

Research Article

Clarifying integrative research concepts in landscape ecology

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Abstract

Integrative research approaches are intensely discussed in landscape ecology, in academia and in research policy. However, confusion over the terminology hampers communication. Many current landscape ecological research projects have difficulties to agree on a common understanding of the core concepts associated with different forms of integrative research. This is also evidenced by the lack of discussion of integrative research concepts in published papers. This hinders integration in research projects and makes the comparison and evaluation of the outcomes of different research concepts impossible. This paper discusses and defines the meanings of interdisciplinary and transdisciplinary (= integrative) research approaches to ease discourse on their application in landscape ecological research. It reviews definitions of the concepts found in the research literature and develops definitions of integrative and associated research concepts (disciplinarity, multidisciplinarity, interdisciplinarity and transdisciplinarity) based on their degree of disciplinary integration and involvement of non-academics. Integrative concepts are viewed as a continuum rather than as fixed categories. The paper discusses the need to develop integrative theory and methods and argues that we should be more explicit when using integrative research concepts in project proposals, project work and publications. Finally, the paper reflects on the ongoing discussion in landscape ecology concerning whether it is developing from an integrative research field towards a discipline in its own right.

Introduction

This paper aims to contribute to an improved understanding of the differences between the concepts of multidisciplinarity, interdisciplinarity and transdisciplinarity and thus contributes to a more precise application of these concepts in landscape

ecology. This is intended to ease communication and information exchange within and between integrative research approaches. For this paper, we use the term “integrative research concepts” when referring to both interdisciplinary and transdisciplinary approaches, following Winder (2003).

Integrative research concepts are increasingly important in landscape ecological research. This is clearly evidenced by the inclusion of sessions and workshops on interdisciplinarity and transdisciplinarity at recent IALE meetings (US-IALE 19th Annual symposium in Las Vegas in 2004, 6th IALE World Congress in Darwin in July 2003, IALE European Conference in Stockholm/Tartu in June/July 2001, 5th IALE World Congress in Snowmass in July/August 1999). In addition, numerous landscape researchers have argued for a more integrative approach in landscape ecology (Naveh and Lieberman 1994; Nassauer 1995; Zonneveld 1995; Hobbs 1997; Brandt 2000; Décamps 2000; Klijn and Vos 2000; Palang et al. 2000; Haberl et al. 2001; Naveh 2001; Wu and Hobbs 2002; Buchecker et al. 2003; Field et al. 2003; Mander et al. 2004). The main driver for the increase in integrative research has been the demand for integrative research approaches by national and international funding agencies (Forskningsrådene 1994; MRIT 1995; BMBF 1996; BMWV-KK 1999; European Commission 2001, 2002; Forskningsstyrelsen 2002; NWO 2002).

Although there is an increasing interest in multidisciplinary, interdisciplinarity and transdisciplinarity, there remains a lack of common understanding in landscape ecology and the wider scientific community of what these research concepts mean. The following section will explain the importance of clarifying integrative research concepts in landscape ecology. We present evidence for the lack of a common understanding of these concepts in current landscape ecological research and provide an overview of consequences of this for research projects and research evaluation. We briefly overview of the emergence of integrative research concepts in academia and their emergence in landscape ecology before we discuss the different meanings of integrative research concepts and propose our own definitions of these concepts. These definitions should not be misinterpreted as an attempt to promote a single, fixed and exclusive view on such concepts. The aim is to make our own understanding explicit to enable others to join the discussion. We argue that it is important to be explicit about the content of the concepts and that we should avoid using them as loose labels attached to research projects.

Finally, we discuss the meaning of integrative research concepts in landscape ecological research

and reflect critically on theoretical and methodological questions of applying integrative research concepts in landscape ecology. The benefits and disadvantages of applying integrative research in landscape ecological research are discussed in more detail in Jakobsen et al. (2004), Tress et al. (in press), and Fry et al. (in press).

The lack of common understanding of integrative research concepts in landscape ecology

We have identified a clear lack of a common understanding of integrative research concepts in landscape ecological research. This lack of common understanding is demonstrated by findings from an international online survey of the INTELS project (see <http://www.intels.cc>). The survey included 232 landscape researchers involved in integrative landscape projects during a 12 months survey-period. Only completed projects were included in the survey. Respondents were from 28 countries covering Europe, America, Australia, Asia and Africa.

The results of the survey revealed that in only 47% of the integrative landscape projects surveyed had the members of the project reached a common agreement on these concepts, although 81% of the researchers stated that they had discussed the concepts of interdisciplinarity or transdisciplinarity with other participants in their projects. This lack of common understanding is a frequent barrier to integration of disciplines in landscape projects. On a list of 12 types of possible barriers for integration 'lack of common understanding' was ranked as second biggest barrier to the integration of disciplines and 42.2% of the respondents perceived the lack of common terminology as either a strong or very strong barrier. Also the studies of Jakobsen et al. (2004) and Tress et al. (in press), using qualitative interviews with researchers involved in integrative landscape projects in several European countries and USA, identify the lack of a common terminology as a major obstacle to integration.

The lack of a common understanding is also reflected in research outputs. We reviewed journal papers published by landscape ecologists, who explicitly state that they use integrative research concepts in their studies. However, the methods used in the papers were not explained in sufficient

detail to identify what the integrative concepts meant to them or how they operationalized integration in their studies. Missing clarification of how the terminology is used can be found for instance in the papers of Akinbami et al. (2003) proposing an integrative strategy for forest–energy–environment interactions, Hostetler (1999) suggesting several research questions for interdisciplinary efforts to analyze the effects of human decisions on bird communities, Capra et al. (2002) presenting a multidisciplinary approach for landscape archaeology studies, Peterseil et al. (2004) researching ecological sustainability of agricultural landscapes by combining remote sensing data with a landscape ecological field survey, Ewan et al. (2004) and Eliasson (2000) reporting on interdisciplinary studies on building ecology and planning as well as climatology and urban planning, and Bettinger (2001) discussing challenges and opportunities associated with using forest vegetation growth and yield models and databases in large-scale, integrated landscape planning projects. Naveh's (2000) conceptual introduction to holistic landscape ecology is a plea for more integrative research but does not explicitly define the proposed approaches. Burel and Baudry (1995) as well as Lavery et al. (1996) report on work done on interdisciplinary research questions: Burel and Baudry (1995) approached social, aesthetic and ecological aspects of hedgerows in rural landscapes for promoting an interdisciplinary research approach in studies of selected landscapes, Lavery et al. (1996) discuss older peoples' mobility and travel in relation to street design and management from an interdisciplinary perspective, however neither study defines the terminology or explains how integration was approached. We can find a similar trend in the papers from Bürgi and Russell (2001), Burley (1995), Clemetsen and Van Laar (2000), Fohrer et al. (2002), Hadac (1977), Höchtl et al. (in press), Johnson (1995), Pickett et al. (in press), Poiani et al. (1998), Van Mansvelt (1997) and others who promote integrative approaches without making explicit what the concepts include.

All papers are examples of the broad spectrum of landscape ecological research and in all papers explicit reference was made to the use of integrative research concepts. However the concepts are not fully explained and in some cases the terms were used inconsistently or exchangeably. A broad variety of terms is used in research papers to

describe different degrees of interaction between disciplines including terms such as interactive, collaborative, integral, integrated, complementary, combined, participatory, transepistemic, trans-professional, system-oriented, comprehensive, problem-oriented, cross-boundary, holistic, multidisciplinary, crossdisciplinary, interdisciplinary, and transdisciplinary. Yet, a clear understanding of the research concepts cannot be derived from most of the publications we have examined.

The consequences of a lack of clear definitions of integrative research modes are very serious for the evaluation of landscape ecological research. If researchers are using the concepts differently, it becomes impossible to compare and evaluate the outcomes of different research approaches. We urgently need this comparison to justify our investment in different integrative research approaches, to have realistic expectations of their products and define their potential and limitations. Lack of a common understanding of what is meant by different integration concepts will also hinder communication between project participants. This will be a hurdle to achieving a general agreement over the project's ambition levels regarding the degree of integration to be achieved. As a consequence of not being able to reach a general understanding of integrative concepts, some projects may give up all ambition to realize integration and return to disciplinary groupings. This effect is also shown by Mercer (2000) and Nicolini (2001). Because researchers and authors of journal papers use the concepts inconsistently with widely varying meanings, it is difficult to present examples for the different research concepts from the field of landscape ecology.

The emergence of integrative concepts in academia

The discussion and application of integrative research concepts is not originated from the landscape ecology field, but from general trends in academia that are briefly reported here. During the late 1960s and the 1970s, discussions about interdisciplinarity and transdisciplinarity began as a critique of the autonomous and elitist approaches of science and higher education. Arguments against the specialization of knowledge are as old as the scholarly disciplines themselves. The idea of shaping knowledge into disciplines was critically

discussed in the eras of Aristotle, Copernicus, Kepler, Newton, Bacon, Descartes, Kant and Humboldt – although with different understandings of what constitutes a discipline – as described by Klein (1990) and Moran (2002) in more detail.

The term “interdisciplinarity” appeared in the 1920s, but according to Frank (1988) and Lattuca (2001) first became widely used after World War II. In the 1960s and 1970s, discussion on interdisciplinarity focused on the perceived inability of disciplinary specialization to solve societal problems. A landmark was the first international conference on scientific approaches crossing disciplinary boundaries, organized in 1970 by the OECD in France. A new vocabulary of disciplinary interactions – multidisciplinary, interdisciplinarity and transdisciplinarity – emerged from the contributions to this conference (CERI 1972; Klein 2001). A major critique expressed at the OECD meeting was the missing link between science and society. Science was perceived as inflexible and unable to cope with societal demands. As a result, new scientific approaches were demanded to face this challenge. Physician Erich Jantsch attended the OECD conference and was particularly influential in setting the parameters of the debate. One of his main criticisms was that knowledge is collected through a variety of disciplines, each one fixed on a search for assumed inherent organizing principles and criteria and valid *a priori* and independent of social activity. This criticism links also to the debate on reductionism versus holism in science that came up in the 1980s, but this debate is not followed up here; for more details see Rowe (1997) and Alrøe and Kristensen (2002). During the 1990s, Gibbons et al. (1994) reinforced the radical statements of the 1970s by claiming that the most important findings and solutions in the future will no longer be produced by academic disciplines.

In the following sections, we refer to Jantsch (1970, 1972) because he had a major influence on the development and understanding of integrative concepts in landscape ecology and other fields. Jantsch is one of the few authors who developed a coherent framework including multidisciplinary, interdisciplinarity and transdisciplinarity and their implications on research. He aimed to provoke a general paradigm shift in academic research and education, one that would impel a restructuring of the academic system over time. In contrast, our

definitions illustrate the different modes of (inter-) disciplinary interaction that can be realized in landscape ecology projects under the research system as it is currently structured.

The emergence and development of integrative concepts in landscape ecology

In the field of landscape ecological research, the debate about interdisciplinarity and transdisciplinarity started in the late 1970s inspired by the discussion in general academia. Again, most authors using the concepts in landscape ecology refer to Jantsch (1970) and early initiatives in ecology during the 1970s by Young (1974), Bierter (1975), and Schultz (1977). Naveh (1978) was the first to introduce landscape ecology as the interdisciplinary scientific basis for environmental education. Naveh and Lieberman (1984) promoted the replacement of conventional discipline-oriented scientific paradigms by transdisciplinary approaches and methods.

Di Castri and Hadley (1986) reflected on the way interdisciplinarity was approached in land use planning projects and concluded that interdisciplinarity can result in a unique array of products, useful to both science and society. They also discussed practical and epistemological obstacles to achieving interdisciplinarity. Wright (1987) was the first to point out that there could be no true interdisciplinarity in land research without specific, integrating concepts and methods. Since these examples, discussion has mainly focused on the long-term development of landscape ecology as an interdisciplinary or transdisciplinary field of research. In this sense, Zonneveld (1988) regarded landscapes as holistic entities which have to be studied “in the emerging transdisciplinary science of landscape ecology” (p. 10). Burel and Baudry (2003) suggested that the motivation for more integrative landscape research projects in the 1970s and 1980s was a reaction to increasing awareness of the need to solve environmental problems and threats to ecosystems.

The literature of the 1990s brought a sharp increase in the number of integrative landscape research projects as documented by Höll and Nilsson (1999), Brandt (2000), Fry (2001), Tress and Tress (2002), Tress et al. (2003c), and Tress et al. (in press). Growing public concern about

environmental issues and the introduction of the concept of sustainability demanded an integrated view of environmental problems, one combining social, economic and ecological perspectives. Leading landscape ecologists, such as Naveh (1991, 1995), Hobbs (1997), Décamps (2000) and others, took up this debate. Several authors such as Moss (2000), Fry (2001), Hobbs and Lambeck (2002), and Opdam et al. (2002) discussed the difficulties of achieving the expectations placed on integrative approaches and their application in landscape ecology. For landscape ecology, this discussion was part of the wider debate on the definition of landscape ecology as either a discipline in its own right or as an interdisciplinary research field as discussed by Wright (1987), Wiens (1999), Moss (2000), and Bastian (2002).

The demand for integrative research is reflected in the topics of recent landscape research projects (results of the INTELS survey, see <http://www.intels.cc>). These include land use history and plant diversity, conservation and management of pastoral landscapes, human impact on landscapes, biodiversity on arable and fallow lands, planning and integrated management of the countryside, restoration or planning of local landscapes (e.g., river valleys or floodplains, mountain sites, woodlands and wetlands), holistic management of national parks and the values of landscape elements such as meadows, ponds and hedgerows from ecological, agro-economic and experience perspectives.

The projects covered a wide range of thematic fields and mostly dealt with combined aspects of nature and culture or human use of land. They thus involved disciplines not only from the natural sciences, but also from social sciences and humanities. Stakeholders were involved in assessing and discussing values of landscape elements and landscape preferences, or they collaborated with researchers to achieve a defined development or restoration goal for a certain landscape.

Overview on integrative research concepts

We propose the use of four concepts when referring to disciplinary interactions in landscape ecology projects: disciplinarity, multidisciplinarity, interdisciplinarity and transdisciplinarity (see Figure 1). Our operational definitions derive from

participation in interdisciplinary and transdisciplinary landscape research and experiences from the INTELS project (Interdisciplinarity and Transdisciplinarity in European Landscape Studies, see <http://www.intels.cc>). The main differences between these proposed concepts are, first, the intensity of cooperation and integration of disciplines and, second, the involvement of non-academic fields. We present an overview of these differences in Figure 2, including also the participatory approach, which is not necessarily a research concept but is discussed under the section of transdisciplinarity because it is frequently used in this context. Disciplinarity is not included in Figure 2 but introduced as a separate concept because it provides an important building block for the integrative approaches.

As well as contrasting our proposed definitions with those of Jantsch, we include the views of other experts in integrative research from outside the field of landscape ecology to broaden the context of a critical reflection on integrative research by including work carried out in other academic areas, yet might offer important lessons for landscape ecology.

Disciplinarity

We suggest that *disciplinary* research be defined as projects that take place within the boundaries of currently recognized academic disciplines, while fully appreciating the artificial nature of these bounds and the fact that they are dynamic. The research activity is oriented towards one specific goal, looking for an answer to a specific question.

Landscapes are not exclusively possessed by any one discipline. They are rather a focal point for several disciplinary research fields, each investigating landscapes from a different disciplinary perspective. In landscape ecological research, many projects take place within the bounds of one discipline (e.g., ecology, biology, hydrology, history, archaeology) and focus in depth on one particular aspect of landscapes. Due to their chosen disciplinary research topic, these projects need not cooperate with other disciplines. Instead, the researcher focuses on a specific question within one discipline.

In a disciplinary approach, no systematic relations or conceptual exchange occurs between

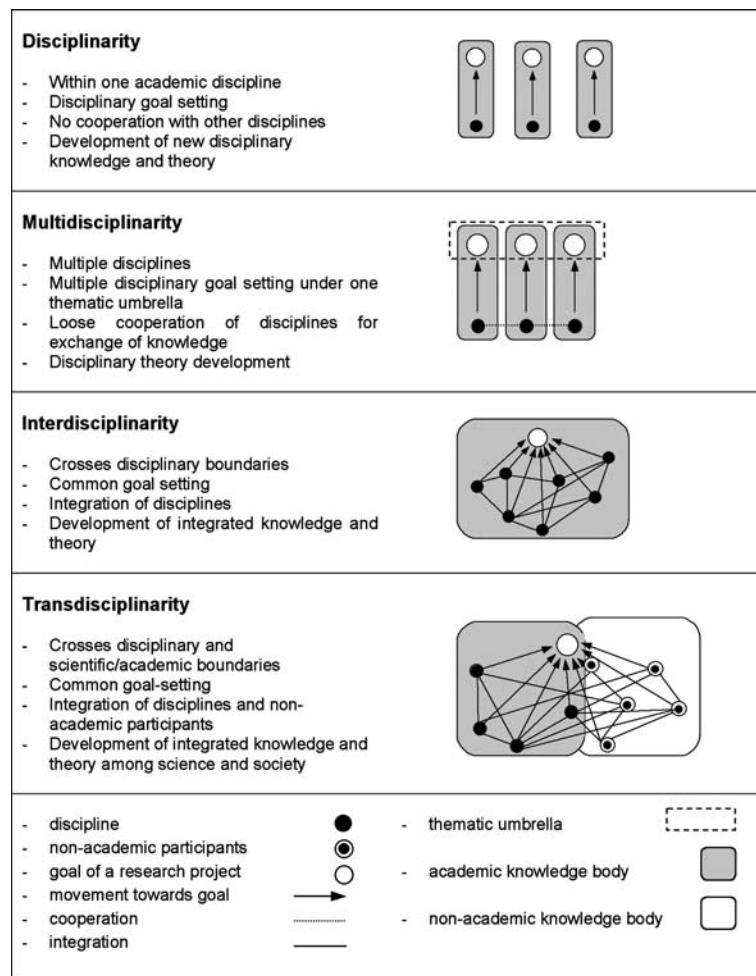


Figure 1. Overview of research concepts: disciplinary, multidisciplinary, interdisciplinarity and transdisciplinarity.

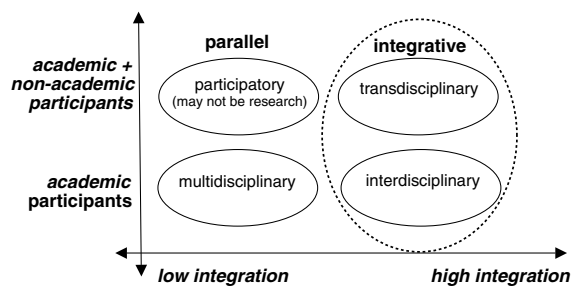


Figure 2. Degrees of integration and stakeholder involvement in integrative and non-integrative approaches.

disciplines (see Figure 1). A disciplinary approach is applied when research is conducted according to the rules and sets of assumptions of one discipline

(e.g., ecology, biology, hydrology or geography) and by members of this discipline.

A *discipline* has its own coherent set of tools, methods, procedures, concepts and theories. Over time, disciplines are shaped by external conditions and internal intellectual demands. Disciplinaryity is a product of the historical development of science and has only been known in its current organizational form since the 19th century as described in more detail by Mittelstrass (1993), Gibbons et al. (1994), and Moran (2002). Disciplines organize experiences into a certain world view. They work within a specific framework of beliefs and criteria for truth and validity that limits the kinds of research questions that can be asked. Form, organization and scope of disciplines can vary enormously and influence the meaning and

boundary of the discipline (Klein 1990). To Winder (2003), disciplines are fixed, governable institutionalized conventions whereas knowledge communities may cross institutional boundaries and are more flexible and dynamic.

The boundaries of disciplines are dynamic and result from differences between disciplines, researchers, languages, types of knowledge, institutions and fields of research as described by Weingart (1997), Moran (2002), and Van Assche (2003). As Winder (2003) points out, some boundaries are more difficult to cross than others, and sometimes boundaries between sub-disciplines can be harder to cross than those between unrelated disciplines. Many of today's disciplines were considered sub-disciplines a decade ago (Defila and Di Giulio 1998). New disciplines and sub-disciplines appear and old ones disappear, reflecting changes in knowledge cultures as well as institutional and financial frameworks.

Multidisciplinarity

Another mode of disciplinary interaction is multidisciplinary research. We suggest applying the term *multidisciplinarity* to research efforts of different academic disciplines that relate to a shared goal, but with multiple disciplinary objectives. Participants exchange knowledge, but they do not aim to cross subject boundaries in order to create new integrative knowledge and theory. The research process progresses as parallel disciplinary efforts without integration (see Figure 1). In landscape ecology research, this could be a project where researchers from geography, biology and planning work parallel to each other along the same general goal setting, for instance the analysis of road traffic on biodiversity. In such projects, each discipline would have its own disciplinary objective.

Nonetheless, the use of this concept varies widely among researchers. To Jantsch (1970), multidisciplinary involves a variety of disciplines that work simultaneously but without building explicit relationships between them. The disciplines involved have different goals and do not significantly influence one another. It is a very loose form of disciplinary interaction. He distinguishes further between pluridisciplinarity and crossdisciplinarity, in which different disciplines

work on the same subject but with different forms and degrees of cooperation and integration. The small theoretical differences are hardly identifiable in research practice. We therefore suggest subsuming all concepts under the term multidisciplinary.

Some authors with expertise in integrative research concepts, for example, Mittelstrass (1996), Karlqvist (1999), and Duncker (2001), use multidisciplinary as a general label for all forms of research involving different disciplines. For them, the disciplinary interaction in multidisciplinary varies from a pure juxtaposition of disciplines to crossing disciplinary borders. Other authors such as Conrad (2002) and Moran (2002) perceive multidisciplinary research as the way different scientific theories and disciplines are assembled to understand and eventually solve a given problem. The disciplines work together, each using its own methods, theories and instruments, without the aim of setting up a joint framework of theory (Conrad 2002). The relationship between the disciplines is merely one of proximity; there is no real integration between them. Following Klein (1990), it is essentially an additive concept, not an integrative one.

Many landscape ecology projects use a multidisciplinary approach, especially to study the multifunctionality of specific landscapes or landscape configurations. To give one example, Burel and Baudry (2003) discuss a multidisciplinary approach being applied in a study of hedgerow dynamics in western France. The study involved geographers, archaeologists, palaeontologists (pollen specialists), botanists and historians. The authors state that a multidisciplinary approach was required because of the difficulty of collating historical documents and combining the spatial and temporal scales appropriate to each discipline. The benefit of a multidisciplinary approach here is that each discipline adds new knowledge from its own perspective to complete the picture like pieces in a jigsaw puzzle.

Interdisciplinarity

We define *interdisciplinarity* in landscape research as involving several unrelated academic disciplines in a way that forces them to cross subject boundaries. The concerned disciplines integrate

disciplinary knowledge in order to create new knowledge and theory and achieve a common research goal (see Figure 1). By unrelated, we mean that they have contrasting research paradigms. Here we might consider the differences between qualitative and quantitative approaches or between analytical and interpretative approaches that emerge when bringing together disciplines from the humanities and the natural sciences as described by Fry (2001). An example from landscape ecological research could be a study investigating the decrease in forest areas through environmental impacts and its influence on human health. Environmental psychologists as well as researchers from the field of forestry, recreation, psychology and ecology would need to work together in this project towards the common goal.

In his definition of interdisciplinarity, Jantsch (1970, 1972) too mentions efforts to reach a common goal. This demands that the disciplines involved readjust their concepts and methods and, as a consequence, a new commonly shared axiom is developed at a level above that of the individual disciplines involved.

To us, *integration* of disciplinary knowledge is a characteristic of interdisciplinary projects. In the process of integration, disciplinary knowledge fuses with that from other disciplines and new knowledge develops. The newly emerging knowledge leads to interdisciplinary theory development. This theory cannot be broken down into its disciplinary ingredients. It would not have emerged through either disciplinary or multidisciplinary efforts. The greatest challenge of integration is to bring different epistemologies together. This requires researchers to become immersed in one another's knowledge cultures, to understand the fundamental differences in their basic theories and axioms and contribute to new knowledge and theory.

The other important aspect of interdisciplinarity is the orientation towards a common goal. We understand this as a clearly defined research question and project goal identified at the beginning of a landscape research project. Having a common goal means that the participating disciplines must focus their efforts towards integration from the very beginning of the research endeavor as highlighted by the studies of Daschkeit et al. (2001), Fry (2001), and

Hollaender (2003). This demands also agreement on how interdisciplinarity is understood and implemented in the project. Projects, which may be unsuccessful in formulating such a common goal and reaching integration, may – despite their intention to be interdisciplinary – end up as multidisciplinary studies, as shown by Tress et al. (in press).

Klein (1990) has shown that the term interdisciplinary is also used to describe efforts by closely related academic disciplines, such as biology and ecology. Seen in the context of long-term academic development, Weingart (1987, 1997), Jaeger and Scheringer (1998), and Schanz et al. (1999) observed that such cooperation across disciplinary boundaries may develop into a new discipline. Closely related disciplines can use one another's methods and theories, have common research paradigms and share axioms, beliefs and sets of rules. Emergence of a new discipline or sub-discipline is often manifested in the appearance of a specialized journal, research program, research unit or the appointment of a research chair.

When working together in a project context, researchers from closely related disciplines can cross subject boundaries more easily than those in unrelated disciplines from different knowledge communities. Thus, development of common theory across boundaries of *unrelated* knowledge communities is a more difficult goal to accomplish.

Several researchers put forward the argument for interdisciplinary approaches in landscape ecology. Nassauer (1995), Naveh (1995), and Décamps (2001) highlight that landscapes are composed of both nature and culture; it is in fact the interaction between the two that creates the landscape. The complex reality of landscapes calls for research input from various unrelated disciplines in the natural sciences, the social sciences and the humanities. Antrop (2003, p. 52) stated that “dealing seriously with the landscape as the object of research, means interdisciplinarity.” The recent study of Santelmann et al. (2004) is presented as one example for an interdisciplinary way of assessing alternative futures for agricultural landscapes in Iowa, USA. The research team has made a successful attempt to integrating methods and data towards presenting integrative results.

Transdisciplinarity

We define *transdisciplinary* research as projects that involve academic researchers from different unrelated disciplines as well as non-academic participants, such as land managers, user groups and the general public, to create new knowledge and theory and research a common question (see Figure 1). Transdisciplinarity thus combines interdisciplinarity with a participatory approach. In a landscape ecological context, the research question could be the analysis of the effects of coastal management plans for tourism and biodiversity. Besides the researchers from ecology, tourism studies, planning and geography non-academic participants such as tourists, representatives of local tourism enterprises and authorities as well as delegates from nature conservation agencies could be involved.

For Jantsch (1970, 1972) *transdisciplinarity* means the coordination of all disciplines and interdisciplines in the education system towards a common goal. He argued for a fundamental reorganization of the whole university system. His view was that transdisciplinarity should coordinate science, education and innovations from all parts of society – including politics – within one system.

In the view of Klein (1990), transdisciplinarity is the ultimate degree of coordination, a system that facilitates the mutual enhancement of epistemologies. Jantsch's definition of transdisciplinarity is designed to overcome the split between science and society. He linked scientific activities at all levels to societal demands and innovations. Both become intertwined to such a degree that they can no longer be treated as separate entities.

To us, transdisciplinarity, unlike other research approaches, transcends academia and involves societal participants. All involved parties, academic as well as non-academic, define and develop the research goals and methods in order to reach a common goal. The transdisciplinary approach entails the integration of the disciplines and sub-disciplines as well as non-academic knowledge related to a certain field of research. In landscape ecological research participation of societal participants can be appropriate for certain research questions because the scope of the investigation and the spatial dimension includes an area that is of interest to a broad group of society.

In research practice, the term transdisciplinary is frequently used to express an intensified form of interdisciplinarity, for which interdisciplinarity is no longer perceived as quite enough. Such definitions can be found in Klein (1990), Mittelstrass (1993), and Moran (2002). These definitions lift transdisciplinarity to the level of a mystic supra-paradigm that can hardly – if ever – be achieved in the daily practice of research.

Involvement of societal participants is also emphasized by Gibbons et al. (1994), who defined transdisciplinarity as “Mode 2” research. To these authors the main argument for transdisciplinarity is that it is more relevant to society than disciplinary research efforts. However, Schanz et al. (1999) argue that all scientific activity that is motivated by more than scientific curiosity has social relevance and is driven by societal interest. It can be argued that current research funding is, to a large degree, policy driven. In many countries, public funding bodies impose close links between societal interests and scientific efforts. We also question the idea that science is in a transition stage, moving from Mode 1 (disciplinary) to Mode 2 research (Gibbons et al. 1994). Instead, we see disciplinary research as providing the basis for transdisciplinary research in a context where both have important roles to play in solving landscape management problems.

Defila and Di Giulio (1998), Häberli et al. (2001) and others mention transdisciplinarity as a way to solve complex societal problems that need a combined scientific and social effort. However, Kemmis and McTaggart (2000) and Van Asselt and Rijkens-Klomp (2002) have shown that the involvement of non-academic actors in the research process is not always successful. Additionally, transdisciplinarity is sometimes used synonymous to a participatory approach and this can cause confusion.

We define *participatory* research as projects that involve academic researchers and non-academic participants to solve a problem. These can be disciplinary or multidisciplinary studies that include non-academic participants. They do not necessarily have to be interdisciplinary or transdisciplinary. Academic researchers and non-academic participants exchange knowledge, but the focus is not on the integration of the different knowledge cultures to create new knowledge and theory. It is also not necessarily research, it might

Table 1. Overview on proposed definitions of research concepts.

Disciplinary	Takes place within the boundaries of currently recognized academic disciplines, while fully appreciating the artificial nature of these bounds and the fact that they are dynamic. The research activity is oriented towards one specific goal, looking for an answer to a specific question.
Multidisciplinarity	Involves different academic disciplines that relate to a shared goal, but with multiple disciplinary objectives. Participants exchange knowledge, but they do not aim to cross subject boundaries in order to create new integrative knowledge and theory. The research process progresses as parallel disciplinary efforts without integration.
Interdisciplinarity	Involves several unrelated academic disciplines in a way that forces them to cross subject boundaries. The concerned disciplines integrate disciplinary knowledge in order to create new knowledge and theory and achieve a common research goal. Unrelated means that they have contrasting research paradigms.
Transdisciplinarity	Involves academic researchers from different unrelated disciplines as well as non-academic participants, such as land managers, user-groups and the general public, to create new knowledge and theory and research a common question. Transdisciplinarity combines interdisciplinarity with a participatory approach.

be development or the application of research (see Figure 2).

Transdisciplinarity, to us, is a *research* approach using both non-academic and scientific knowledge. This implies that practical experience, professional knowledge as well as new knowledge and theory derived from transdisciplinary research projects, have to be fed back into the scientific system for further development. In practice, this means that research results would be disseminated through both scientific and non-academic channels as described by Tress et al. (2003a). When a project includes several professionals coming from different backgrounds to solve a given problem without having a research question as their common goal, we recommend considering this as a transprofessional instead of a transdisciplinary activity.

Our proposed definitions are summarized in Table 1.

Discussion and conclusion

This paper has presented a variety of interpretations of integrative research concepts. It has also provided definitions that we believe can be made operational in the field of landscape ecology. However, whether these or alternative definitions become accepted is not important, what is important is that greater care and precision is taken when using the concepts in research projects and papers to enable effective communication and evaluation of research. It is especially important to link the level of integration required to the specific research question posed at the start of a new integrative research project.

However, the juxtaposition of different disciplines, all related to landscapes, and the exchange of information and cooperation between these disciplines does not necessarily constitute interdisciplinarity in landscape ecology. Whereas interdisciplinarity aims at *integration* of disciplines, multidisciplinary aims at *summing* disciplinary knowledge. In multidisciplinary, disciplinary goals are defined under the umbrella of a common subject or field of interest. Yet the disciplinary goals still determine the research approach and usually members of different disciplines each work on their own disciplinary sub-projects (see, for example EU 5th Framework projects). Weingart (1997), Jaeger and Scheringer (1998), and Tress et al. (2003b) have shown, that we need different approaches for different research questions. The challenge is to understand how to choose the most appropriate approach for a specific landscape related problem.

The lack of common terminology is one of the main obstacles to the integration of disciplines in landscape ecology projects. This situation is not unique to the field of landscape research. Similar experiences are reported from natural resource management (Ewel 2001), urban ecology (Daschkeit et al. 2001), environmental science (Kinzig 2001), social science and the arts (Spanner 2001). In all these fields, the process of integration is hampered by the imprecise and sometimes confusing use of terminology and concepts. Agreement on a common terminology would therefore be of great value. We propose, therefore, the adoption of more detailed methods sections in research papers that state clearly the mode of integration selected and how this was operationalized.

We have stressed the importance of integrative concepts for landscape ecology as evidenced by the increased numbers of such projects in recent years. This is supported by a survey of Wu and Hobbs (2002) who identified interdisciplinarity/transdisciplinarity as one of the six key issues in landscape ecology. However, Antrop (2001) found poor representation of the term interdisciplinarity in papers from the journals *Landscape Ecology* and *Landscape and Urban Planning*. Although we could identify an increasing number of papers referring to integrative approaches we also found that most papers dealing with interdisciplinarity or transdisciplinarity were (guest) editorials (see for example Naveh 1991; Wiens 1992; Brandt 2000; Tress et al. 2001) or discussion papers focusing on the development perspectives of landscape ecology (see for example Moss 2000; Décamps 2000; Bastian 2002; Vos and Meekes 1999).

A review of the debate on integrative concepts in landscape ecology, as reflected in editorials and discussion papers, shows little progress over the last two decades. The dominant topic of the debate has been the argument in favor of more integration in landscape ecology (see for instance Brandt 1999; Naveh 2001). Early important contributions as, for example, from Di Castri and Hadley (1986) or Wright (1987), were not followed up by sustained debate and development. There is thus a lack of critical reflection on experiences with interdisciplinarity and transdisciplinarity in landscape research. We agree with Wu and Hobbs (2002) that finding ways to do transdisciplinary research remains a great challenge for landscape ecologists.

Moss (2000) and Antrop (2001) point out that interdisciplinary work requires method development, conceptual frameworks and interdisciplinary theory. We agree with the need to develop methodologies and for sound theoretical foundations for integrative landscape ecology and would like to encourage authors to use more detailed explanations of their integrative research concepts and their application. Without a common understanding of the basic concepts it will be difficult to make progress in the development of a common methodology and theory. Yet, Burley et al. (2001) and Tress et al. (2003b) stress that it is not the readiness of epistemological developments that has driven the increase of integrative approaches in landscape research, but rather the hope and

demand for better solutions to real-world problems as requested by research policy and society.

The papers of Wiens (1999), Moss (2000), and Bastian (2002) give evidence for the debate over whether landscape ecology is a discipline with its own body of knowledge, theory and methods or a broad collection borrowed from several disciplines, each with their own body of knowledge, theories and methods. The representation of different disciplines in landscape ecological research is often interpreted as interdisciplinarity. In the same way, considering a project to be transdisciplinary when it involves planners, politicians and other stakeholders begs the question of whether “transdisciplinary” refers to the *application* of research in the field of landscapes and not the actual research. We would suggest entitling such projects as participatory or transprofessional cooperation.

Evidence supports the argument that landscape ecology is developing towards a separate discipline. It has, for instance, developed its own academic association (the International Association for Landscape Ecology) that holds regular national and international conferences, and a journal and several university textbooks are published on the subject. However, in the view of Antrop (2003) the formal recognition of landscape ecology as an academic discipline is not yet complete. Development of common theory and methods are still in progress, and many different disciplines still carry out landscape research and have landscapes as their object of research. Perhaps we first need to develop a common knowledge community (in the sense of Winder 2003) before institutionalizing landscape ecology as a discipline.

The discussion on integrative research concepts is mainly a theoretical one at present. Yet only consensus on these theoretical concepts will ensure their proper application in landscape ecological research. We hope that our discussion of concepts contributes to a greater clarity about the specific differences between integrative research modes and eases their application in research projects. We offer a potential classification of approaches to assess projects and papers in landscape ecology. We believe this will help landscape ecology capitalize on the synergy of integration. We found many papers calling for integrative approaches in landscape ecological research, now we need research effort and publications on how integration

can be achieved and how to overcome the barriers we face in this process.

The mission statement of the International Association for Landscape Ecology characterizes landscape ecology as the study of spatial variation in landscapes at a variety of scales: "Above all, it is broadly interdisciplinary" (IALE 1998). It promotes an integrative approach for landscape ecological research. To demonstrate the advantages of integration both for solving landscape management problems and for advancing landscape ecological theory a clearer understanding of what we mean by the different integrative research concepts needs to be developed. A common understanding will be of great help in assessing the performance of integrative research concepts, their potential and limitations.

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