UNDERGRADUATE COURSES IN ECOLOGY IN BRAZIL: PARADIGMATIC APPROACHES

CAMILA FERREIRA PINTO DAS NEVES[1], GIONARA TAUCHEN[2]

Introduction

In Brazil, there are currently eight undergraduate courses in Ecology (BRASIL, 2010) and fifty nine Ecology graduate programs, which include fifty four academic master programs, four professional master programs and thirty five doctoral graduate programs. The growth in the number of courses, in terms of initial professional training as well as the organization of Ecology as a field of knowledge, appears to reflect the current demands of society in relation to ecological issues (BIRNFELD, 2006; LEFF, 2011). Morin (2011) has described the emergence of the field of Ecology as one that stems in part from the content and form of the development of the scientific disciplines, which "after increasing fragmentation and compartmentalization of the field of knowledge, has demolished the natural entities that have always been the focus of great human questions: cosmos, nature, life and, strictly speaking, the human being" (p. 26). Thus, Morin considers fields such as Ecology and Cosmology as poly- or trans-disciplinary and multidimensional sciences because the object of study is a complex system in which interactions, feedback and inter--feedback of their elements form an organized whole. Morin (2011) also considers the challenge of our time our "ability to organize knowledge [...]. It is a non-programmatic but paradigmatic reform" (p. 20).

To promote the development of capabilities and strategies in this field, the pedagogical projects of Ecology courses should include analyses of the history of Ecology, the formation of groups of practitioners within the field and the principles that guide scientific education. This approach may improve the understanding of the fundamentals of professional training in this field and the arising demands. We hypothesize that Ecology has incorporated principles of the Cartesian paradigm, such as reductionism, objectivity and measurement, to provide structure and to be recognized as a scientific field of study. In terms of the differentiation of this paradigm, however, Ecology represents a field of knowledge reconnection, requiring other fundamentals and paradigmatic principles.

[1] Doutoranda of the Program of Postgraduation in Education in Sciences: Chemistry of Vida and Health. Federal University of Rio Grande - FURG. E-mail: Camilapinto.eco@gmail.com

[2] Teacher linked to the Institute of Education . Federal University of Rio Grande – FURG. Giotauchen@gmail.com

In this development, the training projects, particularly undergraduate courses, denote differentiation and paradigmatic constructions.

In the present article, we investigate and analyze the underlying paradigms of the educational proposals of undergraduate courses in Ecology offered at higher education institutions in Brazil. Our analysis is based on Kuhn's framework (2009, p. 64), which defines paradigms[i] as a "set of beliefs, values and techniques that characterize a system of thought, determining a world view that gives homogeneity to scientific production and the organization of society". We believe that by means of educational processes, the acquired models involved in the initial training of ecologists provide what Kuhn (2009, p. 70) refers to as "*status* of community paradigm", insofar as the pedagogical projects of the courses express theories and practices concerning this scientific and professional field. Morin also believes that "a paradigm reigns over the minds because it establishes the sovereign concepts and their logical relationships (disjunction, conjunction, implication), which covertly govern the conceptions and the scientific theories carried out under its purview" (2011, p. 113). From these initial considerations, we ask the following: What systems of thought guide the pedagogical projects of undergraduate courses in Ecology in Brazil? What are the ecological approaches that underlie the pedagogical projects? Do the Ecology courses express shared world views configuring an ecological paradigm?

Methodological approach: the process of analyzing and understanding

The present study is characterized as qualitative because it does not intend to establish a truth or what is right or wrong; instead, it has as its first concern the understanding of reality and its determinations and transformations (MINAYO, 2001). Given the nature of our research problem, we understand the need for a methodological approach supported by a process of understanding, and we have therefore conducted a hermeneutic study according to the documentary sources. According to Hermann (2002, p. 27), "in the methodological sense, hermeneutics is aimed at developing interpretive principles and, at the same time, clarifying the very task of understanding".

For the present analysis, we took as research object the pedagogical projects of Ecology courses at the following institutions of higher education in Brazil (Table 1): São Paulo State University (Universidade Estadual Paulista, UNESP - Rio Claro), Catholic University of Pelotas (Universidade Católica de Pelotas, UCPEL - Pelotas), University Center of Belo Horizonte (Centro Universitário de Belo Horizonte, UNI-BH - Belo Horizonte), Federal University of Rio Grande do Norte (Universidade Federal do Rio Grande do Norte, UFRN - Natal), Federal University of Paraíba (Universidade Federal da Paraíba, UFPB - Rio Tino), Federal Rural University of the Semiarid Region (Universidade Federal Rural do Semi-Árido, UFERSA - Mossoró), Federal University of Goiás (Universidade Federal de Goiás, UFG - Goiânia) and the Federal University of Sergipe (Universidade Federal de Sergipe, UFS - São Cristóvão).

Table 1. Year of establishment of Ecology course programs in Brazil and the administrative categories of the corresponding institutions (BRASIL, 2010)

Institution	Code	Category	Year of coures establishment
UNESP	P1	Public	1975
UCPEL	P2	Private	1995
UNI-BH	P3	Private	2003
UFRN	P4	Public	2004
UFPB	P5	Public	2006
UFERSA	P6	Public	2009
UFG	P7	Public	2009
UFS	P8	Public	2010

Source: www.emec.mec.gov.br. Accessed: 25/01/2012.

We understand that Ecology is not presently restricted to Biology departments, and as such, its discourse is dispersed among different scientific fields (MELLO, 2006) including areas of the Natural Sciences and Humanities. According to Mello (2006, p. 50), "in the different definitions of Ecology made by ecologists, it is observed that each one emphasizes the respective object of study (organisms, populations, communities, ecosystems)". We will therefore address the historical paths of the organization of ecological thinking. We will also discuss pioneers of studies that have led to a broader view of Ecology. This historical perspective will provide a broader understanding of how ecological knowledge is organized and establish a framework for our interpretations and analyses of the course pedagogical projects.

Paths of ecological thinking

The word "Ecology" was coined by Haeckel (1866) to describe a scientific discipline connected to the field of Biology, whose task was to study the relationships between animal species and their environment (ODUM, 2001). Different ideas, projects and world views subsequently emerged, however, that eventually broadened the understanding of Haeckel's Ecology, making it more comprehensive than a discipline within the body of expertise knowledge. As indicated by Lago and Pádua (1985, p. 10), "evidently, this passage from one discipline to a field of thought that seeks to synthesize many different elements generates, among the ecologists themselves, a crisis of method and definition regarding the scope of their own study".

Other meanings are also highlighted by Pinto-Coelho (2002, p. 12):

> 1. Scientific natural history (ELTON, 1927).
> 2. Biology of groups of organisms. Study of structures and function of nature (ODUM, 1963).

> 3. Scientific study of the interactions that determine the distribution and abundance of organisms (KREBS, 1972).
> 4. Study of the environment focusing on the interrelationships between organisms and their surroundings (RICKLEFS, 1980).

This breadth and diversity of understanding may represent a problem in terms of defining the scientific field of Ecology, which encompasses various areas of the Natural Sciences and Humanities (MELLO, 2006), and structuring the ecological paradigm.

To better understand the development of ecological thought, we began with the studies of Lago and Pádua (1985). According to the authors, Natural Ecology is the primary area of ecological thought and centers on the study of ecosystems, i.e., understanding how biological systems such as oceans and forests function. Subsequent specialization in this area led to the emergence of subspecialties such as Forest Ecology, Marine Ecology, Human Ecology, Terrestrial Ecology and Ecosystem Ecology. According to the authors, the concept of the ecosystem is the basis upon which the whole universe rests and is therefore the central component of Ecology:

> Each of these environments is an integrated whole, a functional unit of life, in which the joint interaction of various species of animals and plants present within it, along with the physicochemical background composed by minerals, weather, etc., establishes a balanced system that permits the functioning of the whole. (LAGO and PÁDUA, 1985, p. 18).

Human intervention in these environments required new reflections and studies on ecological thought. In 1960, Social Ecology arose as an area based on the analysis of the impact of societies on natural environments; it generated debates on the effects of degradation, which was made increasingly visible by the exploitation of natural resources, such as deforestation, oil drilling and water pollution. In this context, Morin (2011, p. 28) notes that since the 1970s, "ecological research extended to the biosphere as a whole, perceiving it as a self-regulating megasystem that admits at its core the expressly human technical and economic developments that come to disturb it".

These changes have led to the structuring of ecological movements around the impact of human activity, culminating with movements that propose changes in the relationship between man and nature, from conservationism to ecologism. Conservationism emphasizes the struggle to preserve the natural environment or parts of it. We have, for instance, groups such as the International Union for the Conservation of Nature and its Resources (IUCN - União Internacional para Conservação da Natureza e de seus Recursos) and the Brazilian Foundation for the Conservation of Nature (FBCN - Fundação Brasileira para a Conservação da Natureza). It is important to note, however, that conservationism also involves issues and movements with aesthetic, scientific, economic and other concerns; animal protection groups are one such example.

In contrast to conservationism, ecologism is focused on the improvement of the life conditions of societies and is not limited to the "protection of nature". It proposes

social transformation, which includes changes in the economy and culture of societies. As previously framed, ecologism is not only concerned with "[...] ensuring the survival of the human species but ensuring this survival by building social and cultural forms that allow the existence of a non-oppressive, egalitarian, fraternal and libertarian society" (LAGO and PÁDUA, 1985, p. 37).

In this context, the different paths of ecological thought force ecologists to be concerned with the relationship that man establishes with nature, as it is affected and transformed by human activities. This results in the substantial importance of Ecology as a science that alerts us to the dangers that threaten the planet.

Within the field of Ecology, it can be inferred that a posture of disciplinary reintegration has been assumed because knowledge and skills from different disciplines are used to solve various problems. Morin (2011) has framed this development in the following way:

> Ecology, with the ecosystem as its object of study, resorts to the multiple physical disciplines to grasp the biotope and to the biological disciplines (Zoology, Botany, Microbiology) to study biocenosis. It must further resort to the Humanities to analyze the interactions between the human world and the biosphere. In this way, extremely distinct disciplines are associated and orchestrated within ecological science. (p. 28).

In light of these considerations, it will be critical to understand the conceptions, values, contents and forms that guide the organization of undergraduate courses in Ecology specifically because they are expressions of the paradigms that guide the scientific and professional community.

Organization of paradigms and scientific education in the field of Ecology

Currently, studies on the environment are as complex and multidimensional as studies of man and the relationship between man and the natural systems. Discourse on the environment in this context is subject to ideological disputes, revealing the diversity of understandings and conceptions in the discussion of concepts and meanings.

One of the concepts that may translate this complex scenario is the concept of paradigm. A paradigm describes the specific factors that determine what scientists or members of a scientific community interpret and share with their peers. According to Kuhn (2009), the early development stages of a science are characterized by competition between different conceptions. Moreover, what distinguishes the groups are "their incommensurable ways of seeing the world and of practicing science in it" (p. 23). With regard to Ecology, Mello (2006, p. 22) notes that the paradigm permeating it today makes it "routinely known as the study of the environment; it then becomes a science governed by a shared model throughout the community that is occupied with that object (environment)".

Nevertheless, the leading paradigm is accompanied by controversies, which results in the coexistence of scientific communities that share paradigms or distinct models of

study of Ecology. Thus, referring to Ecology is to invoke the horizon of meaning held by a given paradigm or set of paradigms.

The paradigm governs the action of the groups of scientists who share it. In the case of groups involved in environmental research, there are various scientific communities concerned. In our study of the Ecology courses in Brazil, we understand each course as an expression of scientific communities whose conceptions and practices always presuppose a pre-understanding of reality that determines the object, method, structure, field of action and its investigations (MAIA, 2005).

The disciplinary matrices of the courses are shared by the scientific communities that have structured them and express the following: their symbolic generalizations, beliefs in certain models that help determine what can be accepted as an explanation, values, examples that serve as reference, contents and forms of organizing professional action. This is the process that Kuhn (2009) called scientific education:

> It should be made clear that scientists never learn concepts, laws and theories in the abstract and in isolation. Instead, these intellectual tools are forms encountered in a historically and pedagogically prior unit that displays them with and through their applications. Once accepted, these applications will be presented alongside theory in textbooks that future scientists will use to learn its craft (p. 71).

Scientific communities can be viewed as following a model chosen by a collectivity. It is within this paradigm that the student is prepared for his future professional action, as he will tend to identify with the ideas of his teachers.

In light of the diverse definitions of Ecology, there are controversies and disputes among Ecologists concerning the meaning of Ecology. For example, the definition of Ecology for a population ecologist is developed with the perspective of organisms (as groups); on the other hand, a system ecologist emphasizes energy relations (of the cycles of matter and energy). It is particularly evident that ecological 'science' is permeated by different conceptual, methodological and evaluative perspectives that arise from different groups and can all be termed ecological. Therefore, there is no way to define Ecology as a normal science with respect to the integration of the natural and social sciences.

For Kuhn (2009), a science is considered 'normal' when it is governed by a paradigm that guides the activities and the consensus of the group of scientists working within it. A normal science is understood as one that yields "research firmly based upon one or more past scientific achievements" (KUHN, 2009, p. 29) that are recognized for some time by a specific scientific community, thereby providing the foundations for subsequent practice. In other words, previous scientific achievements represent the foundation of a normal science.

Within a normal science, the solution of problems and the rules that must be followed in devising a solution are predefined by the paradigm adopted by the scientists. Every normal science is paradigm driven. Kuhn (2009) notes that a candidate scientist tends to join a group of researchers who have certain behavior patterns in terms of research knowledge and practice. As this scientist develops behaviors similar to the older

members of the group, he becomes able to act in this area. This is the function of the scientific education system described above.

Considering Biology as a normal science, and that from which Ecology emerged, we must ask what conditions were necessary within the normal science for a new science to arise. Kuhn (2009, p. 73) describes this development as pre-paradigmatic: it emerges as a condition of possibility within the normal science because of the "common and deep discussions about methods, problems and legitimate patterns of solutions". The development of studies begins with different groups seeking to solve problems and to establish a new field of study. Chalmers (1993) notes that:

> Science should contain within itself a way of breaking a paradigm and exchanging it for a better paradigm. In terms of correspondence with nature, all paradigms will be inadequate to some degree. When this lack of correspondence becomes serious, that is, when a crisis occurs, the revolutionary measure of replacing the whole paradigm with another becomes critical for the effective progress of science (p. 122).

Ecology, when disconnected from Biology, assured its own body and was established as an integrative discipline, seeking to articulate social and natural sciences under different epistemological perspectives and world views (MELLO, 2006) (Figure 1). Today, for instance, the various themes of ecology permeate studies on the environment in basic education and are further integrated into higher education curricular studies. They also form part of the coursework in undergraduate and graduate programs in this area.

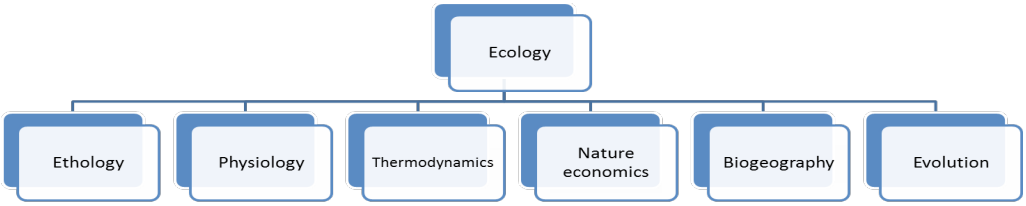

Figure 1. Roots of Ecology

The various sources upon which Ecology was founded and their diversity, in terms of both discipline and methodology, highlight the problems of compatibility, the delimitation of objects of study and the criteria of scientific production (methodology and validation). The differences within the field of Ecology are not exactly paradigm shifts but crises arising from the very constitution of this area of scientific research. From these crises, groups such as the aforementioned conservationists and ecologists arise, struggling for causes such as the protection of natural environments. This leads to the importance of identifying the groups of practitioners within Ecology. This step is of fundamental importance not only for the understanding and establishment of ecological paradigms but also for the professional training that is structured around these paradigms.

One of the critical contributors to the structuring of the field of Ecology is the initial training that occurs in undergraduate courses[ii]. It is during the initial training that we expand our process of scientific education and professional socialization.

A series of theoretical and methodological conceptions exist in textbooks used by professors of undergraduate courses. According to Dutra (1999, p. 3), these textbooks are used because "they do not just make the very scientific revolutions invisible (to students and laymen) but are also used as pedagogical tools to train new scientists according to the current paradigm".

Bombassaro (1995), also anchored in the reading of Kuhn (2009), considers the textbooks and manuals used in scientific education as pedagogical resources extremely important because they are laden with paradigms, thereby introducing the necessary knowledge and scientific culture of the field to the student and allowing him to become a problem solver within these paradigms. As one example, pedagogical project P7 (2009) analyzed in the present study includes the following scientific education aims: to familiarize the ecologist with issues pertaining to the History of Science, the basic concepts in the Philosophy of Science, social context science, paradigms and ideology, the limits of science and scientific teaching and discussion. Pedagogical project P8 (2010) also offers a course called History and Philosophy of Science, which covers scientific revolutions, scientific thought, biological knowledge and contemporary society. These, among other disciplines, provide the student with an understanding of historicity and the ways a science is established.

Science education aims to encourage every young 'scientist' to assess his own skill as a problem solver and thereby expand his comprehension of the world. Considering the professional socialization and instructional materials provided by the curricular projects of the Ecology courses, these approaches, according to Bombassaro (1995, p. 62), aim to "form a community of researchers and determine the research and relevant issues in which this community should engage". Based on these understandings, we will proceed to analyze the ecological paradigms that guide the organization of the Ecology courses.

Paradigms of the pedagogical projects of the Ecology courses

In analyzing the stated reasons for the development of Ecology courses in Brazil, we observe that many of their propositions are motivated by the growing interest in environmental issues, climate change and the demands of natural resource management. These and other factors eventually establish conceptions of Ecology. The specific perspectives and emphases of the analyzed pedagogical projects are summarized in Table 2.

Table 2. Concepts and emphases of the Ecology courses*

Project	Science of Life and the relationships of living beings with the environment, between different species and between man and the environment (2009).	Emphasis
P1		Relationships of ecosystems and populations.
P2	"The study of the interrelationships between organisms and their natural environment, with regard to both biotic and abiotic aspects**" (2010, p. 16).	Interrelationships between organisms and ecosystems.
P3	Not clearly explained.	Ecosystems.
P4	"Ecology is the science of relationships and connections" (2010, p. 2).	Relationships of living beings and the environment.
P5	"Ecology is concerned with the study of man/nature relationships, focusing on the preservation of natural resources and their proper use" (2012).	Relationships of ecosystems.
P6	"Ecology is the science that investigates how organisms interact with each other and with the natural world" (2009, p. 9).	Organisms, ecosystems, communities and populations.
P7	"The study of the natural environment, including the relationships of organisms with each other and their surroundings" (2009, p. 5).	Relationships of organisms and populations.
P8	"The study of nature and its conservation. Ecology aims to study the interactions and relationships between organisms and their environment" (2009, p. 23).	Interactions between organisms and the environment.

* P1 (UNESP), P2 (UCPEL), P3 (UNI-BH), P4 (UFRN), P5 (UFPB), P6 (UFERSA), P7 (UFG) and P8 (UFS).
** "Biotic" refers to the living organisms, such as plants and animals, living in an ecosystem. "Abiotic" refers to the non-living factors in an ecosystem that nevertheless influence the biotic environment; examples include temperature, pressure, rainfall and relief.

In four of the eight projects examined, Ecology is framed as a science that studies how organisms interact with each other and with the natural world (P2, P6, P7 and P8). Specifically, P7 frames Ecology as the "study of the natural environment, including the relationships of organisms with each other and their surroundings". This emphasis on organisms reveals the extent to which Ecology continues to be affected by and considered as a branch of Biology. However, its object of study is the interrelationship between living beings, indicating that its sustaining perspective is more concerned with the relationships established by organisms rather than the organisms themselves. According to Mello (2006, p. 45), "[...] perhaps with the innovations of science, these relationships have taken the place of organisms as the main object of ecological studies and have thus become the main focus of the science". Accordingly, disciplines with a focus on the sciences of man and nature are associated and orchestrated within ecological science (MORIN, 2011).

One of the analyzed projects (P7) is guided by a second perspective: Ecology as a field of study of "organisms and populations". Thus, the focus is extended to groups of the same species and their relationships with the environment. However, organisms and

their dynamics still represent the primary focus. Concerning the term "population", we understand that it was originally used to refer to a group of humans. It is worth noting that in the literature, authors dealing with this concept assign the term much greater depth. Among these authors, we highlight Odum (1988, p. 3), who specifies that "in Ecology, populations include groups of individuals of one type of any organism". For Pinto-Coelho (2002, p. 21), the term can be used to refer to "any group of organisms of the same species occupying a particular space at a particular time". Thus, a population has certain parameters that permit quantitative studies under experimental conditions or in the field. Among the projects analyzed, a third identified perspective was of communities and ecosystems, which appears in at least five of the projects (P1, P2, P3, P4 and P5). According to Mello, the perspective of communities stems from the studies of Möbius conducted in the second half of the 20th century "to refer to the groups of populations that coexist in a given region, where they meet all the conditions for their birth and conservation" (2006, p. 51). The community and the non-living environment work together as an ecological system or ecosystem (ODUM, 1988). As communities can be viewed as an ecological unit whose effect in nature is much less clear, they are assigned different concepts, which for Krebs (1972), derive from plant ecology (PINTO-COELHO, 2002, p. 57):

> a) any set of populations in a given area or habitat with the most varied sizes (KREBS, 1972);
> b) an association between interactive populations (RICKEFS, 1980);
> c) an assembly of people in a given defined area or physical habitat, albeit a poorly defined ecological unit (ODUM, 1972);
> d) a number of species (populations) occurring jointly in time and within the same space (BEGON *et al.* 1990).

The concept of ecosystem (MELLO, 2006) has emerged from studies involving large scale organization and energy exchange between systems. The ecosystem is the basic functional unit in Ecology because it includes both organisms and the abiotic (non-living) environment. According to Odum (1988), living beings and their non-living environments are inseparably interrelated and interact with each other. Ecosystems therefore refer to given areas that include all organisms that work together.

A fourth perspective was identified in only one of the pedagogical projects (P6) and emphasizes the more complex relationships between organisms, ecosystems, communities and populations. We believe that, in accordance with the development of science, the initial stage of Ecology represented nature with a Newtonian character (i.e., analytical-reductionist, mechanistic and deterministic), in which the notion of balance prevailed, with order and predictability as relevant traits[iii]. This stage cultivated the society-nature dichotomy and legitimized the ethics of the domain of the former over the latter. To realize studies, it emphasizes the fragmentation of the component parts, i.e., the decomposition of the whole. The thought is fragmented, and knowledge is considered true based on the processes of verification and testing. Bodies are separated from the external world and perceived as static closed systems. Nature is understood to be anthropocentric: man above or outside nature.

In an attempt to overcome or expand these understandings, the traditional schemes were relativized through a series of understandings that changed the course of sciences; the notion of complexity and unbalance was one of the understandings affected (MELLO, 2006). These changes have contributed to an ecosystemic understanding in the field of Ecology. For Lago and Pádua (1985, p. 17), "the foundation on which the whole universe of Natural Ecology rests is the concept of the ecosystem". Thus, the authors suggest that the notion of ecosystem and its relationships of energy and matter transfer constitute one of multiple paradigms in ecological science. For Vieira (2003), a dualism exists in ecological science: in the ecosystemic view, the basic unit is energy, whereas in the view of Population and Community Ecology, the basic unit is the organism (individuals and species, respectively).

In the ecosystemic view (Table 1), parts are understood as components of a whole. The thought is contextual, seeking connections and interactions. The approximate knowledge emerges from open systems with matter and energy flow. The planet Earth is understood as part of life, and living things are connected in the web of life.

Table 3. Differentiating the reductionist and ecosystemic paradigms (GARCIA, 1994)

Paradigms	
Reductionist	Ecosystemic
• reductionist and specialized science • disciplinary • predictability, certainty, control • linear view • vision of Western culture • nature as a stock of resources • exploration and collapse of ecosystems	• complexity and complementary constitution, antagonistic and recurrent between the parts and the whole • inter- and trans-disciplinary • uncertainties • circular view • cultural diversity • interactions of social systems with natural systems

We understand that the reductionist approach has had significant contributions and promoted the development of science and technology in modern times. Research at the cellular and molecular level, for example, has promoted conditions that may lead to the prevention and cure of cancer at the level of the organism. Nevertheless, many argue that science at the cellular level will contribute little to the well being or survival of human civilization if we continue to misunderstand the higher levels of organization, including the growth and aging of the population, social disorder, pollution and the many forms of overconsumption and exploitation of nature. According to Odum (1988), one possible

solution is assigning equal value to the systemic and reductionist paradigms simultaneously rather than alternately. Consequently, Ecology as an emerging science would seek synthesis and not separation. For example, "a living being cannot be viewed in isolation as representative of a species; it should instead always be viewed and analyzed in relation to the group of vital conditions that constitute it" (BOFF, 2004, p. 17). This view explains why Ecology is considered by authors such as Morin (2008) as "the new systemic science" that strives to reconnect and reintegrate the relationships between the parts and the whole.

In this regard, it is noteworthy that ecosystemic thought reflects the contributions of many disciplines, such as Psychology, Physics and Biology, thereby establishing a field of multidisciplinary and multi-referenced studies. As evidenced by the educational projects analyzed, ecological perspectives also express the historicity of ecological knowledge and record the understandings of the scientific communities that have developed them. Six of the eight courses analyzed include more complex perspectives, indicating an understanding that organisms compose not only ecological communities but also complex ecosystems. These ecosystems contain a multitude of smaller organisms that exhibit considerable autonomy but are nevertheless harmoniously integrated in the functioning of the whole.

Final considerations

Questions have emerged about the model of science that underlies our actions; the relationships between man and nature; the purpose of science in terms of contemporaneity; and the role of institutions in charge of producing, promoting and disseminating science. We are therefore faced with a paradigm of modernity that is strongly reflected in the organization of society and also guides the production and establishment of relationships with knowledge. The conception of development, anchored in this paradigm, has unleashed an often exaggerated consumption of exploited natural resources in order to meet demand. This only increases the impact of human action on the environment, which appears increasingly less sustainable. Thus, society is witnessing a slow progression of social and ecological destruction[iv].

The system of modern thought influences and is influenced by the scientific community, which in turn shares its thoughts and actions in educational institutions. Thus, the pedagogical projects analyzed in the present study reflect these relationships. We acknowledge that Ecology courses are increasingly designed with the intention of guiding purposeful and strategic professional training to address the environmental impacts caused by human action; to identify solutions to problems; and to ultimately prevent actions that harm the environment, such as those associated with pollution, demographic changes and the intensive and unsustainable use of natural resources.

Ecology has been historically shaped and developed. However, is Ecology a science that can provide all of the solutions to environmental problems? We believe that no science alone can resolve all environmental problems, which are complex in nature. Thus, interaction and collaboration with other sciences is necessary.

In this study, we considered the simplifier paradigm and the modernity paradigm at the moment in which Ecology turns to the specialization of knowledge, regards science as

proof and becomes dedicated to the more specialized organism. In our reading, we consider how Ecology advances but nevertheless carries this influence. The systemic paradigm, which also appears in the projects, does not disregard the simplifier paradigm. Instead, consideration is given to the exchange of energy and structure in favor of a broader view, namely, communities and ecosystems.

The pedagogical projects analyzed take an ecological organicist and systemic approach and place greater emphasis on the Ecology of organisms and ecosystems. Considering Ecology in terms of organisms ultimately leads to a discussion about union because organisms form communities and associations whose structures and functions cannot be understood solely by the examination of component parts. For example, Ecosystem Ecology refers to the biotic community alongside its abiotic environment. Von Bertalanffy (1993) recognizes that the systemic view is a precursor to the issue of limitations associated with the analytical procedures of the classical sciences, which themselves result from the paradigm of modernity.

A systemic view presents Ecology as the science of the structure and functioning of the Earth. According to Odum (1988), Ecology is therefore a super-science or a unifying science 'that crowns' the other sciences and is essential to our understanding of the structure and functioning of the biosphere. In our view, Ecology also aims to understand and harmonize the relationship of man with nature—an increasingly difficult task in the modern era.

In our study, we consider the following differences among pedagogical projects: how some courses propose a much more biological approach than an ecological one; how some incorporate contextual and training demands; and how some (namely, those established in 2008 and 2009) are concerned with producing ecologists able to address the 'ecological crisis' generated by the current world view. In light of global warming and imminent climate change, it is increasingly urgent to train professionals who can effectively address these environmental problems. According to Capra (2004, p. 15), "the model of society and the meaning of life that humans have established for themselves, for at least the last 400 years, are in crisis". The emergence of Ecologists is influenced by this context.

Considering studies influenced by the perspective of Kuhn (1999), we assess whether Ecology is configured as a science or a pre-science. We believe that the diversity of understandings regarding this field, expressed in the projects analyzed, reveals a possible lack of consensus in the scientific community in terms of what constitutes a pre-science. Other factors that contribute to this view are the lack of curricular guidelines for the courses and the lack of social recognition and professional regulation of the ecologist.

Notes

[1] Although Kuhn (2009) has expressed a multiplicity of meanings for the term "paradigm", the definition set forth in "The Structure of Scientific Revolutions" is of relevance for our study. We also chose to elaborate the paradigmatic understanding of Kuhn because he is the precursor of such reflections and because of the epistemological contributions arising from his studies.

[ii] Although the first Ecology course was established more than 30 years ago, the increase in the number of these courses occurred only recently in the first decade of this century.

[iii] Such features convey what Santos (1995) refers to as the dominant paradigm: a global model of scientific rationality aimed at discovering the laws of nature, regardless of the place and time in which it is realized.

iv I present this paragraph to consider this apparently visible fact and give voice to a worldview that has been consolidated and can be changed with a 'new paradigm', a concept not addressed in this article.

References

BEGON, Michael; HARPER, John L. & TOWNSEND, Colin R. *Ecology*: Individuals, Populations and Communites. 2º ed. Blackwell Sci. Publ. Oxford, Inglaterra, 1990.

BOFF, Leonardo. *Ecologia*: grito da terra, grito dos pobres. Rio de Janeiro: Sextante, 2004.

CAPRA. Fritjof. *A teia da vida*: Uma nova compreensão científica dos sistemas vivos ativos. Trad. Newton Roberval Eichemberg. São Paulo: Cultrix, 2006.

BOMBASSARO, Leandro C. *Ciência e mudança conceitual*. Notas sobre epistemologia e história da ciência. Porto Alegre: [s.n.], EDIPUCRS. 1995.

BIRNFELD, Carlos André. *Cidadania Ecológica*. Pelotas: Delfos, 2006.

BRASIL, Ministério da Educação – Disponível em:< http://emec.mec.gov.br/>. Acesso em: 17 Out. 2010.

Centro Universitário de Belo Horizonte. *Projeto político pedagógico do curso de Ecologia* - (P3). Disponível em: <www.unibh.br/site/cursos/graduação/Ecologia>. Acesso em: 20 Jul. 2011.

Chalmers, Alan F. *O que é ciência afinal?* Brasília: [s.n.], Editora Brasiliense, 1993. 210 p.

DUTRA, Luiz Henrique A. Kuhn e a Filosofia da Educação. Nel – Núcleo de Epistemologia e Lógica. Universidade Federal de Santa Catarina - UFSC. *Enciclopédia de Filosofia da Educação*. Florianópolis, 1999. Disponível em < http://www.cfh.ufsc.br/~wfil/kuhnport.htm> Acesso em: 10 out. 2011.

GARCIA, R. Interdisciplinaridade y sistemas complejos. In: Leff, E. et. al. *Ciências sociales y formación ambiental*. Gedisa editorial, Barcelona. p. 85-124.1994.

HAECKEL, Ernest. *Generelle Morphologie der Organismen:* allgemeine Grundzüge der organischen Formen-Wissenschaft, mechanisch begründet durch die von C. Darwin reformirte Decendenz-Theorie. Berlin, 1866.

HERMANN, Nadja. *Hermenêutica e Educação*. Rio de Janeiro: [s.n.], DP&A, 2002.109 p.

KUHN, Thomas. *A estrutura das revoluções científicas*. 9º ed. São Paulo: Perspectiva, 2009. 260 p.

KREBS, Charles J. *Ecology* – The experimental analiysis of distribution and abundance. Harper International. New York, [s.n.], 1972.

LAGO, Antônio; PÁDUA, José A. *O que é Ecologia?* São Paulo: [s.n.], Abril Cultural: Brasiliense, 1985. 108 p.

LEFF, Enrique. *Saber Ambiental*: sustentabilidade, racionalidade, complexidade, poder. 8° ed. Petrópolis, RJ: Vozes, 2011.

MAIA, Isabel M. M. R. L. *O desenvolvimento da ciência em Thomas Kuhn.* 2005. Disponível em: <http://www.consciencia.org/contemporanea/kuhnisabel.shtml>. Acesso em: 10/ junho/ 2011.

MINAYO, Maria C. *Pesquisa social:* teoria, método e criatividade. 19ª ed. Petrópolis: Vozes, 2001. 80p.

MELLO, Lilian Medeiros. *O formalismo entre os discursos das diferentes Ecologias*. 2006. 166 f. Tese (Doutorado) - Curso de Pós-graduação em Meio Ambiente e Desenvolvimento, Universidade Federal do Paraná, Paraná, 2006. Disponível em: <http://www.ppgmade.ufpr.br/>. Acesso em: 19 out. 2011.

MORIN, Edgar. *A cabeça bem-feita*: repensar a reforma, reformar o pensamento. Eloá Jacobina (trad). 15º ed. Rio de Janeiro: Bertrand Brasil, 2011. 128 p.

_____. *O método 1*: a natureza da natureza. Trad. Ilana Heineberg. Porto Alegre: Sulina, 2008. 2ºed. 479p.

ODUM, Eugene P. *Ecologia*. Rio de Janeiro: [s.n.], Guanabara Koogan, 1988.

_____. *Ecologia*. Rio de Janeiro: [s.n.], Guanabara Koogan, 1972.

_____. *Ecologia*. 3º ed. Edición. Interamericana, Cidade do México, D. F., México. 1963. 639p.

_____. *Fundamentos de Ecologia***.** Rio de Janeiro: [s.n.], Guanabara Koogan, 2001. 434 p.

Pádua, Augusto J. et al. *Ecologia e política no Brasil*. Rio de Janeiro: [s.n.], IUPERJ, 1987.

PINTO-COELHO, Ricardo M. *Fundamentos em Ecologia*. Porto Alegre: [s.n.], Artmed, 2002. 252 p.

RICKLEFS, Robert E. *Ecology.* 2º ed. Nelson. London, 1980.

_____. *A economia da Natureza*. 5° ed. Rio de Janeiro: Guanabara Koogan, 2003.

SANTOS, Boaventura S. *Um discurso sobre as ciências*. 7º ed. Porto: Afrontamento, 1995.

UNIVERSIDADE ESTADUAL PAULISTA. *Apresentação do curso de Ecologia*, 2009, slide 2, Disponível em:<www.rc.Ecologia.br/ib/coneEcologia/index.php>. Acesso em 29 set. 2011.

_____, *Projeto Político Pedagógico do curso de Ecologia -* (P1). Rio Claro, SP, 2009, 11-12p.

Universidade Católica de Pelotas. *Projeto Político Pedagógico do curso de Ecologia -* (P2). Pelotas, RS, 2010, p.16.

Universidade Federal do Rio Grande do Norte. *Projeto Político Pedagógico do curso de Ecologia -* (P4). Natal, RN, 2010.

Universidade Federal da Paraíba. *Projeto Político Pedagógico do curso de Ecologia -* (P5). Rio Tino, PB. 2012.

Universidade Federal Rural do Semi-arido. *Projeto Político Pedagógico do curso de Ecologia -* (P6). Mossoró, RN, 2009.

Universidade Federal de Goiás. *Projeto Político Pedagógico do curso de Ecologia e Análise ambiental -* (P7). Goiânia, GO, 2009.

Universidade Federal de Sergipe. Catálogo dos cursos da UFS, área 2, p.23. *Projeto Político Pedagógico do curso de Ecologia* – (P8), São Cristovão, SE. Disponível em:<www.ufs.br/cursos/>. Acesso em 20 Jul. 2011.

VIEIRA, Marcus V. A construção do conhecimento na ciência Ecologia. In: *Anais do II EREBIO.* São Gonçalo-RJ, 2003. p. 31-36. Disponível em: <http://www.biologia.ufrj.br/labs/labvert/Artigos/IIEREBIO.pdf>. Acesso em: 04 dez. 2011.

VON, Bertalanffy L. von. *General system theory*. Foundations, development, applications. 11ª ed. New York: George Braziller, 1993.

Submitted on: 04/11/2012
Accepted on: 21/08/2013
http://dx.doi.org/10.1590/1809-44220003911

UNDERGRADUATE COURSES IN ECOLOGY IN BRAZIL: PARADIGMATIC APPROACHES

CAMILA FERREIRA PINTO DAS NEVES, GIONARA TAUCHEN

***Abstract*:** From the end of the century XIX, the Ecology is suffering processes of enlargement and diversification. The objective of this study is to identify the paradigms that pervade the pedagogical proposals of university degree programs in ecology. Each course is understood as an expression of the thoughts and actions of a scientific community, which influence the construction of professional concepts as well as the contents and forms of the field's inquiries. The research is characterized as qualitative, in terms of both documentary and hermeneutic nature. All of the university ecology degree programs in Brazil, which total eight, were analyzed. It was concluded that the structured programs from the turn of the century and onward have included more complex perspectives. Specifically, they are comprised by organisms that are not only part of ecological communities but rather are part of more complex ecosystems, of which contain a multitude of smaller organisms that are endowed with considerable autonomy, and, moreover, are harmoniously integrated in how everything within an ecosystem works.

***Key Words*:** Ecology; Paradigms; Educational projects.

***Resumo*:** Desde o final do século XIX, a Ecologia vem passando por processos de ampliação e diversificação. Por isso, o presente estudo identificou os paradigmas que perpassam as propostas pedagógicas dos cursos de graduação em Ecologia. Entendemos cada curso como expressão de pensamentos e ações de uma comunidade científica, os quais influen¬ciam a construção das concepções profissionais, bem como os conteúdos e as formas de suas investigações. A pesquisa caracteriza-se como qualitativa, de cunho documental e hermenêutico. Foram analisados todos os cursos de graduação em Ecologia no Brasil, que são oito no total. Concluímos que os projetos estruturados, a partir da virada do século, contemplam perspectivas mais complexas, ou seja, compreende-se que os organismos não são apenas partes de comunidades ecológicas, mas complexos ecossistemas, contendo uma multidão de organismos menores, dotados de uma considerável autonomia e, não obstante, harmoniosamente integrados no funcionamento do todo.

***Palavras-chave*:** Ecologia; Paradigmas; Projeto pedagógico de curso.

Resumén: A partir del final del siglo XIX, la Ecología sufre procesos de ampliación y variedad. Este estudio tiene por objetivo identificar los paradigmas que atraviesan las propuestas pedagógicas de los cursos de graduación en Ecología. Entendemos cada curso como la expresión de los pensamientos y acciones de una comunidad científica, que influencian tanto la construcción de las concepciones profesionales como los contenidos y las formas de sus investigaciones. La investigación es de tipo cualitativo, de cuño documental y her¬menéutico. Se analizaron todos los cursos de graduación en Ecología de Brasil, que son ocho en total. Concluimos que los proyectos estructurados, a partir del cambio de siglo, contemplan perspectivas más complejas, es decir: los organismos no son tan solo partes de comunidades ecológicas, sino complejos ecosistemas que contienen una multitud de organismos menores. Están dotados de una autonomía considerable y, no obstante, están integrados de forma harmónica en el funcionamiento del todo.

Palabras clave: Ecología; Paradigmas; Proyecto pedagógico de curso.