty requires that sufficient attention be given to understanding the basic attributes and requirements of its object, which in this case is the ecological economic systems of the planet: that is to say, understanding the sufficient conditions required for the viable forward-going simultaneous continuation of the ecological and the economic systems of human societies. However, that is not the final end of this duty, which also requires that, once construed, these sufficient conditions also be taken into account, if not ensured, in one's decisions and actions, in so far as those actions relate to one's participation in the forum of CEM.

As has been discussed in this chapter, and is also discussed in several other chapters of this book, within ecological economics it is taken as given that the development of an understanding of the dynamic relationships *between* the social and physical systems that comprise ecological economic systems is required. This means that we are talking about a duty that applies not only to individual scientists but also to the individuals who administer the academies of science. That is to say, in so far as the academy is expected to support the work of understanding common good problems in a democracy, there is also an ecological stewardship duty of care accruing to the administrators and directors of universities, a duty of care that calls upon them to give attention to the needs of researchers operating in the epistemological and methodological no man's land of ecological economics.

Re-establishing this direct link between one's professional responsibilities and one's responsibilities as a citizen brings us back full circle to the original principles of citizen duty under the Athenian model of democracy. In ancient Athens, citizen duties were intimately related to the citizen's role within wider Athenian society, as an educated man with certain specific training and responsibilities relating to trade, commerce and the military activities of the state (Finlay 1973; Headlam 1933).[8] In modern democracies this presumption of duty to the common good continues on in the principles of negligence and due diligence, which stipulate the social practice boundaries of a general duty of care that all individuals (including corporations) are expected to exercise towards other individuals. However, where negligence and due diligence set limits to what is acceptable, bounded by the mores of a society, ecological stewardship calls upon each citizen to actively take up an ethically informed social *practice* with their environment as a civic duty. It is a duty that calls upon the citizen to be proactive.

Barry relates this type of citizenship to the idea of work as social practice, proposing that '[t]he more [that] social-environmental purposive, transformative relations [behavings towards the environment] approach the ideal of a social practice, the more that use realizes the virtues of stewardship rather than exploitation' (1999: 240). Here we have the beginnings of a green political theory argument identifying a democratic duty of care that calls upon scholars to keep in mind how their own professional actions may impact upon CEM. In much the same way that we are expected to keep in mind the ethical issues associated with conducting experiments on live animals and human subjects because we have a duty of care to these individuals, we may also be expected to conduct science in a posture of ecological stewardship because we have a duty of care to the ecological systems of the planet.

Conclusions

Given the pressing need for what Max-Neef (2005) has called strongly interdisciplinary research (where not only the outputs but also the principles and concepts of various disciplines are combined), countries and institutions with relatively limited experience of the study of complex sustainability problems certainly have much to learn. However, it seems to us that many of the obstacles we encountered are more characteristic of university education in general than particularly symptomatic of the state of university education in the United Kingdom, including Northern Ireland.

From different points of view of supervisor and student, and together as political science-oriented scholars of ecological political economy, we find that a greater recognition of the challenges and value of conducting good-quality interdisciplinary research is much needed, both in terms of advancing the practical effectiveness of human societies dealing with specific socio-ecological problems (i.e. developing policy related research) and in terms of internal (within the academy) recognition of the intellectual merits of such research. Good-quality

execution of the interdisciplinary research typical of ecological economics – while differing in its scope, methodological approach and subject areas – has the same intellectual virtues and qualities as any journey of scholarly inquiry. However, the institutional rewards of conducting such research are few and far between. While there are some academic positions specifically related to ecological economics, mainly at research institutes, the vast majority of stable university positions remain firmly fixed within the disciplines, and a great many of the ecological economics-specific positions are themselves based within the twenty-first-century meta-disciplines of environmental science and mathematical modelling.

If the community of ecological economics scholars is agreed that politics is a relevant domain of ecological economic inquiry (and we think this can now be taken as given), then the fundamental work of ecological economics' political theorists and political scientists also needs to be supported. In part, this means providing a wider range of ecological economics positions within the academy, but it also means that the scholars and scientists who have become the establishment, in so far as they understand themselves to hold a duty of care for the ecological stewardship of the planet, need to consider how room for this work can be made within their disciplines and within the current institutional structures. This is not simply a question of whether or not a given scholar is eventually forced back within disciplinary boundaries in the course of seeking to establish their career. It is also a question of whether a scholar who has moved out into this no man's land can remain within the academy at all: of whether they can find a position where who and what they are is appreciated and valued (Ravetz 1971). And in the end it is a question of whether or not this line of inquiry can be developed within the academy at all.

In hindsight, our experience of writing and supervising an ecological economics political theory thesis can perhaps best be summarized in terms of living within, participating in and, hopefully, making some small contribution towards the intellectual process of a 'paradigm shift'. The 'no man's land' of ecological political economy is a messy, risky and uncertain interregnum between different paradigms of knowledge production. It is part of the project forged by the first generation of ecological economists, people like Nicholas Georgescu-Roegen, H.T. Odum, Kenneth Boulding, Mary E. Clark, K. William Kapp and C.S. Holling, who all pointed towards this new direction from within their respective disciplines of economics and ecology. As we work now, in the twenty-first century, to grapple with the questions that these pioneers placed before us, we venture into a completely new domain, one that first had to be imagined before it could be explored. At our disposal are some tools that these pioneers prepared for us, alongside those that we are crafting ourselves now as we go along. In the preceding pages we have argued that one of the most important ecological economics tools still to be crafted is academic research institutions that can support the execution of the interdisciplinary work that lies at the heart of this field of inquiry. We have left many threads hanging in the course of our account, which we hope may be taken up and developed by others, and we do not claim to have

exhausted the topics raised here for discussion. Instead, we hope to have convinced our readers that the politics within ecological economics and the politics of ecological economics must be seen and addressed together, as related aspects of a single system of ecological political economy.

Notes

1 By 'environmental governance' we also mean governance for sustainable development/sustainability.
2 Following Hagedorn (2008), Olsson *et al*. (2006), Ostrom (2005), Young (2002) and Vatn (2005), we take it that different institutional configurations may be more or less conducive to sustainable development and we would, on that basis, expect that different challenges and different opportunities arise in other settings where interdisciplinary sustainability research is carried out, such as private research institutes, non-governmental organizations and public authorities and agencies. However, systematic exploration of this variety of settings, a sort of cross-institutional comparative analysis, while a promising follow-up to the work presented here, is beyond the scope of our current discussion.
3 We are indebted to Tommaso Luzzati for suggesting this term 'ecological political economy' and direct readers interested in exploring to topic further to consult Hinterberger *et al*. (1996) and Gale and M'Gonigle (2000).
4 See Røpke (2004) for a brief history of the early development of the field.
5 'Die Philosophen haben die Welt nur verschieden interpretiert, es kömmt drauf an, sie zu verändern' (Marx 1978 [1845]).
6 For reasons of space we here simply state, without argument, our view that this description of the academy and knowledge production is touchingly naive and betrays an innocence in its belief of the university as beyond politics and power that is itself ideological and deeply normative. While ignorance itself may or may not be ideological, to sustain the myth and the conditions that perpetuate a convenient ignorance of the constitutive role of power and politics in knowledge production is without doubt one of the most powerful ideological 'projects'.
7 For example, at the Gund Institute in Vermont, the Beijier Institute for Ecological Economics and the Stockholm Resilience Centre, both in Sweden, and the Institut de Ciència i Tecnologia Ambientals (ICTA) in Barcelona; and within the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia.
8 Here we hasten to emphasize that what is similar here is the principle that the duties of a citizen are duties related to their work, whatever that work may be, rather than the practices themselves, which in ancient Athens included a strict distinction between public patriarchy and private matriarchy.

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