Identifying the role of conservation biology for solving the environmental crisis

Fredrik Dalerum

Research associate, Centre for Wildlife Management, University of Pretoria, Pretoria, South Africa

and

Research associate and Extraordinary lecturer, Mammal Research Institute, Department of Zoology and Entomology, University of Pretoria, Pretoria, South Africa

Correspondence:
Fredrik Dalerum
Department of Zoology and Entomology
University of Pretoria, Private Bag X020
0028 Pretoria
South Africa

Phone: +27 12 420 2539
Fax: +27 12 420 5242

Running head: Conservation and the environmental crisis

Abstract

Humans are altering their living environment to an extent that could cause environmental collapse. Promoting change into environmentally sustainability is therefore urgent. Despite a rapid expansion in conservation biology, appreciation of underlying causes and identification of long-term solutions have largely been lacking. I summarized knowledge regarding the environmental crisis, and argue that the most important contributions towards solutions come from economy, political sciences, and psychology. Roles of conservation biology include providing environmental protection until sustainable solutions have been found, evaluating the effectiveness of implemented solutions, and providing societies with information necessary to align effectively with environmental values. Because of the potential disciplinary discrepancy between finding long-term solutions versus short term protection, we may face critical trade-offs between allocations of resources towards achieving sustainability. Since biological knowledge is required for such trade-offs, an additional role for conservation biologists may be to provide guidance towards finding optimal strategies in such trade-offs.

Keywords: sustainability; conservation biology; social sciences; environmental policy; trade-off

INTRODUCTION

Humanity is threatened with dramatic environmental changes, possibly to an extent that could eliminate much of modern life as we know it (Ehrlich and Ehrlich 2013). We are facing species extinction rates far exceeding historical baselines, a climate change that we still have not quantified the extent, rate and consequences of, and a rapid depletion of natural capital (Walther et al. 2002; Cardinale et al. 2012). Although the environmental movement can be traced back to the 19th century, the realization that we are going towards an unsustainable utilization of natural resources was spurred four to five decades ago by the publication books such as 'Silent spring' (Carson 1962), 'The population bomb' (Ehrlich 1968) and 'Limits to Growth' (Meadows et al. 1972). Since then, there has been an accelerating public and political awareness of environmental problems (Robinson 2006).

The surge of interest in environmental issues generated a parallel increase in research related to the preservation of biological systems (Fig. 1). This line of research was initially deeply connected to existing branches of environmental sciences, particularly ecology, but has evolved into a synthetic scientific discipline in its own right (Meine et al. 2006; Kareiva and Marvier 2012). Much of this work has been devoted to monitor ecological change as a response to disturbance, to predict ecological effects of disturbance, to conserve species, geographic areas or ecological systems, or to restore damaged systems (Fazey et al. 2005; Lawler et al. 2006; Griffiths and Dos

Santos 2012). Substantial progress has been made in all of these fields, and conservation biology has been a continuously evolving discipline which has corresponded to a multitude of definitions (Kareiva and Marvier 2012).

However, some authors have highlighted a lack of focus on finding pragmatic solutions to the underlying causes for environmental problems (Daily and Ehrlich 1999; Whitten et al. 2001; Fazey et al. 2005; Robinson 2006). Two suggested explanations have been given: (i) there is inadequate academic interest in finding such solutions (Whitten et al. 2001), or (ii) the discipline itself is not the appropriate platform for actual problem solving (Mascia et al. 2003). Identifying the reason for this lack of focus on problem solving is clearly relevant for optimized distribution of financial and intellectual resources towards achieving long-term environmental sustainability. If there is inadequate interest among conservation biologists, a radical shift in the scientific direction of conservation biology is obviously necessary, but it would be relevant to still divert resources towards this discipline. However, if the solutions are to be found elsewhere, the most efficient use of resources would be to direct them towards disciplines that better align with identification and implementation of pragmatic solutions. This would suggest that we may not necessarily require more biological knowledge directly applied to sustainability solutions, at least not until solutions have been implemented, but that sustainability policies may be improved more by input from other disciplines than the biological sciences.

In this article I aim to evaluate the potential role of conservation biology in providing solutions to the environmental crisis using a simple binary decision tree, with the aim to evaluate how useful the generation and integration of more and deeper biological knowledge into policy making will be for solving the environmental crisis at this point in time.

A DECISION TREE FOR ENVIRONMENTAL DEGRADATION

Decision trees are often used as a tool to identify the most appropriate action given the current state of knowledge. Core concepts for building decision trees include clear identifications of the problem as well as the desired outcome. In the case of environmental degradation, the problem statement is straight forward; we are having an environmental impact that is too high given the Earth's capacity to re-generate critical natural resources. The desired outcome is to decrease environmental impact to be long-term sustainable or ethically defensible (Meine et al. 2006). Environmental sustainability can here be defined as a resource utilization that lies within the regenerative capacity of the biosphere (Wackernagel et al. 2002).

I have focused the decision tree around a series of sequential questions with a binary answer (Fig. 2). If positive, the decision flow will continue to the next level. If negative, it suggests a deficiency in knowledge or actions, which will require some remedy before continuing to further levels. It also contains a loop, so that the flow will take a circular form until the desired outcome has been reached. We can regard this tree as a heuristic tool to synthesize current knowledge and to identify appropriate actions.

Is there a problem?

The first question is related to the existence of the problem itself. Such a step may seem unnecessary, but it can be useful since it incorporates a knowledge evaluation regarding the existence of the problem into the decision process.

Anthropogenic environmental impact has both ethical and pragmatic dimensions (Robinson 2011). Ethical dimensions were initially raised as the basic foundation for environmental concern, where early environmentalists raised primarily philosophical arguments related to wilderness aesthetics and moral obligations to protect it (Nash 1989). However, an ethical approach to conservation values could lead to conservation goals that are not compatible with human development and welfare (McShane et al. 2011), and ethical dimensions of the current conservation debates are inadequately developed (Miller et al. 2011). Furthermore, the ethical dimension of the destruction of natural resources is a topic of such breadth and complexity that it warrants a discussion beyond the scope of this article. Therefore, without dismissing the supreme importance of ethical dimensions in conservation, and while realizing that human welfare and prosperity are themselves intrinsically linked to ethical issues, I will focus my attempt to answer this first question in the pragmatic domain; Does the current environmental destruction pose a threat to human welfare and prosperity?

The answer to this question is undoubtedly yes given the current state of knowledge (Ehrlich and Ehrlich 2013), although this data interpretation occasionally has been criticized (e.g., Lomborg 2001). Two components of environmental degradation have received disproportionally high attention, the effect of human activities on climate change and on depletion of biodiversity. There is now mounting evidence that these environmental disturbances alone could severely threaten human prosperity, and that they possibly already are doing so (Walther et al. 2002; Cardinale et al. 2012). A direct depletion of natural capital is an additional severe problem regionally. Furthermore, ecological systems are buffered from the effects of disturbances through inherent resilience. Such buffering can lead to dramatic state shifts once critical levels of disturbances have been reached (Scheffer et al. 2001), which have three potentially disconcerting effects. First, because of limited warning signs prior to state shifts, it can be exceptionally difficult to predict when they will occur (Scheffer et al. 2001). Second, it can be equally difficult to predict which state an ecosystem will shift into (May 1977). Third, the reversal of a shift is often not symmetric, so that the disturbance has to be taken further back than the initial switching point for a new shift to occur (Scheffer et al. 2001). Since the current environmental degradation occurs on a global scale, we can expect that it may give rise to large scale state shifts in the Earth's biota that could have potentially devastating effects on human societies (Scheffer et al. 2001).

Are we aware of the problem?

One of the fundamental criteria for any problem solving is that the problem has been recognised. Similar to the first question, this inquiry may seem redundant. However, individual people need to be aware of the problem to enable them to act on it. Therefore, even if there is enough knowledge to initiate the problem solving process, an inherent part of the problem may be that the appropriate people or an adequate number of people may not have reached such awareness. There is mounting evidence that we are in this situation with environmental degradation today (Ehrlich and Ehrlich 2013).

Although the academic community highlighted the urgency of the state of environmental degradation over two decades ago (Union of Concerned Scientists 1992), this knowledge has not fully been transmitted to political leaders (Mooney 2009). Moreover, public recognition of environmental problems is still poor (Robelia and Murphy 2012), and inclinations to respond behaviourally to environmental degradation remains limited (Matutinović 2012). Therefore, we appear to be in a situation where we as a society possess knowledge regarding the seriousness of environmental degradation that has not yet been sufficiently incorporated into the public knowledge domain (Ehrlich 2009).

Because of this discrepancy, this question cannot be given a definitive answer. Although we as a society appear to have reached an adequate awareness of the problem to progress the decision tree to the next level, it seems necessary to bridge the discrepancy between the societal and individual knowledge to empower individuals with the ability to respond to the current problem (Bamberg and Möser 2007). Such bridging would require two steps, which will be the first required actions identified from the decision analyses. First, we have an incomplete understanding of how environmental awareness is distributed (Ehrlich and Kennedy 2005). In order to maximize the impact of information campaigns, we therefore need to map geographic, cultural and social factors associated with knowledge deficiency. Second, the information flow itself needs to be improved. Incorporating scientific understanding into the public knowledge domain has proved problematic (Nisbet and Mooney 2007). Attempts have been made to overcome such barriers (e.g., Ehrlich and Kennedy 2005), but further progress is necessary to effectively communicate current knowledge to the public, particularly since an understanding of the ecological responses to climate change and biodiversity depletion may require a deeper understanding of ecological processes than what currently is being communicated into the public domain (Robelia and Murphy 2012). However, knowledge and understanding alone may not be enough to alter people's behaviour. Instead, the motivational drivers for pro-environmental behaviour are complex. Many factors, some of which may be conflicting, often drive our decisions and behaviour (Kollmuss and Agyeman 2002). Despite the obvious discrepancies between people's environmental awareness and environmental behaviour, problem recognition still stand a necessary pre-requisite for any problem solving process.

Have we identified the cause?

The root of the current predicament condenses down to two key factors. We have become a very large number of people, and given biogeophysical constraints of our finite planet, each individual has on average too high environmental impact (Ehrlich and Holden 1971). We could therefore outgrow our resources, and there is mounting evidence that we have already done so (Wackernagel et al. 2002). Such processes frequently occur at smaller scales, both historically among human populations and among populations of other animals, which typically leads to dramatic population reduction or local extinction (Diamond 2005).

The global human population is undergoing a phase of exponential population growth (Fig. 3a). The causes for this growth are manifold, but related to a shift to sedentary life styles, and increased survival and fertility caused by a combination of increased nutrition and medical expertise (Lutz and Qiang 2002). The world population passed 7 billion people in 2011 and is projected to reach approximately 10 billion people by 2050 (United Nations 2011). Population growth alone could therefore cause serious further stress on the physical environment.

However, the increasing human population is coupled with an increased per capita environmental impact (Fig. 4a), which magnifies the environmental effects of population growth. This increasing environmental impact is intimately connected to two characteristics of the current macroeconomic models (Georgescu-Roegen 1971; Meadows 1972; Daly 1973; Daly 1990). First, resources are typically eliminated in the production functions so that we are managing economies with an inherent assumption of unlimited resources (Jackson 2009). Second, economic performance is measured in terms of economic growth (Mankiw 2009). Therefore, current macroeconomic theories have received an increasing amount of criticism over the past decades (e.g., Georgescu-Roegen 1971; Daly 1973; Lundberg 1996; Czech 2000; Jackson 2009). Economic activities appear to be related to environmental impacts (Fig. 4b). This relationship has together with the lack of economic recognition for resource limitation and the assumption of perpetual growth as a good index of economic performance been identified as the core drivers behind the current environmental crisis (Meadows et al. 1972; Daly 1990; Arrow et al. 1995).

To summarize question three, we seem to have accumulated an appropriate understanding of the causes for environmental degradation. Therefore, it does not appear that our ability to solve the problem is hampered by a lack of understanding of what is causing it.

Have we identified a solution?

Four decades ago, Ehrlich and Holden (1971) described human environmental impact as:

$$I = P \times A \times T \qquad (1)$$

where I = human environmental impact, P = human population size, A = human material consumption and T = environmental efficiency of technologies supporting this consumption. Hence, to decrease impact we either need to decrease all of these terms, or some of them enough to compensate for a lack of decrease in the others.

There are ethically sound strategies for reducing population growth (Engelman 2012). These strategies are all targeting declines in fecundity, and are linked to improving equity in education, civil rights and economic development, both across genders and societies. Even without direct implementation of these strategies, human population growth is declining and the world population is predicted to stabilize within the next 100 years (Fig. 3b; Lutz and Qiang 2002). However, projections of human population growth are uncertain, and even the predicted asymptotic population size of 9-10 billion people could be difficult to sustain within biogeophysical limits. Since adequate implementation of fertility reducing strategies could reduce population growth to population sizes substantially below current predictions (Engleman 2012), there is a direct need to alleviate poverty, and in particular poverty related society and gender biases in education. We may therefore have identified possible solutions to reduce the impacts caused by population size, at least as far as possible within ethically defendable limits.

Although economic welfare drives several aspects of human wellbeing, the strength of the relationship is weak at high levels of economic activity (Fig. 5a,b). These asymptotic relationships suggest that it is possible to sustain a less material intense economy without sacrificing human prosperity (Jackson 2009). Therefore, there appears to be a great opportunity for decreasing environmental impact by eliminating large parts of current human consumption. Such reduction in consumption would, however, require radical shifts in macroeconomic theories as well as in human behaviour patterns. Whilst there has been some progress in developing modern economic theory, such theory developments are still in their infancy. Furthermore, we still have inadequate information of how to alter human behaviour, particularly since there appears to be a discrepancy between environmental values and the willingness to alter behaviour in correspondence to these values (Kollmuss and Agyeman 2002; Matutinović 2012). In particular, since altering human value norms may be central to enable a shift towards more environmentally efficient human behaviour, there is an urgent need to improve our understanding of how such norms form, disperse and become incorporated in human societies (Ehrlich 2009).

Finally, it is often argued that economic progress will lead to diminished environmental impacts through progression towards more resource efficient technology (Lomborg 2001). Although there is some evidence for such relationships on microeconomic scales, there is currently no macroeconomic support (Czech 2008). A central concept in this argument is decoupling, i.e. the de-linking of economic growth from environmental degradation (UNEP 2011). It is important to distinguish relative from absolute decoupling, where relative decoupling describes the reduction in resource intensity per unit of economic output and absolute decoupling the reduction in resource intensity of an economy regardless of its size (Jackson 2009). Although there is evidence for relative decoupling in some economic sectors (UNEP 2011), there is not yet any evidence for absolute decoupling (Jackson 2009).

The finite boundaries to our planet coupled with the current lack of empirical support for absolute decoupling suggests that a stabilization or decline in population growth and consumption may be the most fruitful ways of decreasing human environmental impacts. It is important to recognize that a decline in consumption must be caused by redefinitions of macroeconomic theories, since declines in consumption under the current economic paradigms would likely cause economic and societal collapse. Central to such solutions are to rebuild human value norms to enable transitions into less material intensive ways of life in the economically developed societies, and to enable a sustainable trajectory of humanitarian development for developing societies. Although we seem to have identified the required actions for reducing population growth, we still need to develop modern economic theories and to improve our understanding of how large scale changes in human behaviour can be initiated.

Have we implemented the solution?

Although we have achieved a significant conceptual understanding of how to transform human societies into more environmentally sustainable ones (e.g., Lundberg 1996; Czech 2000; Jackson 2009), the implementation of such transformations are still at very early stages. However, there is a rising environmental concern, particularly in developed countries. We now face the challenge of turning this concern into action, which requires alterations in the everyday habits of a large number of people, as well as substantial political commitments to drive changes through all sections of society. Because of the close relationship among economic structures, political policies, and the motivational drivers behind human behaviour, facing this challenge will require substantial and intensive collaborations among a series of disciplines within the social sciences, in particular psychology, economy and political sciences, as well as a closer dialogue between academics, non-political organizations and politicians (Mascia et al. 2003; Ehrlich and Kennedy 2005).

Did the implemented solution solve the problem?

Although we are yet a long way from being able to answer this question, we would at a time when solutions have been implemented need to evaluate the outcome against the overall goal of achieving sustainability. If the implemented solutions did not achieve those goals, it would be an indication of i) the causes for the problem were not accurately or completely identified, ii) the identified solutions were not appropriate for addressing those causes, or iii) the implementation of the identified solutions were not adequate for the solutions to have the desired effects (Fig. 2). Since sustainability benchmarks must be based on ecosystem performance, there will here be a clear role for conservation biology to first set these benchmarks, and second to evaluate whether or not they have been met by the implemented solutions. In addition, there is an equally clear role for biological knowledge in providing necessary information for aligning societies with environmental values better that what has been done so far in modern times.

CONCLUSIONS

In this attempt to synthesize what we know about the consequences of and the causes for environmental degradation, the decision tree identified four actions: I) Increase individual awareness of the seriousness of the present situation regarding environmental degradation, II) Reduce human population growth by decreasing geographic, social and gender bias in economic development and education, III) Identify alternative economic theories that permit resource limitation and are not based on perpetual growth as a core measure of utility, and IV) Identify and promote changes in human value norms that allow for a shift towards more resource efficient human behaviour. These actions require expertise from fields such as economy, political sciences, and psychology. Substantial progress is necessary in these disciplines, for instance a better understanding of how human value norms are formed and maintained in different societies, an understanding of why environmental values are not resulting in pro-environmental behaviour, knowledge of how to appropriately incorporate environmental values as economic commodities, and knowledge of how to effectively manage large scale economies without the implicit assumption of perpetual growth.

Building on this realization, we can identify three clear roles for conservation biology. First, because the problem is related to the functioning of biological systems, biology is one of the primary platforms for identifying concerns regarding detrimental environmental effects of human activities. Second, since it is likely that the transition into sustainable structures of human societies will take time, biological resources need to be preserved until sustainability has been reached. Third, once action has been taken towards reforming human societies, there is a clear role for biologists to evaluate the ecological effectiveness of implemented solutions and to provide information necessary to for societies to align effectively with environmental values. While the role of identifying concerns has largely been played out during the past decades, the second and third roles are at the very core of contemporary conservation (Leader-Williams et al. 2010).

Although it may be theoretically possible to re-direct financial resources from activities that cause environmental degradation to processes aiming at improving our relationships with the environment, such re-routing of finances is not realistic under current economic theories. Founded in the three Rio conventions on Biodiversity, Climate Change and Desertification, substantial political efforts have been put towards generating additional resources for improving environmental sustainability. For instance, there have been several attempts of putting monetary values on environmental ones, such as the Economics of Ecosystems and Biodiversity (http://www.teeb.org).

However, such efforts have lately been criticised (Turnhout et al. 2014). Furthermore, environmental values have not yet received full economic recognition, and can thus not be directly used in economic transactions. Therefore, funding towards improving human-environmental relationships remains relatively limited. The disciplinary discrepancy between finding long-term solutions versus short term protection therefore raises an important question which has not been adequately addressed in the conservation debate. Under the assumption that there is a limitation in the amount of resources available to eliminate environmental destruction, how large a proportion should be spent on eliminating the cause of the problem versus lowering the symptoms of its impact? Optimal solutions hinge on the relative rate of destruction compared to the rate of elimination of the cause of the destruction. A high rate of destruction would lead to a necessity for designating a large amount of resources towards protection. This could, however, lead to a negative feedback in which there are not enough resources designated to processes promoting environmental sustainability, which could lead to further depletion of environmental resources and potentially ecological collapse. I suggest that much work is needed in this realm. Apart from providing short-term protection, one of the potentially most useful roles for conservation biologists could be to provide biological guidance in terms of the optimal trade-off strategies given economic, social and environmental realities.

Author biography

Fredrik Dalerum is a terrestrial ecologist who focuses on the biology and conservation of mammalian carnivores, functional aspects of biodiversity and general issues of conservation and environmental sustainability.

Address: Department of Zoology and Entomology, University of Pretoria, Private Bag X020, 0028 Pretoria, South Africa

e-mail: fredrik.dalerum@zoology.up.ac.za

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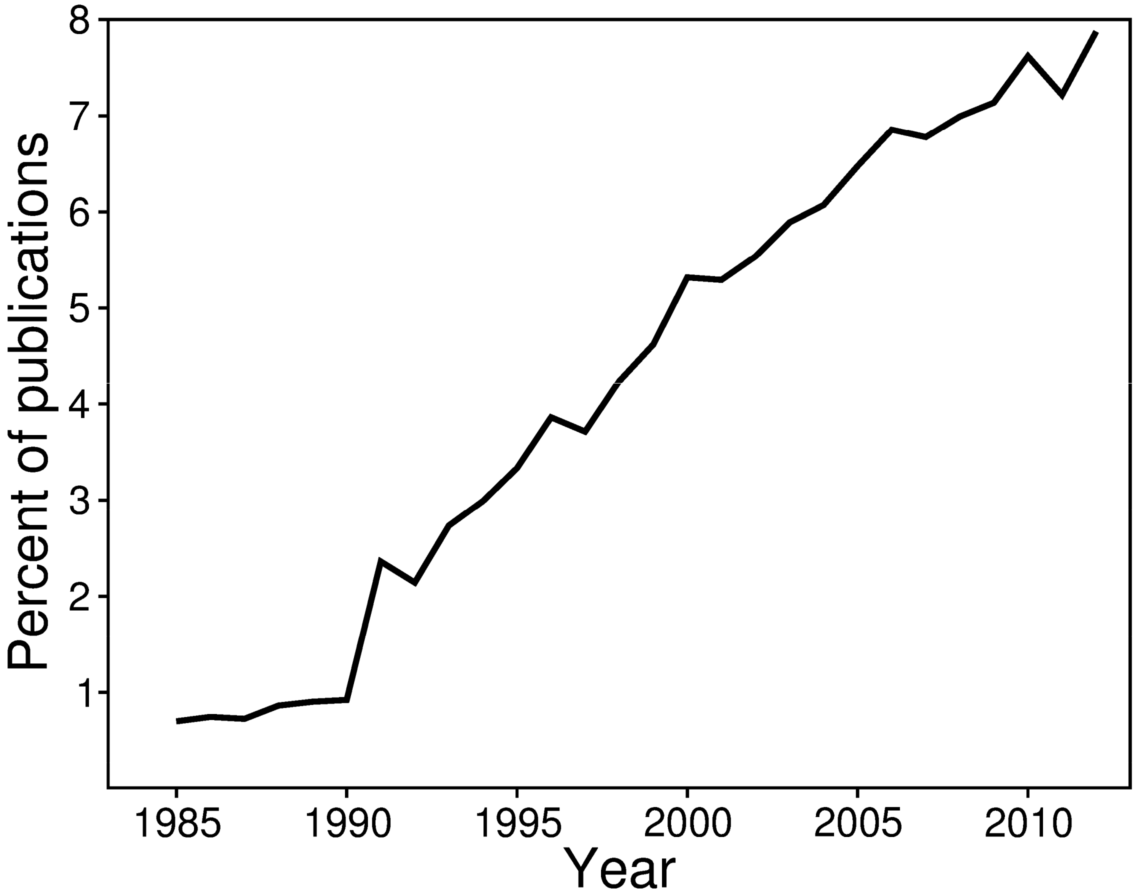

Fig. 1. Percentage of scientific publications in the field of environmental sciences and ecology that contain the search term ”conservation” between 1985 - 2012. Data are from ISI Web of Science (http://www.isiwebofknowledge.com/, accessed 2013-01-19).

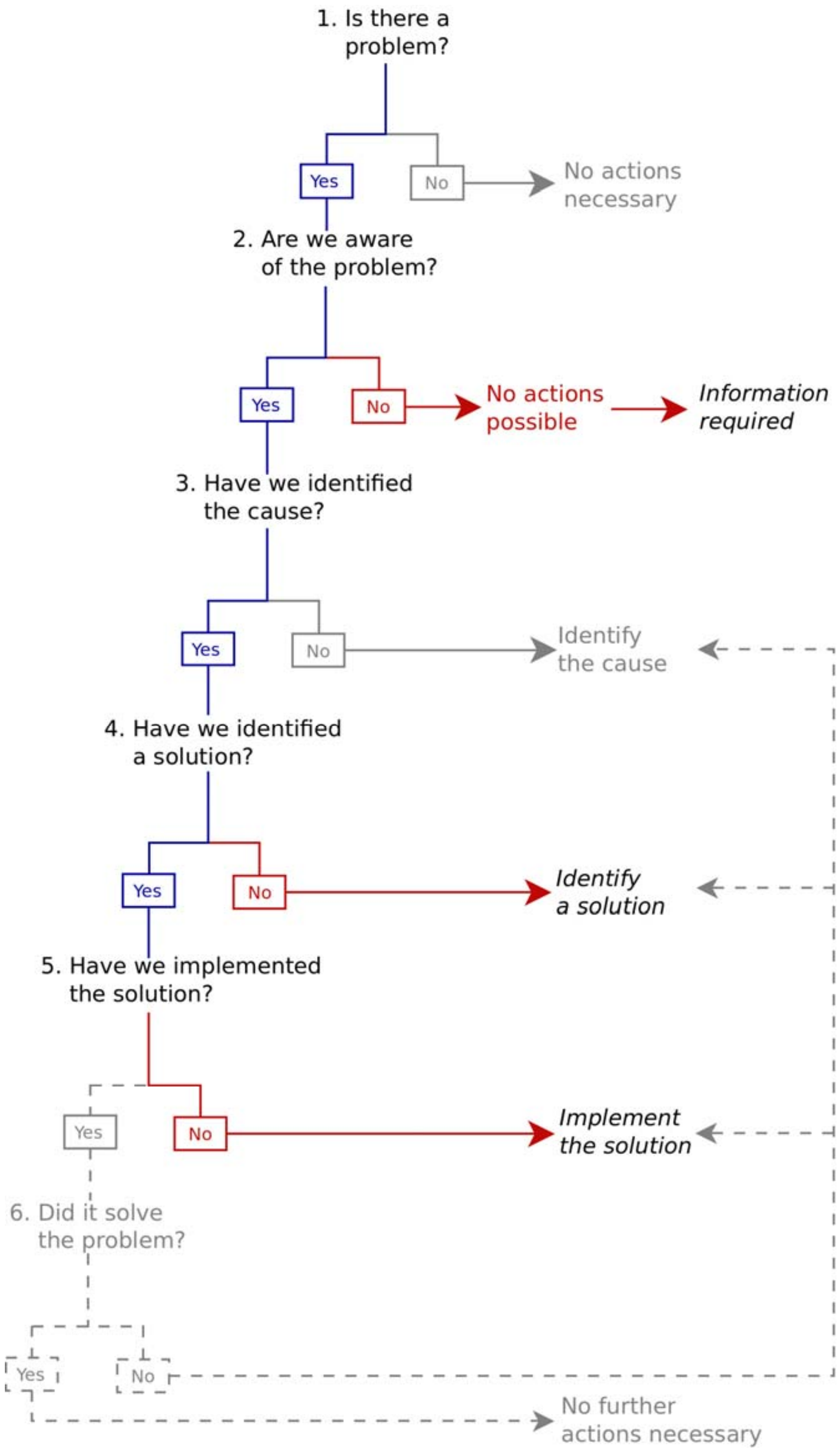

Fig. 2. A decision tree for the global environmental crisis. Each question has been framed to require a binary answer. If positive, the decision flow will go on to the next level, and if negative it suggests an action to remedy the identified deficiency in knowledge or actions. Grey arrows indicate steps that are fulfilled or are not correct, red arrows indicate steps necessary to take given the current situation, and hatched grey arrows steps still needed once the current required actions have been taken.

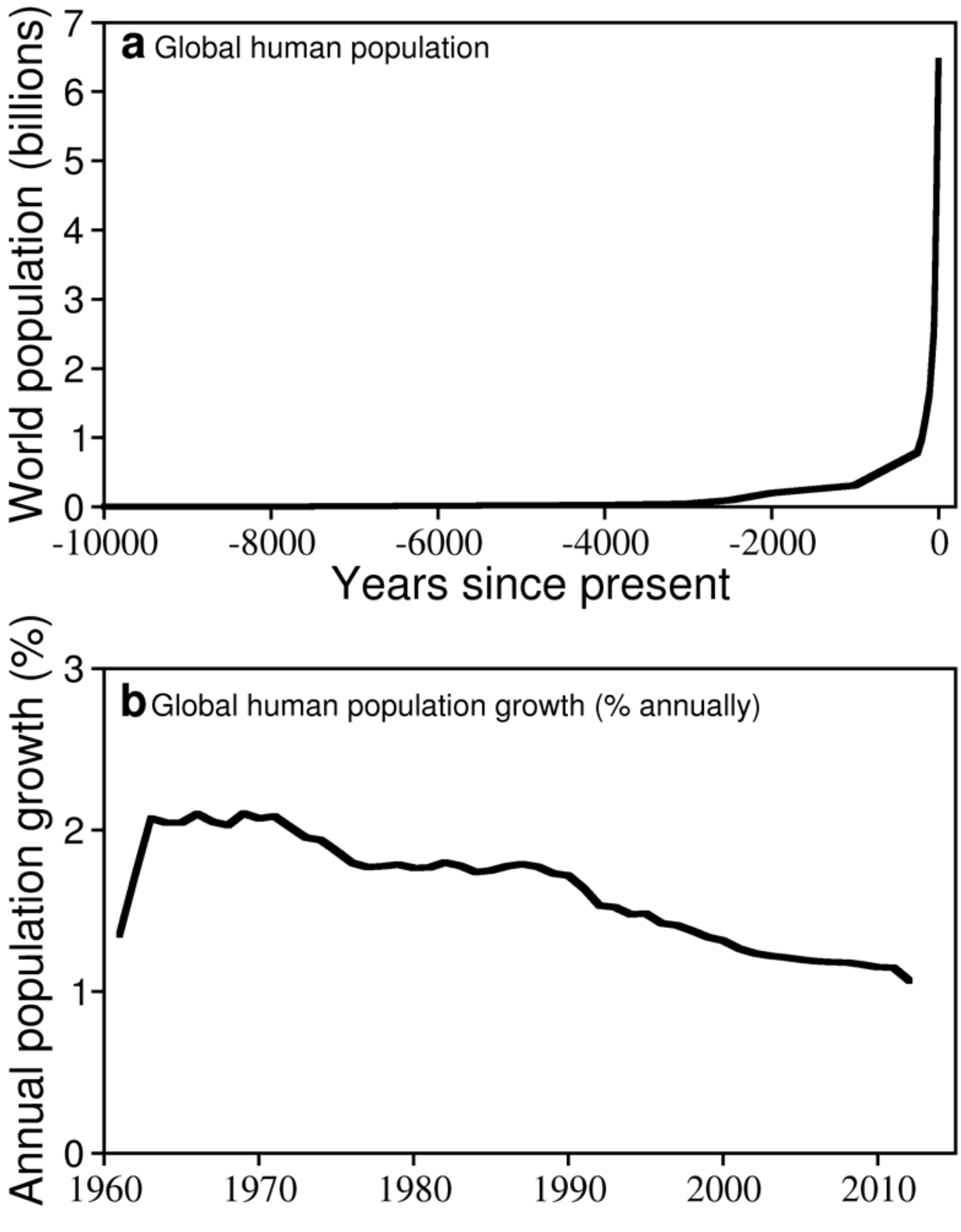

Fig. 3. The trajectory of the exponentially increasing human population over the past 10,000 years (a), and the trajectory of annual population growth over the past 50 years (b). World population data are taken from the US Census Bureau (http://www.census.gov/population/international/data/) and global annual growth rate from the World Bank (http://data.worldbank.org/).

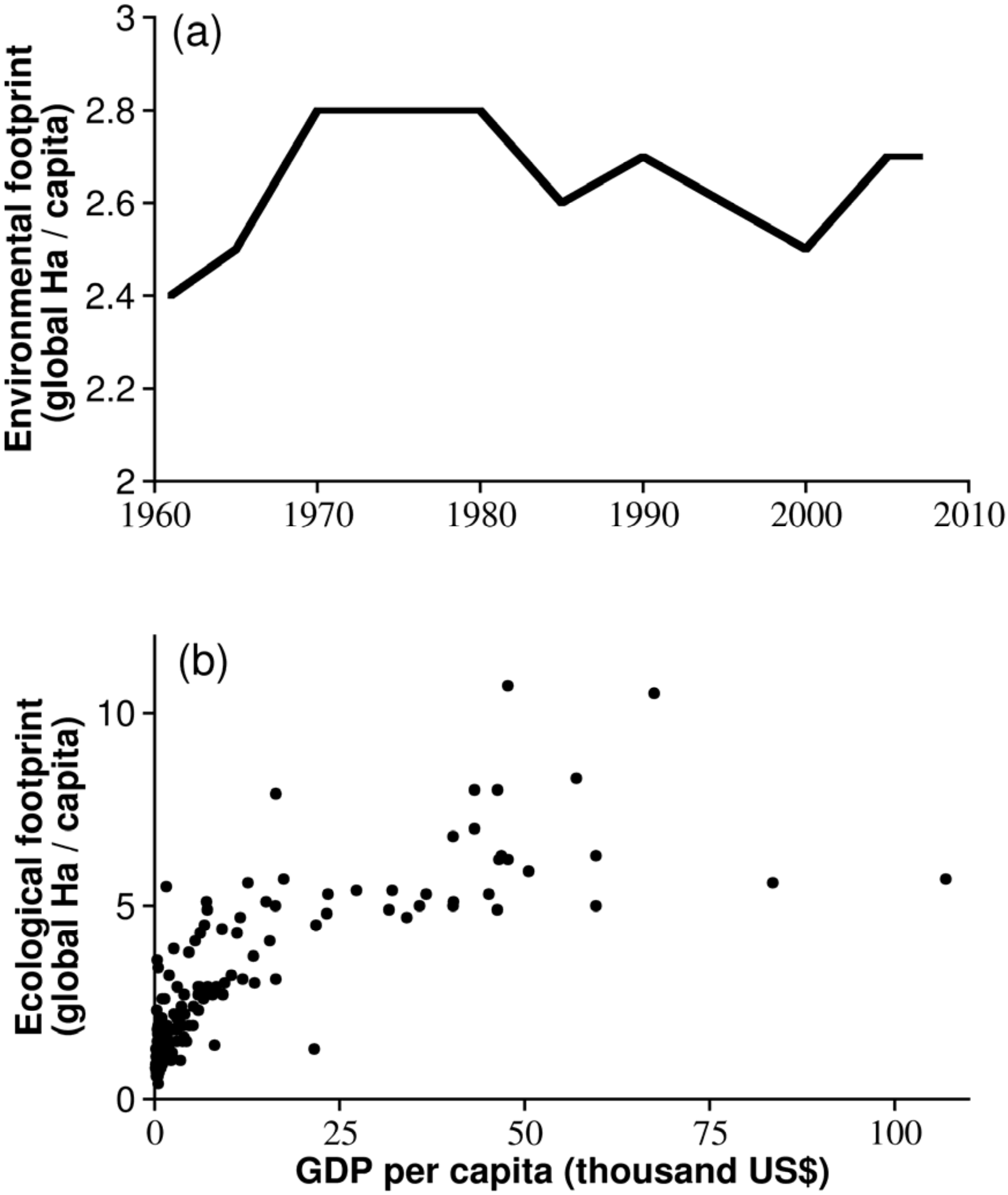

Fig. 4. Ecological footprint, estimates as global hectares per capita, over the past 50 years (a) and the relationship between the scale of economic activities (Gross Domestic Product per capita) and ecological footprint for 148 countries during 2007 (b). Environmental footprint data are taken from the environmental footprint network (http://www.footprintnetwork.org/atlas) and GDP from the World Bank (http://data.worldbank.org/). The methods used to calculate ecological footprint are given in Borucke et al. (2013).

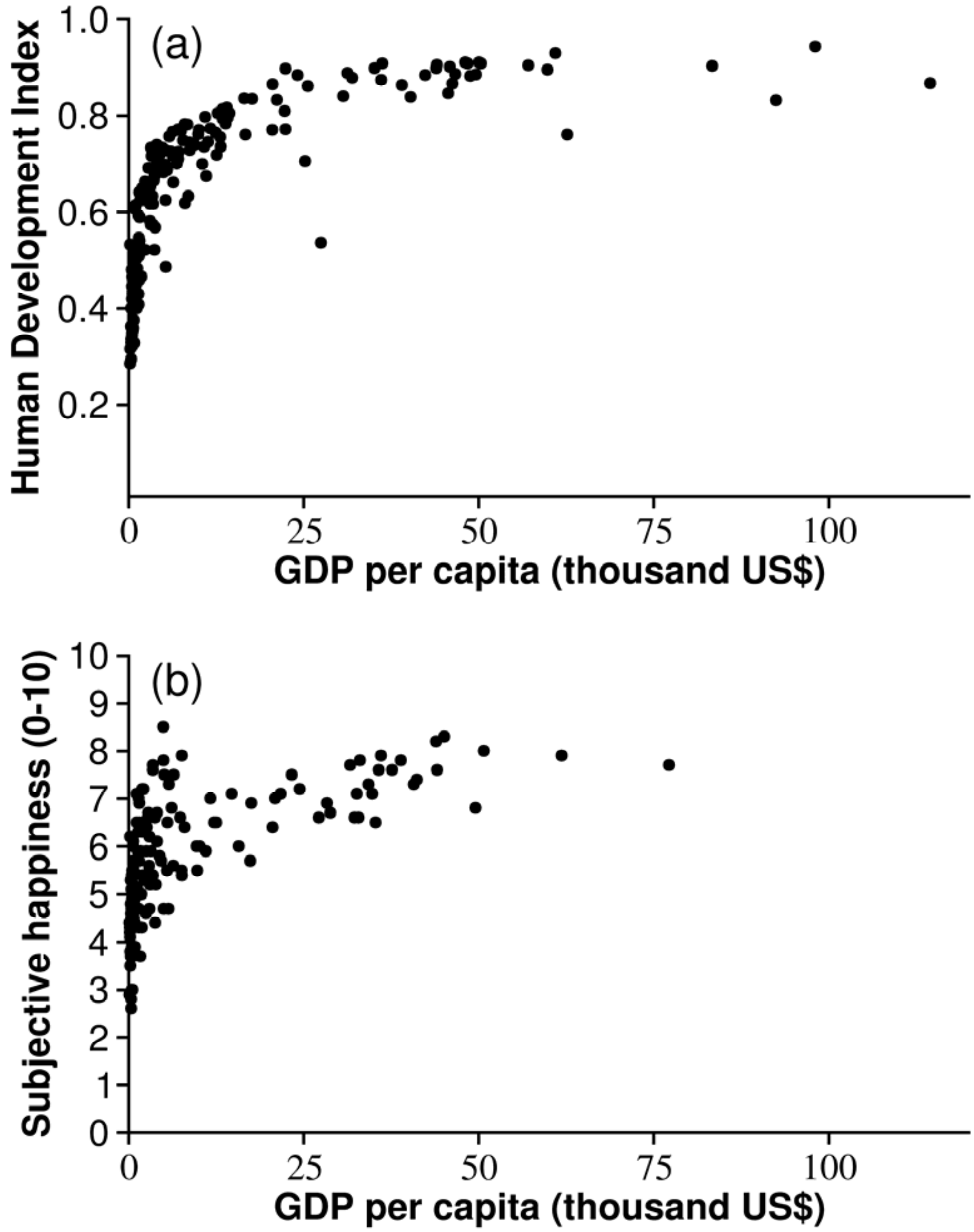

Fig. 5. Relationship between the scale of economic activities (Gross Domestic Product per capita) and human development (United Nation's developed Human Development Index) for 175 countries during 2010 (a) and between average GDP per capita and average subjective happiness (indexed by a subjective scale ranging from 0 to 10) for 144 countries during 2000-2009. Data on GDP are taken from the World Bank (http://data.worldbank.org/), data on the human development index from United Nations Development Programme (http://hdr.undp.org/en/statistics/data/) and happiness data from the world database of happiness (http://worlddatabaseofhappiness.eur.nl/).