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# Practising interdisciplinarity in the interplay between disciplines: experiences of established researchers

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ABSTRACT

This paper focuses on the practice of interdisciplinary research and its relationship with disciplines within the context of sustainability research. Disciplines are defined as institutions, i.e. conventions, norms or formally sanctioned rules that coordinate human action [Vatn, A., 2005. Institutions and the Environment. Edward Elgar Publishing, Cheltenham, UK). These institutions coordinate the practice of research. The central claim of this study is that interdisciplinary research occurs at the interplay between disciplinary institutions. These ideas are developed through the analysis of nine qualitative interviews conducted with established researchers who share an interest in studying issues of environmental sustainability. Specifically, this analysis identifies the motives of researchers who engage in interdisciplinary research and discusses the key characteristics of interdisciplinary research practice. The findings suggest that interdisciplinary research practice relies on disciplinary institutions as points of theoretical and methodological reference. Yet, the paper points at tensions that occur between the practice of interdisciplinary research and the practice of more traditional disciplinary research.



## 1. An interdisciplinary turn?

Interdisciplinary research, research cutting across established disciplines, is on the rise. In Europe, for example, funding bodies from both private and public organisations appear to be increasingly interested in interdisciplinary research as a method to address socio-environmental challenges (Luks and Siebenhüner, 2007). Researchers are responding to these new demands adjusting their practice to address both the concerns of policy makers and interests groups (Benner and Sörlin, 2007; Chompalov et al., 2002). In addition, the social evaluation of research is generating an additional set of targets shaping the content and practice of scientific research (Lubchenco, 1998; Benner and Sörlin, 2007; Nowotny et al., 2006).

Scholars have long emphasised the need to understand the forces that drive, and the barriers that restrict, the practice of interdisciplinary research (e.g. Klein, 1996; Nowotny et al., 2006; Brewer, 1999; Bruce et al., 2004; Frs, 1962; Griffin, 2006; Heathington et al., 1978; Hukkinen, 2003; Jakobsen et al., 2004; Petts et al., 2008; Vincenti, 2005). Still, additional research is needed to complement previous efforts, like those in Weingart and Stehr (2000), about what interdisciplinary research practices entail and how they are related to the research practice of more conventional single-discipline research.

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Thus, this paper focuses on the practice of interdisciplinarity and its relationship with institutionalised disciplines. The ideas contained in this paper emerged from discussions between the authors and the opportunity to meet researchers from a variety of backgrounds sharing an interest in environmental sustainability. To take advantage of such opportunity, the authors of the paper undertook exploratory qualitative research aiming to understand the practice of interdisciplinary research in environmental sciences and its impacts on the careers of scientists who work outside of a single discipline. During this study, the researchers found it useful to describe disciplines as institutions. Institutions can be defined as conventions, norms or formally sanctioned rules coordinating human action, in this case, the practice of research (Vatn, 2005). More specifically, interdisciplinarity can be regarded as institutional interplay (Young, 2002). Using such an institutional conceptualisation as a departure point, qualitative research was carried out to engage with the practice of interdisciplinary research and its relationship with disciplinary institutions.

Often, tensions emerge between disciplinary and interdisciplinary research, as current disciplinary institutions appear to hinder the practice of interdisciplinarity. However, this paper argues, disciplines are important points of reference for the practice of interdisciplinarity. The following section explores the current literature on interdisciplinary research. Section two presents the methodology used in this study, and section three explains the results obtained. Finally, section four discusses the results in the light of the literature to conclude that there are important synergies between disciplinary and interdisciplinary research.

## 2. Disciplines and interdisciplinary research: institutions and interplay

For the purposes of this paper, interdisciplinary research is defined as research that cuts across disciplines. The term interdisciplinary research is also related to multidisciplinary and transdisciplinary research. Multidisciplinary research occurs when different disciplines work together on a defined problem without influencing each other (Max-Neef, 2005). Transdisciplinary research cuts across different knowledge cultures including academics and what is commonly referred to as 'lay' communities (e.g. Mittelstraß, 2001; Klein, 2004; Max-Neef, 2005). This paper focuses on research that goes beyond the addition of results from different disciplines (multidisciplinary research), but does not extent beyond the practices of academic researchers. Thus, the paper focuses exclusively on interdisciplinary research.

The concept of interdisciplinary research dates back to the 1930s procedures of the Social Science Research Council of the United States of America dealing with the collaboration of more than two professional societies (Klein, 1996). By the 1980s Clifford Geertz had brought interdisciplinarity into the scientific discourse by stating the need for 'genre mixing' in the social sciences and humanities (Geertz, 1980). More recently, interdisciplinary research and collaboration among scientists has increased significantly. The reasons for such a rise are varied. Interdisciplinary research may be regarded as:

- the result of changes associated with knowledge-based economies (Hicks and Katz, 1996);
- a necessary turn away from reductionist approaches to scientific progress (Lessard, 2007);
- a response to the challenges of an increasingly complex world (Latour, 1998; Lubchenco, 1998; Nowotny et al., 2006);
- an approach to refine tools for practical work (Hukkinen, 2003); or
- a complementary element to ongoing specialisation in knowledge production (Weingart, 2000).

Researchers have also pointed to the difficulties of drawing boundaries between disciplinarity and interdisciplinarity as forms of knowledge production (Klein, 1996; Mittelstraß, 2001). For example, researchers do not necessarily share the same understanding of interdisciplinary research (Vincenti, 2005). Aram (2004) observes that interdisciplinary research derives from the confluence, fusion or synthesis of disciplinary knowledge and from the re-definition of the disciplines. Some argue that the 're-imagination' of disciplines is already occurring as disciplines are now producing numerous specialisms, often overlapping and intermixing across social and natural sciences (Ramadier, 2004; see also Klein, 1996; Mittelstraß, 2001). However, despite possibly changing roles, Klein (1996) insists that disciplines continue to bear core elements of current forms of knowledge production. Such views suggest that disciplinary and interdisciplinary research may be closer than is commonly understood.

Institutions can be defined as those sets of conventions, norms and formally sanctioned rules constructed by societies that coordinate and regulate human interactions (Vatn, 2005). Disciplines can be understood as institutions that coordinate the production of knowledge. Generally, disciplines contain a set of instructions on how to generate knowledge including subject definitions, conceptual approaches, cognitive structures, goals and norms (Klein, 1996). Such constructs constrain the research activity that occurs within disciplinary spheres (Petts et al., 2008). According to Good (2000) disciplines are historical entities that can be seen as changing frameworks organising scientific activities. Disciplines are used to address well-defined issues but they are transformed over time to the extent that the initial logic and practices of a discipline may disappear (Good, 2000). In the late twentieth century such processes may have been accelerated by a re-contextualisation of disciplines, a weakening of disciplinary boundaries and an alteration of identities, which all led to changes in canons, codes and categories of knowledge production processes (Klein, 1996).

Formerly unchallenged knowledge and expertise hierarchies may be called into question by a wide array of scientific communities and the public (Klein, 1996; Wynne, 1996). Individual researchers or groups of researchers can expand or break the boundaries of disciplines to different degrees and hence facilitate interdisciplinary research, even though interdisciplinary research is mediated by the structures of power that draw the boundaries between disciplinary and interdisciplinary research (Klein, 1996). Therefore, one could understand interdisciplinary research as occurring in the 'border areas' between disciplines (Klein, 1996). However, in practice, the borders may be more amorphous than

anticipated. Bibliometric research reveals that there exists substantial boundary-crossing between disciplines in terms of authorship of publications and readership (Pierce, 1999). Lau and Pasquini (2008) assert that disciplinarity and interdisciplinarity are under constant negotiation, at least within the field of geography.

Challenges to interdisciplinary researchers emerge from the working practices of those individuals who strongly adhere to the institutions of a discipline and their operation within organisations. In his 'Structure of Scientific Revolutions', Kuhn (1962) provides a detailed account of the process of knowledge reproduction through textbooks and the reproduction of knowledge in higher education institutions. Disincentives resulting from academic reward structures and evaluation procedures, almost entirely developed along disciplinary lines, constitute serious barriers to interdisciplinary research (Heathington et al., 1978; Vincenti, 2005; Lau and Pasquini, 2008). For example, one of the vehicles for the reproduction of disciplinary institutions is the educational process. Education is produced through a series of formally sanctioned rules, exams, research projects, and practical work, all within the contours of particular disciplines. Such institutions have been commonly identified as one of the main obstacles for interdisciplinarity (Frs, 1962). Single-discipline education is still predominant in higher education (Max-Neef, 2005). The literature suggests that disciplinary institutions will continue to be reproduced and, as a result, the education programmes of future scientists will be based on the single-discipline tradition. Once education is completed, the researcher will be encouraged to remain within a single discipline by a range of disciplinary institutions such as: the dominance of disciplinary publishing for career advancement (Griffin, 2006; Campbell, 2005); the review processes of funding proposals (Griffin, 2006; Porter and Rossini, 1985); and the performance indicators used within university departments (Bourke and Butler, 1998). Some recent research suggests that researchers may struggle to obtain recognition for interdisciplinary research from traditionalist research institutions, such as scientific journals (e.g. Tress et al., 2006).

The practice of research and interaction with other researchers further develops the single-discipline orientation. For example, Sundberg (2007) reports that individuals who are setting up experiments, even within collaborative contexts, may not be able to question experts on the use of particular instruments. This division of scientific labour often requires scientists to reproduce well-known conventions already embedded within their discipline. Moreover, such division of labour requires that research groups adopt specific types of organisation, which may further hinder interdisciplinary collaboration (see Hollingsworth and Hollingsworth, 2000). For example, Chompalov et al. (2002) found that the strict standards imposed by funding agencies of particle physics lead research groups to develop structures that lacked the flexibility required to collaborate with other research groups (let alone other disciplines). Conversely, in loosely structured groups the emergence of ambiguous or undefined tasks may lead researchers to revert back to pre-existing disciplinary norms and structures (McCorcle, 1982).

The adoption of rigid research protocols and hierarchies within the context of single-discipline research can also be found within interdisciplinary research teams. One of the major obstacles reported for interdisciplinarity is the requirement that researchers operate with methods and theories used within their home disciplines (Frs, 1962). Petrie (1976) suggested that, in order to gain mutual understanding, individuals need to learn the observational categories and concepts of other disciplines involved (see Bromme, 2000). This process, however, may take several years (Pohl, 2005; Campbell, 2005; Vincenti, 2005; Klein, 2006).

The literature discussed suggests that understanding disciplines as institutions and interdisciplinary research as occurring within the interplay of these institutions may help to conceptualise the barriers to interdisciplinary research. These include conventions, norms and rules that are specifically stipulated within the institutional construction of disciplines and the organisation of science in general. They seem connected to more complex methodological and theoretical conventions, which frequently escape the attention of the analyst (see Pickering, 1995). Daniel Bromley (2006) describes disciplines as interpretive or epistemic communities in which a community of practitioners is bound by specific agreements regarding questions thought worthwhile to ask and covering laws consisting of axioms and truth claims. These epistemic institutions imply not only certain assumptions and applicability postulates, but also methods of inquiry (Bromley, 2006). Experts, including researchers, are held accountable by the discipline to which they belong (Bromley, 2006). As a result, researchers tend to refer to established institutions in the process of fixing their beliefs on how they are prepared to act as professionals who are embedded within particular disciplinary and social contexts (see Bromley, 2006). Consequently, when disciplinary agreement relating to assertions they are making is absent, these arguments lose their legitimacy (Bromley, 2006). This may limit the opportunities of a researcher to embrace principles of other disciplines and could be an important determinant of interdisciplinary research practices in the interplay of disciplinary institutions.

Interplay is a concept that is used in institutional analysis to refer to the interactions between and among institutions at similar and different levels of social organisation (Young, 2002). Horizontal interplay occurs among institutions at similar levels of social organisation, while vertical interplay occurs when certain institutions are influenced by institutional arrangements determined at higher or lower levels of social organisation (Young, 2002). For example, horizontal interplay occurs between different disciplines because they are institutions at the same level of social organisation. However, these institutions are also influenced by other institutions at higher and lower levels of social organisation such as governmental policies that influence science, funding structures, and even social conventions in everyday interactions between researchers and other actors. Interdisciplinary research can thus be defined as the interplay between epistemic institutions. The resulting conceptualisation of interdisciplinarity places researchers in an institutional context that influences their interdisciplinary practices, whilst researchers themselves can also transform interdisciplinary practices and institutions respectively.

This approach is different to previous conceptualisations of interdisciplinary research as scientific communities (e.g.

Newman, 2001), epistemic communities (Haas, 1992), transepistemic arenas (Knorr-Cetina, 1982) or seeing disciplines as intentional organisations (Turner, 2000). Traditional concepts of scientific communities have approached the production of science as the aggregation of the actions of individual scientists, thus applying a methodological individualist paradigm to analyse these processes. Institutional analysis, in contrast, emphasises the existence of social structures that shape individual behaviour. However, the definition of institutions proposed here does not preclude the possibility of human agency influencing institutions. Instead, this approach intends to bridge methodological individualism and structuralist approaches to understand disciplines and interdisciplinary research.

The concept of epistemic communities as developed by Haas (1992) is close to an understanding of disciplines as institutions. Epistemic communities can be understood as networks of professionals sharing a core of beliefs. The core of beliefs provides the basis for individual action and establishes criteria to validate these actions within a particular epistemic community. The main difference with the approach presented here is the dependence of the notion of epistemic communities on the consensus of its members. Thus, structural constraints shaping epistemic communities are only effective as long as its members agree upon them. This notion may fail to recognise that the process of dissension and questioning have also a great impact in the formation and reproduction of disciplines.

Within this paper, disciplines are studied as institutions and interdisciplinary research as institutional interplay. The hypothesis is that disciplinary institutions shape the practice of interdisciplinary research, whether hindering or facilitating it. Thus, this paper explores how disciplinary institutions are embedded within the practice of interdisciplinary research, according to the accounts of researchers involved in interdisciplinary projects.

## 3. Methodology

The research aimed at understanding the interdisciplinary practices of researchers working in environmental sciences and related fields. The sample was drawn opportunistically, using the researchers' contacts, and included internationally recognised researchers that participate in interdisciplinary projects addressing environmental and sustainability issues. The sample included nine researchers with a range of socio-cultural backgrounds, age and nationality (see additional detail in Table 1). All interviewees had participated in interdisciplinary research projects bridging the natural and the social sciences. Most of them explained that they had received a single-discipline education or an education based on two disciplines; however, some of them had received additional interdisciplinary training at later stages of their research career. Each interviewee had extensive experience working interdisciplinarily on empirical and theoretical issues in the field of sustainable development in diverse environmental, social, political and cultural contexts. Because the sample was selected using the researchers' contacts, the sample has a bias towards social sciences, in particular, economics.

In-depth face-to-face interviews were conducted with each participant. The interviews lasted between forty-five minutes and one hour. An interview guide was used consisting of themes, which were raised through open-ended questions during the interview process. The key questions focused on how researchers operate within their institutional context. The goal of the interviews was to explore with these scholars their impressions of interdisciplinarity, the role of scientific knowledge producers within society and their reasons for taking an interdisciplinary approach to sustainable development research. Four overarching themes emerged out of the interviews, as they were issues of importance for all research participants. They constitute the conceptual strands of this analysis, as detailed in Table 2.

Further analysis examined how the different accounts given by the researchers reflected the emergence of interplay between disciplinary institutions. In particular the analysis looked at how research practices were shaped by disciplinary institutions. The following section presents the results in four sections: 1) the context in which interdisciplinary research occurs; 2) the individual practice of interdisciplinary research; 3) interdisciplinary research as a social practice; and 4) cross-referencing between disciplinary and interdisciplinary research.

## 4. Results

### 4.1. *The context of interdisciplinary research*

Higher education organisations may be considered to be the contact point of individuals with research, and their initiation in disciplinary institutions. Some interviewees explained that

**Table 1 – Summary characteristics of the population of study.**

| | | |
|---|---|---|
| Total Sample | 6 mid-career researchers and 3 late-career researchers | |
| Gender | Male | 7 |
| | Female | 2 |
| Countries of Origin (7 in total) | Slovakia (1 person), Slovenia (1 person), Czech Republic (2 people), Germany (2 people), Norway (1 person), Sweden (1 person), USA (1 person). | |
| Disciplinary Training of Scholars (12 in total) | Economics (General Microeconomics, Environmental Economics, Ecological Economics, Agricultural Economics, Institutional Economics), Forestry Engineering, Agriculture (primarily Agronomy), Political Science, Philosophy, Business Studies, Environmental Science, Community Planning, Architecture, Natural Sciences (chemistry, biology, biochemistry, microbiology), Computer Science, Community Development. | |

**Table 2 – Summary of Analytical Categories.**

| | Discussion Area | Key Themes |
|---|---|---|
| 1 | How the researcher came to do interdisciplinary research | •Important personal relationship to nature or interest in natural scientific systems<br>•An intellectual journey as a student in which each degree and supervisor-student relationship reflected a different dimension of the persons interest<br>•Intellectual and/or professional circumstances that created an opportunity to work interdisciplinarily<br>•A substantive interest in the ecological, economic and institutional dimensions of the empirical phenomena they studied |
| 2 | Experiences of undertaking a career as an interdisciplinary researcher within academia | •Funding sources and the requirements of funding bodies<br>•The ways in which interdisciplinary research was valued in their specific university and department and how this enabled or constrained their professional opportunities<br>•The perceptions that other academics have of their work<br>•An acknowledgement of the professional costs that have been associated with maintaining careers built upon interdisciplinarity |
| 3 | Pragmatics of doing interdisciplinary research | •Motivations for conducting interdisciplinary research<br>•Practical issues affiliated with conducting interdisciplinary research<br>•Reflections on disciplinary factors that limited or inhibited interdisciplinary collaboration<br>•Reflections on what makes an interdisciplinary collaboration successful<br>•Specific thoughts on the challenges of conducting interdisciplinary work that involves researchers from both the natural and the social sciences |
| 4 | Reflections on working as a scientific researcher within society | •Reflections on science in society<br>•Reflections on being a scientist in society<br>•Reflections on working with communities<br>•Reflections on working with the media |

they had made the decision to work in a university because relative to working in government or industry, the university provided more freedom and intellectual stimulus.

However, the tension between intellectual freedom and the limitations that researchers experienced in the academic context was a recurrent theme. Each research participant had experienced challenges from the university when undertaking interdisciplinary research. Within the university context, however, these came from various levels:

1) ministerial and funding bodies which did not support or could not understand the need for interdisciplinary research;
2) universities that had little enthusiasm for interdisciplinary research;
3) university departments that did not support interdisciplinary research; and
4) colleagues who were hostile to taking an interdisciplinary approach within their particular epistemic community.

Interviewees highlighted the responsibility of the university in promoting intellectual freedom: if a university does not support a research initiative, it tends to fail. Yet, the institutions, which govern action within a university, evolve through multiple interactions between the individuals that belong to the university. Some interviewees expressed their frustration with the way disciplinary institutions continue to be reproduced, often in spite of their efforts to work for change:

> [For university officials an] image of the university was formed in graduate school and they said 'Ah, well the way the university is structured is THIS way'. And I always wondered where did they come up with the idea that that was the ideal structure of the university. It is because that was [the way it was] when they went to university.. So you see, what we take as the normal structure of disciplines and science, teaching and socialization itself is constructed, isn't it? (R1, PhD, Male).

Following this argument, universities appear to be 'manifestations of the power structure' influenced by the same constraints that shape other organisations with less 'intellectual freedom' to say what they want. The same interviewee continued his argument:

> Just because someone works at the university and not on the payroll of Monsanto or Pioneer or whoever, don't assume that they have a better fix on truth than anybody else, right, because universities, research institutions, themselves must get funding from someone - from a foundation, from the government.. (R1, PhD, Male).

Most interviewees shared a preoccupation with the role of the universities. In addition, researchers also expressed their concerns about the influence of other organisations on their research. For example, another interviewee explained that interdisciplinary research was hindered by how funding bodies support research projects and promote the development of new teaching programmes. All interviewees called for shifts in the funding mandates and accreditation systems of university programs. An environmental researcher stated that in Germany, to enable 'real' interdisciplinary research, universities and departments need more autonomy from the Ministries because the latter gives the final approval for new teaching programmes. Another interviewee expressed frustration with national research funding mandates:

> National funding now only supports policy projects and they don't support primary research. (. . .) [But] for the social sciences it is impossible to say that you will just take

> primary research from somewhere else. You can't do that. You need to have your own people who know your own arena in order to be able to analyze what is going on (R2, PhD, Female).

This interviewee seems to suggest that the funding bodies' emphasis on policy projects does not favour interdisciplinary research as it is commonly assumed. Instead, she explains that to participate in policy projects of an interdisciplinary nature, she also needs funding for primary research to create a knowledge base so she can understand 'what is going on'.

Not everything is seen negative, however, as all interviewees had successfully secured funds for conducting interdisciplinary research. However, some research participants suggested that their funding required them to revise their research agendas. This led interviewees to explore different avenues to support their research ranging from funding independent research privately (with one's own funds) while others depended almost exclusively on national research councils.

Yet, interviewees reported examples in which funding bodies' intervention has fostered, not hindered, interdisciplinary research. For example, one ecological economist applauded the German Ministry of Education for commissioning a neoclassical economic research institute to develop an ecologically oriented economic solution to a practical policy issue. This project was a strategic success, as the institute became a more cooperative contributor to sustainable development. In this case the government took responsibility for encouraging the research community to contribute constructively to the sustainable development agenda through the way it distributed its research funds.

In another example, an environmental economist discussed the political and social impact created by an interview in the Financial Times with the Czech Republic President's presentation to the U.S. Senate in which he raised the issue of rights and freedoms within international efforts to address climate change. In her opinion the Czech President challenged the use of scientific knowledge by different interest groups and as a result:

> [He] initiated debate in newspapers about the role of scientists and the role of politicians and about the perception of climate change. And people have started to think about it, to develop arguments, and to discuss it and to present opinions. (...) [I]t has definitely promoted discussion and critical thinking on both sides and got people looking for specific arguments based on the need to convince the other party about the story (R3, PhD, Female).

A sense that interdisciplinary research is widely supported at the policy level, although this support does not necessarily correspond with the specific actions of funding donors and science evaluation organisations, emerges from these interviews. For example, within a university, interdisciplinary research may be officially supported but structurally and ideologically unsupported:

> In my university we have big problems because [it] is still a very traditional organization; it still needs a lot of 'transitioning'. It is very much felt that interdisciplinary cooperation is expected and welcome but in reality it's not (R2, PhD, Female).

Both within funding agencies and higher education institutions it appears that an official commitment to do interdisciplinary research is not sufficient to have such research done. This apparent contradiction points to the resilience of disciplinary institutions to which science refers and explains why researchers may find it challenging working within the interplay between disciplines when conducting interdisciplinary research.

For example, several interviewees had firsthand experience working in university departments that had taken decisions to actively hinder interdisciplinary work. As a consequence, interdisciplinary researchers felt like outsiders and eventually took radical decisions, such as to leave the department of their 'home discipline' in order to work in a more constructive professional environment:

> I left [the department] this year after a process, where I actually had established the teaching programme I wanted to have, but I still felt it became more and more alien to what the department did and wanted to do (R4, PhD, Male).

This interviewee expressed that it was painful to leave his 'home discipline', which continues to act as a reference point for his research.

More formally, interdisciplinary researchers may be threatened by the way their work is evaluated within university promotion and tenure systems. In many countries promotion is linked to the contribution that individual researchers make to their department's ability to attract core funding. Ways in which individual scholars' contributions are ranked include their teaching, departmental service, success in attracting research grants and publishing. All research participants had published in peer-reviewed journals and many also had books in circulation. However, a few interviewees felt that their record of publication was less likely to advance their careers than those of colleagues that had kept their work within one disciplinary tradition. Here again it was observed that the disciplines are perpetuated by the establishment of formally sanctioned rules and expressed, in this case, in the form of reduced performance in career advancement indicators.

### 4.2. *Practice of research*

Considering the difficulties in doing interdisciplinary research and the challenges that interdisciplinary research poses for a scientist's career, one inevitably wonders about what motivates certain people to become involved in interdisciplinary research. Some of the interviewees reflected on this issue when talking about their students and their own responsibility as educators. Interviewees expressed concern about educating students in multiple disciplines because they anticipate that their students will have more difficult career trajectories than peers who choose a traditional path.

At the same time, interviewees emphasised the importance of acquiring appropriate disciplinary training. The notion of postgraduate training as a form of apprenticeship

was also expressed when certain research participants suggested that in order to have an academic career it was important for students to first learn a disciplinary craft. Once they had met all the training standards and succeeded in securing a place in the academy, students could embark on more creative and 'risky' interdisciplinary work.

The opportunity to undertake interdisciplinary research programmes was also regarded as a relatively new option for students. The research participants were university students between the late 1970s and early 1990s and found that typically there were few interdisciplinary programmes during this time. They described undertaking interdisciplinary research via one of three avenues:

1) As a result of being required by employers to work in interdisciplinary teams;
2) As a result of circumstance, for example the need for interdisciplinary collaboration in order to solve a practical problem; or
3) As a result of a conscious effort to work interdisciplinarily because it was felt to be the best way to address a particular issue of concern.

The reasons for continuing to do interdisciplinary research were varied. Some interviewees stated that given the agenda setting activities of universities, they should assume the responsibility to support research designed to generate novel insights, even when it poses challenges to existing political, economic and social institutions. The realisation that universities may somehow be dependent upon vested interests of third party organisations because of their reliance on the funding accessed through them explains why the responsibility for innovation is often transferred from the university to individual researchers. On the other hand, research participants felt that their careers were also rewarding because they enriched their lives both personally and professionally. Interviewees felt that doing what they believed in, mastering a breadth of issues, and developing knowledge and skills that enabled them to combine different types of knowledge was deeply satisfying. The resounding sentiment expressed in the interviews was that if people combine knowledge and have a certain quality of mind and personality they will enjoy conducting interdisciplinary research despite, and because of, its challenges.

Researchers appear to have operational freedom if they remain disciplinary uncommitted. Within this freedom there is not only responsibility for others but also the need to confront one's own preconceptions, disciplinary habits and zones of comfort. In this sense, one of the major challenges to the practice of interdisciplinary research came from the researchers themselves. Interviewees described a 'fear' of doing interdisciplinary research. For example, one interviewee explained that it is disorienting to step beyond one's discipline and into arenas that are conceptually and methodologically unfamiliar:

> If you have a hammer everything is a nail.. when you go beyond that you feel like you are on extremely shaky ground. And I understand it; I have had that feeling myself. But the only way to go about things is to be willing to try to develop new models even though you know that you will not be able to produce in the most famous journals before someone is able to break this new ground (R9, PhD, Male).

Interviewees found several reasons behind that fear of abandoning one's home discipline. The first was becoming inappropriately confident in one's understanding of another discipline:

> The danger that I often am afraid of is that I read two books in a field and then since I see some connections between that field and the one I work with, I feel quite certain I have understood what it is about. So the danger may be that you have simplified things too much (R4, PhD, Male).

The second is losing contact with one's own knowledge. Interdisciplinary work brings researchers together to contribute their own disciplinary knowledge to a collective research project. The goal is therefore to produce greater insight into the subject and not to exclude certain bodies of knowledge:

> In interdisciplinarity the idea is not that you completely outsource the answer to your question and then you say you don't know about it and then you get disconnected from what you do know. That gets dangerous. I think that the point of interdisciplinarity is to work with someone who has better knowledge or a different view and then to try and combine [different points of view] (R5, PhD, Male).

The third is figuring out how to use knowledge one has learned through reading other disciplines without formal training and to use it in such a way that the work as rigorous:

> I have been reading brain sciences lately because I am working on some issues concerning how we choose [as economic agents]. Reading brain science helps me to sort out the question 'is there plurality out there?' So it's a way to try to build a stronger argument.. But [can I use work] from only two groups in brain science? Can I take the chance of going public and saying this? (R4, PhD, Male).

Paradoxically the results seem to suggest that being educated in specific disciplines can enable researchers' to freely pursue interdisciplinary research programmes. This dynamic is clarified when reading interdisciplinarity through the lens of institutional theory. First and foremost, interdisciplinary research cannot exist without the disciplines themselves. As one of the interviewees highlights, the objective of interdisciplinary research is not to become disconnected from one's original discipline(s) but rather to push the boundaries of a discipline, including questioning its main tenets. Creating and working within these tensions cannot be done without understanding what the main beliefs of the discipline are and where the borders of the discipline are drawn. Therefore, interdisciplinary research occurs only within the interplay of disciplines and needs those disciplines as points of reference.

### 4.3. *Interdisciplinary research as a social practice*

A cornerstone of interdisciplinary research for all interviewees was the practice of working collaboratively with people trained in other disciplines. The goal of such collaborations was epistemologically grounded because it was felt that such an approach would enhance their understanding of sustainability issues. As a result, developing strategies for how to best assemble an interdisciplinary research team emerged as a key priority within the practice of conducting interdisciplinary research.

The methods used by research participants to select groups varied. When forming groups, some selected members that they had worked with in the past because through these previous working processes they had the opportunity to evaluate the collaborative strengths of various researchers. Others assembled groups based on their sense that the researchers complemented each other well. Once assembled, in order to develop the group's cohesion the research participants set their groups tasks such as producing deliverables (e.g. a book) before embarking upon larger research projects. Although team members were selected on account of their expertise in various disciplines, all research participants agreed that when assembling a successful interdisciplinary working group the potential candidates' understanding of science was less important than their ability to work collaboratively.

Research participants also addressed the notion that each discipline understands 'context' in a different way. Therefore, to work on interdisciplinary teams people need a basic understanding of the principles of the other disciplines represented in the group.

> Many times we have started to do interdisciplinary work but it becomes evident that people are too narrow in their disciplines and the result is that they put non-connected pieces about one problem on the table. And so sometimes the projects fail or somehow we don't really produce a holistic result (R5, PhD, Male).

Participants felt that researchers should reflect upon their values and be able to defend the validity of them. Reflexivity was also important in that if a scientist is challenged and finds her or his position indefensible then that position requires rethinking:

> We have our own values. The subject area we select is based on our personal values and you can never get away from that. I cannot say that I have a better solution to a question than others [but I have to ask] does it make sense for society? Is this knowledge that society needs? And then the question comes: who judges?

Interviewees suggested that, when working with teams, interdisciplinary collaborators must develop understanding not only at the intellectual level (i.e. a basic agreement about theory and methods) but also at the personal level (i.e. as a person with an open minded character who is willing to re-evaluate pre-conceived notions about an issue). Clearly, the assemblage of a team is central to the successful development of interdisciplinary research.

In contrast, working with colleagues outside of interdisciplinary teams was often met with disinterest, competition and hostility when issues of ideological and theoretical difference came to the fore in departmental business. In one example an interviewee explained why he could not conduct interdisciplinary research with his immediate colleagues:

> . . .[everybody is] guarding their small garden. Many times it's actually for financial reasons and not for scientific reasons. And of course the specificity of my institution also is that this is an organization where either you have natural scientists, so pure natural scientists who don't see any need to co-operate with social scientists, or you have technicians who are, I would say, pure technicians and don't really think about the influence of humans on the techniques. . . (R5, PhD, Male).

This interviewee went on to explain that his colleagues saw little need to look for collaboration beyond their particular disciplinary speciality. In other cases research participants dealt with more direct hostility from colleagues. Words they used to describe how they thought colleagues perceive them included: 'puzzled', 'controversial' and 'I think they hate me'. Hostility was primarily aroused when colleagues felt that a research participant was challenging the fundamental tenets of a discipline.

> People [in my discipline] find people like me inconvenient. They don't know what to do with me because I don't subscribe to the catechism. You know what, a discipline is more like a religion where you come into a community and adhere to the rules of community and you agree to live by them, to abide by them (R1, PhD, Male).

The interviewee perceives here that colleagues are hostile towards him because his research challenges the conventions of their discipline. As the researcher explains, disciplines have norms not only for knowledge production but also for guiding the interaction of researchers within the community. This results in the creation of 'disciplinary camps'. For example, an interviewee described the relationship between Ecological Economics and Environmental Economics, two sub-disciplines apparently concerned with the same objects of study:

> [T]here is an International Society for Ecological Economics. There is also an Association for Environmental and Resource Economics. These are two different tribes and they rarely speak to one another. So you take your pick, which tribe are you are going to belong to? So I belong to both. And so what that means is that the environmental resource economists have decided that they will ignore me (R1, PhD, Male).

### 4.4. *Cross-referencing between disciplinary and interdisciplinary research*

The interviewees can be roughly divided in two groups according to how they understood themselves to be interdisciplinary. One group described themselves as interdisciplinary scholars because they had studied more than one

discipline and therefore possess the ability to combine at least two disciplinary views when conducting their own work. The other group described themselves as being rooted in one discipline and using diverse intellectual activities to enhance their understanding of practical problems to communicate effectively with colleagues working in other fields. This second group of researchers felt that people have to understand their own craft in order to solve problems and make valuable contributions to collective initiatives:

> [To solve problems we need] people who are extremely deep and competent in a discipline, in an epistemic community, but who can talk with respect to people from other epistemic communities. So in that sense I am a believer in multi-disciplinary work for problem solving but disciplinary work for creating epistemic understanding. But understand that creating an epistemic community is different from solving the problem of sustainability, or GMO crops or something else. So we need both. (R1, PhD, Male).

One researcher recommended that interdisciplinary groups should have a balanced representation of disciplines as this may encourage an ethos of equal respect for all the disciplinary institutions represented in the group. This group composition may also enhance and facilitate communication and group learning:

> At least a quarter of the members of your group should understand what you are talking about. Then you can explain it to the rest of the people. But of course you have the learning process. But you need to have somebody else who is helping you to get messages across (R2, PhD, Female).

Understanding the academic milieu as well as the ontological, epistemological, and methodological orientations of colleagues were key ingredients of successful interdisciplinary collaborations. Research participants highlighted four ways in which this disciplinary understanding becomes important:

1) Understanding the preoccupations of each member of a team when developing concrete solutions. For example, one environmental economist expressed frustration because the costs and benefits she had identified for various scenarios were not considered important by ecologists and thus, the collaboration broke down;
2) Understanding the methodological tools available within each discipline, which helped researchers building realistic expectations about what a particular discipline has the capacity to address;
3) Understanding the conversations each discipline is having about the subject being studied;
4) Understanding the professional costs and benefits for team members of doing interdisciplinary research and using this information to develop deliverables and/or publications that facilitate the career development of all team members.

Disciplines are, therefore, a point of reference for interdisciplinary research in that not only do they provide the researcher with a foundation of knowledge but they also set rules of communication between researchers. At the same time part of the frustration in doing interdisciplinary research was related to the need to transcend disciplinary institutions by creating new frames of reference for research:

> So it needs to become something new that combines social and ecological aspects or social research and ecological research and brings them together with other concepts which are familiar in both cases but that build [an understanding of] the concept using a new approach and to make sure that none of them dominate (R2, PhD, Female).

Within the context of research for sustainable development, developing trust between natural and social scientists is deemed important because creating a conceptual framework using one science and inserting knowledge from another does not work in practice. Some felt that new frameworks were needed because existing disciplinary institutions did not allow for finding a middle ground between the disciplines:

> It is not such a problem to be interdisciplinary as long as you are working with the same methods. In the natural sciences they work more or less with the same methods and in the social sciences, again, the methods are similar. But when you bring the natural and social sciences together the methods change, the scales are different. So that is why I think that interdisciplinarity is difficult work, it is difficult to create a paradigm that the sciences can share (R5, PhD, Male).

This quote suggests that existing disciplines may not be providing space needed for interplay; hence interdisciplinary research is challenging. Similarly, many interviewees expressed their concern that truly interdisciplinary research would require going beyond conventional disciplines and creating new research institutions—new norms, new rules, and new conventions to guide collaboration.

## 5. Discussion and conclusion

Within the interviews conducted, research participants highlighted the dependence of interdisciplinary research on disciplinary institutions at three levels: 1. organisational (university, research organisations, funding bodies), 2. research community (research colleagues, and project team members) and 3. individual practices. Disciplinary institutions regulate which questions to ask, theories and methods to be employed in which context and which truth claims to make (see Bromley, 2006; Pickering, 1995). In this study, the empirical data suggests that disciplines set rules for behaviour within interdisciplinary communities.

The research practice appears to be shaped by explicit norms embedded in the discipline. Some of them influence the career of the researcher (e.g. the need for formal education within a discipline, the structures of promotion and recognition). Other explicit norms are related to the research practice, particularly regarding the range of applicable methodologies

and the rules to implement them. Finally, explicit norms embedded in disciplines influence the relationship of the researcher with institutions at other organisational levels. For example, funding structures may be shaped according to disciplinary conventions. Some interviewees explained that interdisciplinary work depended on funding for primary research alongside project-based funding, because this was needed to develop the researchers' knowledge base. In addition, the research practice may also be shaped by implicit conventions, some of which could be very specific to each particular discipline. Some of these conventions appear to govern what is considered acceptable knowledge within a particular discipline and the limits of intellectual freedom.

Some researchers referred to the research as a craft, and described the process of acquiring research skills as an apprenticeship. This suggests that research requires not only mastering the knowledge and norms of disciplines but also learning other practices established by usage and disciplinary habits, customary conventions that are not necessarily embedded in textbooks. Some of these 'craft skills' were considered essential for the success of interdisciplinary research: familiarity with concepts and methods, the ability to both defend and criticise one's own discipline(s) and the need to understand the full complexity of problems appears to require a good understanding of the disciplinary field.

This analysis suggests that disciplinary institutions may question both the validity of the results of the interdisciplinary researcher and the ethos of these researchers. The effects of this intra-community regulation are related to the dissatisfaction that interdisciplinary researchers experience with respect to disciplinary institutions. The interviewees suggested that doing interdisciplinary research may distance the researcher from their 'home discipline' and this could pose an obstacle for their career because recognition structures are discipline-based. However, interviewees also felt rewarded by their involvement in different fields, the achievement of a more original type of knowledge and the belief that their research reflects their values (see also Brewer, 1999; Campbell, 2005; Chen, 1981; Forman and Markus, 2005; Scerri, 2000). Individual researchers can overcome institutional constraints encountered when doing interdisciplinary research as individuals or in groups. This empirical research shows examples of how researchers have adapted their particular situations to carry out the research that they considered worthwhile.

The findings of this paper support the hypothesis that interdisciplinary researchers operate within the horizontal interplay between disciplines because they bring the norms, conventions and rules of their own discipline(s) to the interdisciplinary research. At the interplay disciplines may share some norms and conventions. The researchers will need to explain their discipline's conventions and engage with the criticisms from other disciplines. Following their interdisciplinary research experience, interviewees pointed out some necessary qualities of the interdisciplinary researcher, which can be regarded as emerging conventions within interdisciplinary research. The capacity to work collaboratively and an ethos of respect for other disciplines were described as essential characteristics of interdisciplinary researchers.

Both the literature and the empirical data suggest that vertical interplay with other social institutions play an important role in shaping interdisciplinary research practices alongside horizontal interplay (see also Hollingsworth and Hollingsworth, 2000). Although the data suggests that this may not be always rewarding or effective, interviewees explain that they can take advantage of alternative institutional arrangements within the state and civil society in order to advance their particular research objectives, for instance, by targeting specific funding agencies (see also Nowotny et al., 2006; Klein, 1996; Turpin and Garrett-Jones, 2000).

In summary, the results of this study suggest, in line with Bromley (2006), Mittelstraß (2001) and Klein (1996), that the integrity of disciplinary traditions remains important for interdisciplinary research, because interdisciplinary research occurs with reference to disciplines. Disciplinary institutions appear to be necessary for both guaranteeing the foundations of knowledge and providing a common ground for communication with colleagues. The analysis suggests that at the interplay between disciplines – with disciplinary institutions serving as reference points – interdisciplinary researchers have the freedom to challenge the conventions of their own discipline and produce innovative research.

Some interviewees claimed that new frameworks were needed to understand interdisciplinary research. Some of them went further to defend that interdisciplinary research should transcend more traditional disciplinary research. This resonates with several calls for re-definition of modern epistemic institutions found in the literature (e.g. Klein, 1996; Nowotny et al., 2006; Lessard, 2007). It appears that new interdisciplinary institutions are needed to provide an exclusive space for interdisciplinary research. Klein (2000) explains that once the requirements of interdisciplinarity are formalised, new institutions move from the margins to the centre and become, de facto, a new institutionalised hybrid discipline (Klein, 2000). This suggests that formalisation would displace interdisciplinarity from the interplay between institutions. The hypothesis that emerges is that the formalisation of interdisciplinary research may compromise its capacity to challenge current states of affairs and generate critical experimental spaces within which knowledge related institutions can be redefined (see also De Mey, 2000).

The results suggest that there is a fruitful interaction between disciplines and interdisciplinary research. Thus, it appears that policies establishing formal norms to regulate or facilitate interdisciplinary research could be unproductive if they lead to the demise of interplay among disciplines. On the other hand, interdisciplinary research appears to have an important role to play in challenging disciplinary institutions. As the analysis of the interviews suggests, interdisciplinary research may help challenging disciplinary boundaries and questioning the foundations of each discipline.

The results of this research need to be treated with caution because they are based upon exploratory research among nine researchers. However, it shows that the institutional approach is a valid perspective to study disciplines and interdisciplinary research. Further empirical research could contribute to explain the role of disciplinary institutions in shaping research practices.

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## REFERENCES

Aram, J.D., 2004. Concepts of interdisciplinarity: configurations of knowledge and action. Human Relations 57 (4), 379–412.

Benner, M., Sörlin, S., 2007. Shaping strategic research: power, resources and interests in Swedish research policy. Minerva 45, 31–48.

Bourke, P., Butler, L., 1998. Institutions and the map of science: matching university departments and fields of research. Research Policy 26, 711–718.

Brewer, G.D., 1999. The challenges of interdisciplinarity. Policy Sciences 32, 327–337.

Bromley, D.W., 2006. Sufficient Reason: Volitional Pragmatism and the Meaning of Economic Institutions. Princeton University Press, Princeton.

Bromme, R., 2000. Beyond one's own perspective: the psychology of cognitive interdisciplinarity. In: Weingart, P., Stehr, N. (Eds.), Practicing Interdisciplinarity. University of Toronto Press, Toronto, CA.

Bruce, A., Lyall, C., Tait, J., Williams, R., 2004. Interdisciplinary integration in Europe: the case of the Fifth Framework Programme. Futures 36, 457–470.

Campbell, L.M., 2005. Overcoming obstacles to interdisciplinary research. Conservation Biology 19 (2), 574–577.

Chen, R.S., 1981. Interdisciplinary research and integration: the case of $CO_2$ and climate. Climatic Change 3, 429–447.

Chompalov, I., Genuth, J., Shrum, W., 2002. The organisation of scientific collaborations. Research Policy 31, 749–767.

De Mey, M., 2000. Cognitive science as an interdisciplinary endeavour. In: Weingart, P., Stehr, N. (Eds.), Practicing Interdisciplinarity. University of Toronto Press, Toronto, CA.

Forman, J., Markus, M.L., 2005. Research on collaboration, business communication, and technology: reflections on an interdisciplinary academic collaboration. Journal of Business Communication 42 (1), 78–102.

Frs, H., 1962. Institutional means of collaboration between the social sciences. Social Science Information 1, 5–22.

Geertz, C., 1980. Blurred genres: the reconfiguration of social thought. American Scholar 42 (2), 165–179.

Good, G.A., 2000. The assembly of geophysics: scientific disciplines as frameworks of consensus. Studies in History and Philosophy of Modern Physics 31 (3), 259–292.

Griffin, G., 2006. Balancing agendas: social sciences and humanities in Europe. Arts and Humanities in Higher Education 5, 229–241.

Haas, P.M., 1992. Epistemic communities and international policy coordination. International Organization 46 (1), 1–35.

Heathington, K.W., Cunningham, J.L., Mundy, R.A., 1978. Management of interdisciplinary research in universities: the state of the art. Educational Researcher 7 (1), 11–14.

Hicks, D.M., Katz, J.S., 1996. Where is science going? Science Technology and Human Values 21 (4), 379–406.

Hollingsworth, R., Hollingsworth, E.J., 2000. Major discoveries and biomedical research organizations: perspectives on interdisciplinarity, nurturing leadership, and integrated structures and cultures. In: Weingart, P., Stehr, N. (Eds.), Practicing Interdisciplinarity. University of Toronto Press, Toronto, CA.

Hukkinen, J., 2003. From groundless universalism to grounded generalism: improving ecological economic indicators of human-environmental interaction. Ecological Economics 44, 11–17.

Jakobsen, C.H., Hels, T., McLaughlin, W.J., 2004. Barriers and facilitators to integration among scientists in transdisciplinary landscape analyses: a cross-country comparison. Forest Policy and Economics 6 (1), 15–31.

Klein, J.T., 1996. Crossing Boundaries. Knowledge, Disciplinarities, and Interdisciplinarities. University Press of Virginia, Carlottesville and London.

Klein, J.T., 2000. A conceptual vocabulary of interdisciplinary science. In: Weingart, P., Stehr, N. (Eds.), Practicing Interdisciplinarity. University of Toronto Press, Toronto, CA.

Klein, J.T., 2004. Prospects for transdisciplinarity. Futures 36 (4), 515–526.

Klein, J.T., 2006. Afterword: the emergent literature on interdisciplinary and transdisciplinary research evaluation. Research Evaluation 15 (1), 75–80.

Knorr-Cetina, K., 1982. Scientific communities or transepistemic arenas of research? A critique of quasi-economic models of science. Social Studies of Science 12, 101–130.

Kuhn, T., 1962. The Structure of Scientific Revolutions. University of Chicago Press, Chicago.

Latour, B., 1998. From the world of science to the world of research? Science 280 (5361), 208–209.

Lau, L., Pasquini, M., 2008. 'Jack of all trades'? The negotiation of interdisciplinarity within geography. Geoforum 39, 552–560.

Lessard, C., 2007. Complexity and reflexivity: two important issues for economic evaluation in health care. Social Science & Medicine 64 (8), 1754–1765.

Lubchenco, J., 1998. Entering the century of the environment: a new social contract for science. Science 279, 491–497.

Luks, F., Siebenhüner, B., 2007. Transdisciplinarity for social learning? The contribution of the German socio-ecological research initiative to sustainability governance. Ecological Economics 63 (2–3), 418.

Max-Neef, M.A., 2005. Foundations of transdisciplinarity. Ecological Economics 53 (1), 5.

McCorcle, M.D., 1982. Critical issues in the functioning of interdisciplinary groups. Small Group Research 13 (3), 291–310.

Mittelstraß, J., 2001. Wissen und Grenzen. Philosophische Studien. Suhrkamp Verlag, Frankfurt/Main.

Newman, M.E.J., 2001. The structure of scientific collaboration networks. PNAS 98 (2), 404–409.

Nowotny, H., Scott, P., Gibbons, M., 2006. Re-thinking Science–Knowledge and the Public in an Age of Uncertainty. Polity Press, Cambridge.

Petrie, H.G., 1976. Do you see what I see? The epistemology of interdisciplinary inquiry. Journal of Aesthetic Education 10 (1), 29–43.

Petts, J., Owens, S., Bulkeley, H., 2008. Crossing boundaries: interdisciplinarity in the context of urban environments. Geoforum 39 (2), 593–601.

Pickering, A., 1995. The Mangle of Practice. The University of Chicago Press, Chicago and London.
Pierce, S.J., 1999. Boundary crossing in research literature as a means of interdisciplinary information transfer. Journal of the American Society for Information Science 50 (3), 271–279.
Pohl, C., 2005. Transdisciplinary collaboration in environmental research. Futures 37, 1159–1178.
Porter, A.L., Rossini, F.A., 1985. Peer review of interdisciplinary research proposals. Science, Technology and Human Values 10 (3), 33–38.
Ramadier, T., 2004. Transdisciplinarity and its challenges: the case of urban studies. Futures 36 (4), 423.
Scerri, E.R., 2000. Interdisciplinary research at the Caltech Beckman Institute. In: Weingart, P., Stehr, N. (Eds.), Practicing Interdisciplinarity. University of Toronto Press, Toronto, CA.
Sundberg, M., 2007. Mobilizing networks: the researcher roles in atmospheric science. Acta Sociologica 50 (3), 271–282.
Tress, G., Tress, B., Fry, G., 2006. Publishing integrative landscape research: analysis of editorial policies of peer-reviewed journals. Environmental Science & Policy 9 (5), 466.
Turner, S., 2000. What are disciplines? And how is interdisciplinarity different?. In: Weingart, P., Stehr, N. (Eds.), Practicing Interdisciplinarity. University of Toronto Press, Toronto, CA.
Turpin, T., Garrett-Jones, S., 2000. Mapping the new cultures and organization of research in Australia. In: Weingart, P., Stehr, N. (Eds.), Practicing Interdisciplinarity. University of Toronto Press, Toronto, CA.
Vatn, A., 2005. Institutions and the Environment. Edward Elgar Publishing, Cheltenham, UK.
Vincenti, V.B., 2005. Family and consumer sciences university faculty perceptions of interdisciplinary work. Family and Consumer Sciences Research Journal 34 (1), 80–103.
Weingart, P., Stehr, N., 2000. Practicing Interdisciplinarity. University of Toronto Press, Toronto, CA.
Weingart, P., 2000. Interdisciplinarity: the paradoxical discourse. In: Weingart, P., Stehr, N. (Eds.), Practicing Interdisciplinarity. University of Toronto Press, Toronto, CA.
Wynne, B., 1996. May the sheep safely graze? A reflexive view of the expert-lay knowledge divide. In: Lash, S., Szerszynski, B., Wynne, B. (Eds.), Risk, Environment and Modernity: Towards a New Ecology. Thousand Oaks, Calif, Sage, London.
Young, O.R., 2002. The Institutional Dimensions of Environmental Change—Fit, Interplay and Scale. The MIT Press, Cambridge, Massachusetts.

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