Toward a More Expansive Conception of Ecological Science

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Abstract

There are two competing conceptions of the nature and domain of ecological science in the popular and academic literature, an *orthodox* conception and a more *expansive* conception. The orthodox conception conceives ecology as a natural biological science distinct from the human social sciences. The more expansive conception views ecology as a science whose domain properly spans both the natural and social sciences. On the more expansive conception, non-traditional ecological disciplines such as "ecological psychology", "ecological anthropology" and "ecological economics" may legitimately be regarded as sub-disciplines *of ecology*, and the practitioners of such disciplines as *ecologists.* The orthodox-expansionist issue is significant both for the practice of ecology and for the self-identity of the philosophy of ecology. I argue in favour of the expansionist conception of ecology on general conceptual grounds, and by developing the case for one particular non-traditional ecological discipline, *ecological psychology*.

Key Words:
ecology, nature and domain of; ecological psychology; J.J. Gibson; philosophy of ecology.

Introduction

There are two competing conceptions of the nature and domain of ecological science in the popular and academic literature, one that has achieved the status of orthodoxy among professional ecologists, and another more expansive conception of ecology that, while a minority view among ecologists, is favoured by certain groups of environmentalists and academics in the social sciences and humanities. The orthodox view conceives ecology as a natural biological science distinct from the human social sciences. The more expansive conception views ecology as a science whose domain properly spans both the natural and social sciences. On the more expansive conception, non-traditional ecological disciplines such as (for example) "ecological economics" and "ecological psychology", may legitimately be regarded as *sub-disciplines of ecology*, and the practitioners of such disciplines as *ecologists.*

The issue of whether to adopt the orthodox or the more expansive conception of ecological science is significant both for the practice and the philosophy of ecology. The aim of this paper is to offer considerations in favour of the more expansive conception of ecological science, and to explore its significance for the philosophy of ecology.

Section 1 sets up the distinction between the orthodox and expansionist conceptions of ecology, and offers some general arguments in favour of expansionism. Section 2 uses a case study of a non-traditional ecological science – the branch of perceptual and cognitive psychology known as "ecological psychology", founded by American perceptual psychologist J. J. Gibson – to illustrate and deepen the general claims made in Section 1. I argue that ecological psychology should be regarded as a legitimate sub-discipline of ecology, and that this conclusion undermines the orthodox conception. I use this case study to show how an expansionist conception of ecology functions to broaden and deepen the set of philosophical problems that can naturally be called problems for the philosophy of ecology.

1. Two Conceptions of the Nature and Domain of Ecological Science

In addressing the nature and domain of ecological science, it is useful to begin with historically influential and widely accepted definitions of the subject matter of ecology.

Definitions of the Subject Matter of Ecology

The first person to use the term "ecology" to denote a distinct field of scientific inquiry was Ernst Haeckel:

> By ecology we mean the body of knowledge concerning the economy of nature – the investigation of the total relations of the animal both to its inorganic and to its organic environment; including above all, its friendly and inimical relations with those plants and animals with which it comes directly or indirectly into contact – in a word, ecology is the study of those complex interrelations referred to by Darwin as the conditions of the struggle for existence. (1866, trans. in Allee et al 1949: frontispiece)

The reference to Darwin is significant because it establishes a precedent for conceiving ecology as essentially an organism-centered science that makes necessary reference to evolutionary concepts such as "adaptation", "competition", and so forth. Yet Haeckel's definition remains ambiguous with respect to the intended scope of ecological theorizing. How broad is the domain that includes "the total relations of the animal both to its inorganic and organic environments"? How indirect is "indirect contact" allowed to be? Haeckel's definition is often paraphrased as "the study of the relations between organisms and their environments" in introductory textbooks and dictionary entries, but not all ecologists are happy with a definition so broad that it threatens to exclude almost nothing.

Ecologists wishing to place clearer constraints on the domain of ecological theorizing have focused on that subset of the total relations between organisms and their environments that influence "the conditions for the struggle of existence". On this view, ecology is the scientific study of those factors that "determine the distribution and abundance of organisms". This conception of ecology is favoured by population- and community-oriented ecologists that seek to situate ecology firmly within the life sciences, emphasizing its overlap with the sciences of behaviour, genetics, physiology and evolution (Andrewartha 1961; Begon et al 1990; Krebs 2001).

There is another tradition in ecology that focuses on the network of material cycling and energy flow in ecological systems. Ecological science in this "ecosystem" or "process-functional" tradition emphasizes the dependence of organic life on complex

biochemical and energetic processes occurring at varying spatial and temporal scales (O'Neill et al 1986). A recent definition of ecology accepted by the Institute of Ecosystem Studies (IES) in Millbrook, New York, attempts to accommodate both the population-community and process-functional schools of ecology:

> Ecology is the scientific study of the processes influencing the distribution and abundance of organisms, the interactions among organisms, and the interactions between organisms and the transformation and flux of energy and matter. (Likens 1992)

This definition is admirably ecumenical, but for many, still overly broad. Consider the consequences of taking as one's organism of study the *human* organism. One might ask what sorts of phenomena would *not* fall under this definition.

Ecological Orthodoxy

The orthodox conception of ecology is motivated in part by the belief that for ecological science to develop and mature (indeed, to be taken seriously as a science at all), it must carefully delimit the sorts of phenomena it studies. The orthodox conception that one finds in standard ecology textbooks (e.g. Begon et al. 1990; Krebs 2001) has the following features:

- Ecology is a pluralistic discipline with many sub-fields, but ultimately it is to be understood as a *natural* (as opposed to "social"), *biological* (as opposed to "physical") science. (Begon et al 1990: x; Krebs 2001: 2)
- Ecology may deal with various physical, chemical and biological phenomena at the individual, population, community and ecosystem levels, but the *ultimate aim* of ecological science is to explain and predict *patterns and changes in the distribution and abundance of organisms*. Ecology is, fundamentally, a science of *demographic* processes. (Begon et al 1990: 122; Krebs 2001: 7).
- Ecology focuses on the *natural world* of plants and animals. Ecologists are concerned with human beings only to the extent that human activity has *impacts* on the distribution and abundance of plants and animals (which, everyone admits, are significant). Ecology does not study the root causes of human impacts on the environment, or the social ramifications of such impacts. That is the job of

interdisciplinary fields like "environmental studies", which should be distinguished from the natural science of ecology. (Krebs 2001: 6).

- Many standard definitions of ecology, such as Haeckel's 1869 definition as a science of the "total relations of the animal to both its organic and inorganic environment", or the IES definition, are useful for conveying the flavor of ecological science, but are too broad and vague to properly delimit ecological science (Krebs 2001: 2)

The orthodox conception was strongly influenced by the rise of evolutionary and population ecology in the 1960s and 70s, which reinforced an organism-centered, demographic conception of ecology; and the appropriation of the term "ecology" by the environmental movement over that same period, which demanded that ecologists clarify how their scientific discipline was different from a general social concern for environmental welfare. And as mentioned, it was also influenced by a felt need among professional ecologists to defend the scientific status of their discipline, and to set it on a path toward scientific maturity.

Ecological Expansionism

By contrast with the orthodox conception of ecology, the expansionist conception possesses the following features (note: the formulations below are mine, but the sentiments can be seen in Keller and Golley 2000: 14-18. See also Holling 1998):

- Ecology is a pluralistic discipline with many sub-fields, and should be understood both as an *interdisciplinary* science that spans the physical, biological and social sciences, and as a *synthetic* science that has as one of its aims to *integrate* ecologically relevant information from various different spatial and temporal scales and levels of organization, including human social organization.
- Ecology deals with various physical, chemical and biological phenomena at the individual, population, community and ecosystem levels, but the *ultimate aim* of ecological science is (roughly) to explain and predict properties of living systems (individuals, populations, communities) as functions of their relationships to their various biotic and abiotic environments. These properties include, but are not

restricted to, demographic processes concerning abundance and distribution of organisms.

- Human beings are the most ecologically influential species on the planet, and *human ecology* (broadly construed) is an important and legitimate branch of ecological science. Human ecologists study the ecological dimensions of human nature and human activity, including phenomena that might also be studied by economists, sociologists, psychologists, anthropologists and historians. Disciplines such as *ecological psychology*, *ecological economics*, and *ecological anthropology*, which are not regarded as branches of ecology on the orthodox conception, are so-regarded under the expansionist conception.
- The standard definitions of ecology, such as Haeckel's 1869 definition and the IES definition, while admittedly broad, should be read at face value, for they accurately capture the general focus on organism-environment relations that characterizes ecological thinking, and the breadth of the domain of ecological science.

As far back as 1940 one finds articles in the journal *Ecology* arguing for a conception of ecology as a general science that would include both the biophysical and "semiotic" dimensions of organism behaviour, including human behaviour (Haskell 1940). The expansionist conception is evident in the writings of system-oriented ecologists (e.g. Odum 1971; Odum and Odum 1976; Ulanowicz 1997), and it flourished during the heyday of ecosystem and systems ecology (approximately 1950-1970; see Golley 1993). With the neo-Darwinian synthesis and the rise of population and community ecology over the past 30 years, expansionism has become a minority position among mainstream ecologists, but it has seen a resurgence in certain branches of applied ecology, such as conservation ecology (Holling 1998) and sustainability theory (Allen et al. 2003), and it has always been foundational to human ecology (Erlich 1997, 2000).

Note: While many expansionists are also sympathetic to holism, I am not identifying the expansionist conception of ecology with ecosystem or systems ecology, or holistic conceptions of the organization and development of ecosystems. Nor am I identifying the expansionist conception with the broad set of meanings with which the term "ecology" has been used in the popular and academic literature (ecology-the-ethic,

ecology-the-worldview, etc.). The expansionist conception of ecology is a conception of the nature and domain of ecological science, of what sorts of phenomena, and what sorts of theories and methodologies, are appropriately called "ecological".

What's at Stake?

The dispute between ecological orthodoxy and ecological expansionism may appear to be of little practical significance for ecologists, but this is not the case; the issue is fundamental to the self-conception of ecology as a scientific discipline. Professional ecology is organized as a network of overlapping sub-disciplines, and general questions concerning what is to count as an ecological problem or an ecological theory (as opposed to, say, a "biological", "chemical" or "sociological" problem or theory), and discipline-specific questions concerning whether a given bit of research falls under a particular branch of ecology or another, are continually faced by journal editors and government and private research funding organizations. What guides individuals charged with such gatekeeping functions is a general conception of what ecological science is, what distinguishes the various sub-disciplines of ecology, and how ecology ought to be practiced, both generally and within discipline-specific traditions. Whether the gatekeepers are defenders of orthodoxy or expansionism can make a real difference to the social structure and practice of ecology.

The orthodoxy-expansionism issue also bears on the debate over the role that ecological science can and ought to play in environmental problem solving. Many advocates of the expansionist conception believe that, insofar as environmental problems can be regarded as symptoms of a dysfunctional ecological relationship between human beings and the natural environment, then these are central problems for the science of human ecology. Defenders of orthodoxy resist the assimilation of applied environmental problems with all their confounding ethical, social and political dimensions, to ecological science. Expansionists, by contrast, believe that ecology, as a science of *synthesis* as well as analysis, is better suited than most to deal intellectually with problems that require integrating information from many topic areas, scales and levels within ecology, as well as collaboration and integration with the physical and social sciences. In addition, expansionists believe that ecologists can contribute in deeper ways, by studying the

ecological dimensions of human psychology and social behaviour that may underlie contemporary environmental attitudes and practices (e.g. Erlich 2000). Related to this issue is the question of how some environmental philosophers seek to use ecology as a foundational discipline for constructing normative theories prescribing how we ought to treat the environmental. In general, ecological expansionists are more sympathetic to such efforts, since they understand ecology as bearing directly on fundamental questions of human-environment relations (e.g. Golley 1994).

Finally, the orthodoxy-expansionist debate is important to the identity of the philosophical specialization that calls itself "philosophy of ecology". A survey of articles published in *Biology and Philosophy* over the past five years reveals a growing interest in ecological science among philosophers of science. With some notable exceptions (e.g. Haila and Taylor 2001), the majority of published journal articles on such topics have tacitly assumed the orthodox conception of ecological science; their authors regard the philosophy of ecology as a specialization in the philosophy of science that focuses on the distinctive theoretical, methodological and conceptual problems of behavioural, population and community ecology as these fields are understood within the orthodox conception. But if the expansive conception of ecology is adopted, philosophers of ecology will have before them a wider array of ecological sub-disciplines to investigate, and a wider range of philosophical issues to consider. Ecological psychology, for example, regards the phenomena of human perception, cognition, and action as fundamentally *ecological* phenomena, as does ecological anthropology regard human social behaviour. The philosophical problems of these fields are not simply problems for a narrow branch of the philosophy of science, as the philosophy of ecology is currently perceived, but foundational problems for the core philosophical disciplines of metaphysics, epistemology, and value theory (I will follow up this point later in the paper). In short, an expansive conception of ecology may serve to both broaden the philosophy of ecology and move it closer to the center of philosophy itself.

An Argument for Ecological Expansionism

The basic argument for ecological expansionism is grounded in the incontrovertible fact that human beings are part of the natural world, that for millennia they have been players

in the evolutionary drama unfolding within the ecological theatre of this planet. Human beings interact with ecological agents and the physical environment at varying spatial and temporal scales, and questions concerning the factors that influence the distribution and abundance of populations, or the relationships between species behaviour and characteristics and the flow of matter and energy in ecosystems, are just as applicable to human beings as to any other species. If we accept anything like Haeckel's or the IES definition of ecological science, we cannot avoid the conclusion that human beings are legitimate objects of ecological study. Nor can we avoid the conclusion that an ecology of human beings, if it is comprehensive, will address phenomena that would ordinarily be studied by the social sciences, including psychology, anthropology and economics.

There is additional support for ecological expansionism in the fact that *there already exist* non-traditional ecological disciplines that are conceived by their practitioners as continuous with a general science of ecology. Ecological psychologists seek to further "the development of psychology as a branch of ecological science" (editors' preface in Lombardo 1987); ecological economists develop models and frameworks that explicitly acknowledge that "humans and their economies are parts of larger natural ecosystems and coevolve with those natural systems" (Farber and Bradley 1996: 1). If we grant that these disciplines qualify as sciences, then there seems little reason to deny them the label "ecological". At least, the onus is on defenders of orthodoxy to say why any given discipline should not be so-regarded.

A General Worry

We should pause to consider a general worry about the sort of expansionism that is being advocated here. One might grant that human psychological and social phenomena may be profitably conceived as ecological phenomena, but believe that the scientific study of such phenomena will simply have too little in common with orthodox ecology to warrant regarding it as part of a common scientific enterprise. Human beings are, after all, unique among terrestrial species. Human cognition, language use, technology and culture entail that our interactions with one another, with other species and with the physical environment are *more complex and multi-faceted than*, and in many respects *qualitatively different from*, those of any other species. The worry, then, is that a human ecology

adequate to the phenomena will necessarily employ theories, concepts and methods that are not generally applicable to non-human species, and hence will remain a distinct type of science, with both naturalistic and hermeneutic dimensions that contrast sharply with the theories and methods of orthodox ecology. But if so, then why broaden the conception of ecology to include such fundamentally different disciplines under the same category? What exactly is to be achieved by this?

One can formulate this objection along more pragmatic lines. Given the fundamental differences between human and non-human ecology, we should expect the *training* of human and non-human ecologists to necessarily differ as well. A comprehensive education in human ecology will require, among other things, exposure to principles and methods of some subset of sociology, anthropology, psychology and economics, but *none* of this human-specific disciplinary training will be of much use or interest to the orthodox ecologist interested in, say, community assembly rules in marine ecosystems, or nitrogen fixation and cycling in deciduous forests, or evolutionarily stable strategies in intraspecies spider fights. Nor will much of what is taught to orthodox ecologists be useful to the human ecologist interested in, say, the ecological factors that influence the onset of economic depressions or the wholesale collapse of civilizations. Thus, given the limited time and resources available to prospective ecologists, and the inherent differences in the nature and complexity of human vs. non-human ecology, the prospects appear dim for even a minimal unification of ecology along the lines envisioned by expansionism.

It is on this last assumption – that ecological expansionism either implies or is predicated on identifying a common theoretical or methodological core shared by all ecological sub-disciplines – that these objections turn. But the expansionism being advocated here neither implies nor is motivated by such global unificationist sentiments. Nor does it demand that all ecological sub-disciplines be taught to aspiring ecologists. My claim is that adopting an expansionist conception of ecology will help promote fruitful cross-fertilization of ideas and methods and encourage novel forms of interdisciplinary research between otherwise isolated ecological sub-disciplines. This position is consistent with the existence of, and support for, specialized training and a high degree of sub-disciplinary autonomy. But it is not difficult to see points of contact

where ecologists and social scientists could benefit from cross-disciplinary dialogue and training. The case is most obvious for the various branches of applied ecology that more often deal with human-environment interactions (conservation and restoration ecology, for example), but many branches of so-called "pure" ecology may also benefit. There are close associations between, for example, population ecology and human demography, behavioural ecology and (as we shall see) Gibsonian ecological psychology, and systems ecology and ecological economics. My aim is to promote productive "pair-wise" interactions among ecological sub-disciplines that cross traditional disciplinary boundaries. Whether such interactions lead to (local or global) conceptual or methodological unifications is a contingent matter to be determined by the progress of these disciplines.

A related concern about ecological expansionism has to do with the *quality* of the science that is conducted under the banner of "ecology". We should expect that, due to the inherent complexity of human-environment relations, the human ecological sciences will not be as rigorous or well developed as the orthodox ecological sciences, and we may thus be concerned that expansionism poses a risk to the status of ecology as a mature, empirical science. But it is important not to confuse the distinction between *ecological* science and *non-ecological* science on the one hand, and *good* science and *bad* science on the other. An expansionist conception of ecology broadens the category of sciences that qualify as "ecological", but it is neutral with respect to the goodness or badness of any such science. The latter evaluation will always be discipline-specific. If ecological psychology, say, is judged to be *bad* science, then we have good reason to not take it seriously, and to exclude it from our list of sub-disciplines of ecology. My concern is to block the initial judgment to exclude such non-orthodox disciplines from the list simply because their intended domains of application may not strongly overlap with the domains of orthodox ecological disciplines.

To sum up: In the first half of the paper I introduced the distinction between orthodox and expansionist interpretations of ecological science, offered an initial argument in favor of expansionism, and considered an initial set of objections. I also made some rather grand claims about the significance of the orthodoxy-expansionism issue for the philosophy of

ecology. In the second half of the paper I will discuss a non-traditional ecological discipline – ecological psychology – in greater detail. This case study will help press the case for including ecological psychology as a branch of ecology, and illustrate how that inclusion undermines the orthodox conception of ecology. It will also help to develop the claim that ecological expansionism brings the philosophy of ecology closer to the center of philosophy.

2. Ecological Psychology: A Case Study of a Non-Traditional Ecological Science

The American psychologist James J. Gibson developed what is known as the "ecological" approach to perception, action and cognition in a series of papers and monographs spanning a thirty-five year period (Gibson 1950, 1966, 1979/1986). For Gibson, perception is understood as the ability of an organism to have its behaviour be guided or regulated by information that specifies the relationship of the organism to its ecological environment. Gibson's most distinctive theoretical claim is that the information for perception is already present in the ecological environment, in the form of structured energy patterns in the ambient energetic array surrounding an organism (in the "light environment" for visual perception, in the "sound environment" for auditory perception, etc.). His research showed that considerably more ecologically and behaviourally relevant information is present in the environment than is traditionally assumed, and that many complex behavioural tasks can be understood in terms of the direct, unmediated "pickup" and exploitation of this information by the perceiving agent.

Gibson's research inspired a branch of psychology that has come to be known as "ecological psychology", which attempts to understand both animal and human behaviour and cognition within a broadly Gibsonian framework. Only a small percentage of researchers self-identify as "Gibsonian" or "ecological" psychologists, but recent interest in so-called "embedded/embodied" and "dynamical systems" approaches to cognition has sparked renewed interest and appreciation for Gibson, as these approaches have much in common with (and are in significant respects anticipated by) the ecological approach (see Port and van Gelder 1995: 38).

Elements of Ecological Psychology: Affordances and Ecological Information

Consider two animals, a gopher and spider, situated in an open area, surrounded by a variety of objects (grass, trees, tree stumps, a small pond). There is a sense in which the gopher and the spider share a common environment – they are surrounded by the same physical and energetic "stuff" – yet in another sense, the gopher and the spider live in very different environments. For the gopher, a tree is something that obstructs its motion, that it can hide behind, but cannot climb. For the spider, the tree is a climbable thing. The gopher can burrow into the dirt and soil, but the spider cannot (assuming it's not a burrowing spider). The spider may be able to walk across the surface of the pond, but the gopher cannot. Different aspects of the shared environment of the gopher and the spider respectively afford different opportunities for behaviour and action. Gibson argued that the study of an organism's behaviour must focus on the "ecological" environment of the organism, the environment that affords the opportunities and resources on which the life of an organism depends.

Gibson used the term "affordance" to refer to those properties of the ecological environment of an animal that support its behavioural potentialities. The pond affords walking-on for the spider (and any other water-walker), but not for the gopher; the "walk-on-ability" of the pond surface is an affordance property of the ecological environment of the spider. Similarly, a coffee cup affords grasping – has the affordance of "graspability" – for some animals, but not for others. These affordance properties of the environment are relational properties, but they are not subjective; they are properties of the environment that are indexed to the behavioural and morphological traits of organisms.

The principle claim of Gibsonian psychology is this: *what an organism perceives is the affordance properties of its ecological environment*. Perception, for humans and animals, is the perception *of* affordances. The objects, substances and events that make up the ecological environment of an animal are analyzed in terms of their affordance properties.

How is the perception of affordances made possible? This question is answered, to the satisfaction of most Gibsonians, by Gibson's concept of "ecological information". To understand the theory of ecological information it will be helpful to introduce the

notion of the "ambient optical array". Take a point in space where an observer might be located, and define a sphere of any given radius about that point. From the point of view of the hypothetical observer, the ambient optical array is a nested array of solid angles extending outward from the center of the sphere and passing through its surface. It may be helpful to think of the optical array in phenomenological terms as the array of adjacent and nested patches of varying luminosity that we observe in our visual field as we turn our heads, but it should always be kept in mind that the optical array is a structure external to the observer, and should not be confused with its projection onto the retina of the eye.

Gibson argued that the *information* that specifies affordance properties of the ecological environment is to be identified with (for the case of visual perception) *the invariant structures of the optical array that specify the relationship of the organism to the environment*. As the point of observation moves, the optic array changes – a flow of points of luminosity is induced over the surface of the sphere that we have arbitrarily chosen to specify the optic array. As I move forward, the patch of blue to my right moves behind me, while new points of luminosity appear from a radiating source in front of me, and disappear into a converging sink behind me (we notice this effect most strikingly when driving through heavy snow, or playing video games that recreate this flow pattern in order to create the sensation of motion). But some features of the optic array do *not* change as I move forward; they are *invariants* of the flow field. For example, rigid surfaces have a visual contour that changes as I move past them, but these changes are not arbitrary; they have an invariant property that identifies them as perspectival projections of a rigid surface in three-dimensional space. Gibson's research focused on invariants that specify fairly simple features of environmental layout, such as the size, shape, distance and relative position of objects (what is called "exterospecific information"), and invariants that specify features of the perceiving agent, such as whether the agent is stationary, rotating, or moving forward or backward ("propriospecific information"). Another class of invariants specify behavioural potentialities of an agent relative to its environmental situation, such as the graspability of an object, or the climbability of a set of stairs ("expropriospecific information"). It is important to remember, however, that these different types of invariants are merely

graded differences within the category of affordances, and hence in all cases what is perceived are not properties of the environment or the agent *simpliciter*, but properties of the agent-in-relation-to-environment.

A well-known example of research in ecological optics is the study of an invariant known as the "time-to-contact parameter", or "τ" (Lee 1980). Imagine a circle drawn on a brick wall as you drive toward it. In your visual field, the circle will expand at a rate that is a function of your distance from the wall, x, and your instantaneous velocity, dx/dt (which I will write as $\dot{x}$). If nothing changes, you will hit the brick wall at the time specified by $x/\dot{x}$, or $\tau(x)$. This quantity, τ, is a measure of the inverse of the rate of dilation of an optical solid angle, and is an objective property of the ambient optic array that specifies an affordance property of the environment for any moving observer, namely, the time remaining before contact with an approaching object. If an animal is capable of detecting τ, then it can use the information provided by τ to regulate its movement.

Real-world animal locomotion involves changes in velocity, and an animal will need to regulate its movement to control its impacts with approaching objects or surfaces. For this purpose one can consider how τ changes with time, $\dot{\tau}$. It can be shown that $\dot{\tau}$ specifies several different types of collision behaviour, from decelerating controlled collision (as when, for example, a bird alights on a tree branch), to accelerating, impactful collision (as when a dolphin rams a shark in the gills), to decelerating braking (as when a car comes to a complete stop just before hitting a brick wall) (Lee et al. 1993).

Is information specifying $\dot{\tau}$ available in the optical array? David Lee and his colleagues argue that not only is such information available, but it is available in several forms. In general, any sensory variable (acoustic, for example) can yield information about $\dot{\tau}$ if that sensory variable is a power function of the distance between observer and the approaching surface (Lee et al. 1992).

Of course, from the fact that an affordance property is specified by an invariant of an ambient energetic field, it does not follow that animals actually *use* that invariant to regulate their behaviour; this needs to be established experimentally, and the conducting and evaluation of such experiments is an important part of ecological psychology. In fact, there is evidence for the use of $\dot{\tau}$ in the regulation of the diving behaviour of

gannets, a fish-eating sea-bird (the gannet begins its descent at such altitudes that it must fold back its wings prior to impact with the surface of the water in order to avoid breaking them) (Lee and Reddish 1981); in the characteristic landing behaviours of flies and pigeons (Lee et al. 1993); the mid-air "docking" behaviour of hummingbirds with birdfeeders (Lee et al. 1991); and in the control of overhand drives of top-class table-tennis players (Bootsma 1988).

An example of a more complex affordance property, and one that brings out dramatically the concept of an agent-centered property of the ecological environment, is the climbability of stairs (Warren 1984). Given a set of staircases of varying rise heights and depths, human beings are able to pick out by visual inspection (even from slides) the stairs that are most comfortable for them to climb. When you put them on a stair-climbing apparatus that allows variation in riser height, the most energetically efficient riser heights for a given individual (as measured by oxygen consumption) correspond to the riser heights chosen by an individual from visual inspection. These vary as one might expect; taller people are more comfortable climbing stairs with a higher riser than shorter people. Yet clearly, what is being perceived is not an externally defined metric property of staircases, but an action-specific property of staircases that is defined in terms of intrinsic body-scaled units of the actor (in this case, leg length and riser height are correlated for optimal stair-climbing efficiency).

These examples help motivate the claim for which Gibson is most well-known in philosophical circles, namely, that perception involves the *direct* pickup of ecological information specifying the affordance properties of the environment, without the need for additional information processing by the organism (e.g. inference on sense data) or epistemological intermediaries (e.g. internal *representations* of the environment). In down-playing the role of internal symbolic representations of the world in explaining behaviour, Gibson is at odds with more orthodox symbolic-computational and connectionist approaches to perception and cognition. (Whether there is any real incompatibility between Gibson and mainstream psychology is a question to which we return below.)

But is it Good Science?

It seems obvious to most people that ecological psychology satisfies the standard definitions of the subject matter of ecology. However, one might grant that ecological psychology is a legitimate candidate for a branch of ecological science, but still be concerned that the science in question is not of sufficient quality or relevance to warrant serious consideration (this is the "good science/bad science" issue). Minimally, we should expect of any candidate ecological science that it have some claim to empirical adequacy within its intended domain of application. But then the fact that only a small minority of psychologists are willing to call themselves "ecological psychologists" is cause for concern, as it implies that the majority of psychologists find something objectionable about the approach. What exactly is so objectionable? In addition, any candidate ecological science should at least be consistent with established biological and ecological theory. Can ecological psychology satisfy this demand? We shall consider these questions in turn.

i) Why is the ecological approach a minority position among psychologists?

I have acknowledged that the ecological approach to psychology is a minority school, but also that many of Gibson's insights have entered the mainstream of cognitive psychology Where there is widespread skepticism or disagreement with Gibson is with respect to his perceived anti-cognitivist, anti-representionalist stand. Gibson is often interpreted as asserting that there is no need to postulate *any* sort of internal information processing (including, for example, inferences on sense data) in order to account for visual perception (e.g. Bruce and Green 1990: 377). Such a view, if true, would indeed fly in the face of widespread consensus in psychology and cognitive science. But there is little evidence that Gibson categorically rejected all forms of internal information processing. As Mark Rowlands states it, Gibson's claim is that "we cannot begin to estimate what internal processing an observer needs to accomplish unless we already understand how much information is available to that observer in the optic array" (Rowlands 1999: 108). The more information that is present in the optic array, the less internal information processing the observer needs to perform. What draws Gibson's ire is the all-too common practice of *assuming* that a given task requires a certain kind of internal information processing *without even investigating* the information that might be available

for that task in the ecological environment of the observer. Gibson's research showed that in many cases, at least certain kinds of internal information processing are unnecessary because sufficient information adequate to the task is already present and available in the environment. As a methodological research program, Gibson was interested to see *how far psychology could go* without positing internal information processing, but this is not the same as asserting that internal processing *never* occurs. Rowlands believes, and I concur, that Gibson-style analyses *ought to be* a component of *any* cognitive science research program that aims to uncover the information structures and processes that support perception and cognition.

It may be objected that this account of ecological psychology understates the tension between Gibson and mainstream psychology. Fodor and Pylyshyn (1981) argued that the Gibsonian account of perception involves a tacit inference from properties of the light (that are noninferentially "picked up") to properties of the environment, and that this inference can only be plausibly interpreted in terms of internal information processing involving representations. Not surprisingly, Gibsonians charged Fodor and Pylyshyn with misunderstanding the ecological approach and failing to appreciate the weaknesses of their own representation-based accounts of perception and cognition (Turvey et al. 1981). There isn't space here to evaluate this exchange in any detail. For present purposes, what is important is that debate over the role of representations and internal information processing in cognition has resurfaced in recent years with the rise of embedded/embodied and dynamical systems approaches to cognition, and there is a significant contingent of workers who are strongly critical of the classical cognitivist account of the role of representations in perception and cognition, and who endorse a broadly ecological orientation within the cognitive sciences, if not all the details of Gibson's own formulation of this orientation (McClamrock 1995: 138; Kelso 1995: 35-43; Port and van Gelder 1995: 38-39; Clark 1997: 50, 172). Thus, while it is true that certain claims associated with Gibson's philosophy of mind and perception, such as the claim that representations play *no* role in perception and cognition, are resisted by many psychologists and philosophers, it is also true that many other elements of the ecological approach have gained wide acceptance, even if not explicitly endorsed under the labels "Gibsonian" or "ecological".

ii) Is ecological psychology consistent with established biological and ecological theory?

Darwinian evolutionary thinking had a strong influence on Gibson. It was his conviction that perception is fundamentally an *adaptation for survival* that led Gibson toward his ecological model. An explicit argument for the evolutionary advantages of ecological information processing has recently been elaborated by Rowlands (1999, 2000). Rowlands uses evolutionary game theoretic reasoning to defend the following principle:

> If it is necessary for an organism to be able to perform a given adaptive task T, then it is differentially selectively *dis*advantageous for that organism to develop internal mechanisms sufficient for the performance of T when it is possible for the organism to perform T by way of a combination of internal mechanisms and manipulation of the external environment. (1999: 80)

He calls this the "barking dog principle", after the old adage: *why keep a dog if you are going to bark yourself*? In the barking dog example, the adaptive task is to warn of and discourage intruders. To perform this task without the benefit of any external tools or manipulation of the environment, one must personally spend considerable time and energy surveying for and discouraging intruders. If a dog is available that will do the job for you, then clearly it will pay to acquire the dog, as it will free up resources that could be used to perform other adaptive tasks. Rowlands gives a general argument that the "internal mechanisms only" strategy is evolutionarily more costly than the "internal plus external mechanisms" strategy. Thus, we should expect evolution to favour phenotypic traits and behavioural strategies that exploit external information-bearing structures where these are available. This applies to any task of adaptive significance, including cognitive tasks involving perception, memory, thinking and so forth. In the end, Rowlands uses this argument to defend a broadly ecological (what he calls "environmentalist") conception of perception and cognition (1999: 100-201).

Further conceptual and evidential relations between ecological psychology, behavioural ecology and evolutionary theory have been explored in Reed 1996 and Rowlands 2001. Reed follows Gibson in characterizing the theory of affordances as a development of ecological *niche* theory (Gibson 1979/1986: 128; Reed 1996: 39), a view that has been supported by at least one ecosystem ecologist (Patten 1991: 310). The point

is simply this: not only is ecological psychology *consistent* with evolutionary biology, there are attempts in the literature to *deduce* the broad principles of ecological psychology from evolutionary considerations, and *integrate* Gibsonian concepts into the theoretical framework of behavioural, population and systems ecology.

I conclude, then, that the minority status of ecological psychology is not based on any fundamental incompatibility with mainstream psychology and cognitive science, nor on conspicuous failures of ecological psychology to account for phenomena within its intended domain of application. Nor is there any incompatibility between ecological psychology and mainstream biological and ecological science. Indeed, it can be argued that the central principles of ecological psychology are supported on evolutionary grounds, and may provide useful resources for application in other areas of ecology.

If Ecological Psychology is a Branch of Ecology, Then We Must Reject Orthodoxy

It seems clear that the orthodox conception of ecological science cannot allow ecological psychology to count as a legitimate branch of ecology. First, while ecological psychology is clearly a science, it deals with *psychological* phenomena such as perception, memory, cognition, and action that lie outside the domain of orthodox ecology conceived as a natural, biological science. Second, in its focus on *individual-level* phenomena, ecological psychology fails to satisfy the ultimate aim of the orthodox conception of ecology, which is to elucidate *demographic* processes at the *population and community level*. Third, in its concern with *human* perception and action, ecological psychology violates the orthodox prescription to consider human activity *only* insofar as it impacts the demographics of plant and animal abundances. Thus, the orthodox conception rules out ecological psychology as a legitimate branch of ecology.

But if the above discussion has persuaded us that we ought to accept ecological psychology as a branch of ecology, then we must reject the commitments of the orthodox conception of ecology on which they are based. The expansionist conception of ecology articulated above may not be the only logically possible alternative to the orthodox conception, but in lieu of such alternatives, I conclude that there is good reason to accept something like it.

Consequences for the Philosophy of Ecology

I stated earlier that accepting an expansionist conception of ecology has a significant impact on what we understand the *philosophy of ecology* to be. Among philosophers of science, the philosophy of ecology is regarded as a fairly narrow specialization concerned with interpretive and methodological issues in (predominantly) population and community ecology, with some interest in conceptual issues in conservation biology (e.g. what is "biodiversity"?). One can read a dozen papers in the philosophy of ecology and never encounter an attempt to address problems in epistemology, metaphysics or value theory that would be regarded as *fundamental* by workers in those core fields of philosophy. But a non-traditional, human ecological discipline like ecological psychology *invites* such fundamental considerations, and a *philosophy* of such a field cannot avoid them.

Consider, for example, the problem of clarifying the nature and role of affordances in ecological psychology. An affordance is a relational property of organisms-in-environments, but exactly what kind of a property is this? There is considerable dispute over this question among philosophical interpreters of ecological psychology. Some argue that affordances cannot be thought as existing without the organisms that perceive or use them ("mutualists" as Reed calls them; e.g. Noble 1981; Still and Good 1998), but others, including Gibson himself, argue that affordances have an objective, independent existence (the "graspability" of a cup is a relational property of the cup indexed to the behavioural and morphological capacities of certain classes of organisms, but the cup is still graspable even if there are no suitable organisms around to grasp it) (Gibson 1979/1986: 128; Reed 1996: 26). This is a problem for the *metaphysics* of affordances, but when one recalls that affordances are the primary objects of perception and knowledge in ecological psychology, it becomes an *epistemological* problem concerning the origins and status our knowledge of the external world. There is a range of views on what sort of epistemology is suitable for (or implied by) ecological psychology, but there is widespread agreement that any such epistemology will differ from traditional "subject-object" epistemologies that impose a sharp, principled distinction between properties of the knower and properties of the known (Lombardo

1987: 309-333). There is also a small but growing literature that attempts to clarify and develop Gibson's claim that the *meanings* and *values* of the environment for an organism are themselves part of that environment; that meanings and values are *external* to the organism (Reed 1996: 96-110; Rowlands 2000: 139-160).

Now, one might grant all of the above but object that the philosophical issues raised by ecological psychology are not in principle *inaccessible* to the philosophy of orthodox ecology. If it is true, for example, that the theory of affordances can be interpreted as a development of ecological niche theory, and niche theory is an accepted part of orthodox ecology, then why are these philosophical issues not issues for orthodox ecology? And surely orthodox behavioural ecology must raise fundamental issues of perception and knowledge not dissimilar to those that occupy ecological psychologists, for behavioural ecology assumes that organisms have access to information about their environment.

First, we should acknowledge that the distinction between orthodox and non-orthodox (or human) ecology is not a sharp one; we have already noted points of contact between sub-disciplines from both sides. Indeed, it is *precisely because* there are shared phenomena of interest between orthodox and non-orthodox ecological researchers that cross-disciplinary dialogue has a chance of being productive for both parties. But we must also acknowledge that orthodox and non-orthodox ecologists bring different attitudes and methodologies to the study of such shared phenomena. Orthodox ecologists may be motivated to look more carefully at the metaphysical and epistemological status of an expanded conception of the ecological niche, say, but if they are operating within the orthodox "mode", they will do so in the first instance because they believe such an expanded niche theory may better explain the *distribution and abundance of organisms*, not because it may better explain *psychological phenomena of perception, cognition and action*. Consequently, the specific questions that are considered important, and the modes of theoretical development and experimental inquiry that are brought to the investigation, will be different for orthodox and non-orthodox ecologists.

This is evident, for example, in a recent major work on "niche construction" by Odling-Smee et al, in which an expanded niche theory (characterized in terms of coupled organism-environment relations entailing a co-evolving set of genetic, organismal and

environmental properties) is brought to bear on the traditional problems of evolutionary biology and orthodox ecology, including human behavioural ecology and cultural evolution, a clear "overlap" region with many branches of non-orthodox human ecology (Odling-Smee et al. 2003). The niche concept employed in this work has many affinities with the conception of organism-environment relations advocated by ecological psychologists, and (in my view) has considerable potential as a point of contact and resource for productive dialogue between orthodox ecology and ecological psychology. But Odling-Smee et al. make no effort to develop the metaphysics and epistemology of the niche in a way that would support a general theory of the relationship between environmental information and the assembly and control of goal-directed behaviours, or with a view to addressing problems posed by distinctively human perceptual and cognitive capacities, as ecological psychologists do (Heft 1989; Turvey 1992; Kadar and Effken 1994; Reed 1996). Odling-Smee et al. *could* pursue these issues, but they *don't*, and likely *won't*, because such issues are simply not regarded as fundamental to the concerns of orthodox ecologists.

Thus, while there may be no *in-principle* barriers preventing the philosophy of orthodox ecology from addressing fundamental issues of concern to non-orthodox human ecologists, in *practice* there are significant differences between orthodox and non-orthodox ecologists over the sorts of issues that are regarded as fundamental to their respective disciplines. In practice, a philosophy that embraces the more expansionist conception of ecology advocated in this paper will consequently embrace a broader range of questions as fundamental to the philosophy of ecology.

Conclusion

In this paper I've tried to argue for a more expansive conception of ecological science, and consequently for a philosophy of ecology that is both broader and deeper in scope than currently understood. I used ecological psychology as a case study of a non-traditional ecological science that satisfies the standard definitions of the subject matter of ecology, and used the philosophical problems of ecological psychology to illustrate how the philosophy of ecology might be enriched by accepting a more expansive conception of the nature and domain of ecology. My aim was not to focus attention

exclusively on ecological psychology, but rather to use the discipline as a wedge, to slip between the cracks of the orthodox conception of ecology and pry it open, giving space for consideration for other non-orthodox ecological sciences and the possible contributions they might make, both to ecological science and to the philosophy of ecology.

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