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Business, Ecosystems, and Biodiversity: New Horizons for Management Research

Monika I. Winn[1] and Stefano Pogutz[2]

Abstract

Whether to secure critical resource inputs or responding to demands ranging from local communities to international stakeholders, leading multinational companies increasingly engage in ecosystem management by developing operations models with biodiversity, ecosystem conservation, and ecosystem restoration in mind—often in partnership with international conservation organizations. While promising to infuse business strategy with knowledge from natural science, specifically ecology, the emerging practice appears well ahead of research in this area. This article aims to encourage research into how organizations can manage their relationship with the natural environment so as not to destroy the very life-supporting foundations provided by nature. Bridging knowledge domains, the article introduces key concepts from ecology and social ecology to organization and management studies—*ecosystems, biodiversity, ecosystem services*, and *ecological resilience*. We illustrate these concepts with advances in ecosystems management and conclude with suggestions for future research in sustainability management, organization theory, and strategic management.

Keywords

corporate environmental management, corporate sustainability, ecosystems, biodiversity, ecosystem services, ecological resilience, interconnectedness, nature conservation, organization theory, strategic management

Introduction

In their recent article calling on scholars to place their effort behind the development of sustainability management theories, Starik and Kanashiro (2013) conclude that so far, "the promise of infusing management theory with biophysical foundations remains largely unrealized" (p. 8). While management scholarship and theory development might struggle to find ways to bridge relevant knowledge domains from natural and social sciences in order to account for, explain, and contribute to stemming or reversing current global trends of ecosystem degradation, business is charging ahead. Theorizing about "sustainability management" may not as yet offer effective

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conceptual frameworks linking management with its biophysical foundations, but we do find promising initiatives in the practice of business.

There are quite a few examples of smaller firms and new ventures designed on business models that acknowledge both their immediate dependence and their impact on nature; Stoneybrook Organic Farm and Nature's Path are just two examples. More surprising, perhaps, are recent developments in large corporations. For instance, dozens of well-known multinational enterprises managing vast, complex, and global supply chains have recently become engaged in initiatives that suggest they not only recognize their biophysical foundations but are also actively developing the capacity to better understand and work with those foundations, thus avoiding destructive and enabling constructive, even restorative, management practices instead.

Unilever, a global consumer goods company with presence in 190 countries, 2 billion consumers worldwide, and 2011 revenues of €46.5 billion, recognized that dependence firsthand in 2002. As one of the world's largest buyers of fish for its Iglo, Findus, and Birds Eye brands, the company found itself highly vulnerable to the effects of the overharvesting of ocean fish, especially cod, the main fish species used in the company's premium frozen food product—fish sticks. Cod stocks in the western North Atlantic had declined abruptly in the 1990s due to overexploitation. Cod prices subsequently increased dramatically, eroding the margins of Unilever's cod-related product lines. The company tried to substitute this whitefish with New Zealand hoky fish, but consumers in the United Kingdom, dissatisfied with the taste and quality, rejected the alternative. Retailers responded by delisting the product through 2004, further hurting profitability (Maitland, 2005; Porritt, 2005).

Unilever's story is not unique. While only a small fraction of Unilever's profits were affected, economic survival of product lines for many firms across different industries depends on the availability of and their ability to manage and use specific ecological services (World Resources Institute [WRI], Meridian Institute, & World Business Council for Sustainable Development [WBCSD], 2008)—yet such services are in major decline worldwide (Millennium Ecosystem Assessment [MEA], 2005). *Ecosystem services* have been defined as the benefits that human populations and organizations derive—directly or indirectly—from proper ecosystem functioning (Costanza et al., 1997). An ecological system or *ecosystem* is "a natural unit consisting of all the plants, animals, and microorganisms (biotic) factors. . . interacting with all of the nonliving physical and chemical (abiotic) factors of this environment" (Levin, 2009, p. 779) through characteristic energy flows and material cycles. An interesting observation is that "since the beginning of life on Earth, organisms have not only adapted to physical conditions but have modified the environment (e.g., increase O2 and reduce CO2)" (E. P. Odum, 1992, p. 543).

A massive worldwide effort to assess the current status and trends of global ecosystem functioning, the MEA classified ecosystem services into four categories: the provisioning of goods and products (e.g., wood, fibers, freshwater, food, genetic resources), regulation services (e.g., climate regulation or pollination), cultural services (e.g., recreation or tourism), and supporting services (e.g., water cycling or nutrient cycling; Fisher, Turner, & Morling, 2009; MEA, 2005). Ecosystems vary in their ability to withstand and rebound from disturbances like increased floods or droughts, pollution, or encroachment by human settlement, and that ability or *ecological resilience* is weakening overall (Rockström et al., 2009). The notion of *biodiversity* (defined as "the variety of life, including variation among species and functional traits," Cardinale et al., 2012, p. 60) and its relevance for business has also become a topic of growing attention in international conventions (e.g., MEA, Biodiversity Conventions), and it has begun to find its way into the vocabulary of firms—especially large corporations.

A growing number of corporate initiatives suggest that, over the past decade, firms are beginning to focus on managing relevant ecosystems, or rather ecosystem functions, more deliberately.[1] But while biological diversity and ecosystem services may have entered the language of firms, these issues have not yet garnered much interest in the management literature. We suggest that this is in part a matter of disciplinary separation: Natural science domains like biology or ecology, but even fields like ecological economics, arguably in greater disciplinary proximity, appear to exist in knowledge domains that—in certain aspects—remain quite separate from organization studies (T. B. Porter, 2006).

We say this although fruitful theoretical advances in organization studies such as "population ecology" or "coevolution" have indeed applied discoveries from biology and ecology to the dynamics of human organizations, by using principles of nature's functioning as interpretative lenses to theorize about human organizations and organizational networks. With very few exceptions, however, (e.g., Hoffman, 2003; T. B. Porter, 2006; Stead & Stead, 2009; Whiteman, Walker & Perego, 2013, covered in more detail below), such approaches do not build the actual, material aspects of nature's condition and functioning into their theorizing about organizations and organizational dynamics. These bodies of organizational theory use ecological concepts and principles as analogies—they look to nature to understand and theorize *about* organizations (Oswick, Fleming, & Hanlon, 2011). The focus and intent of this article is different. It looks to nature to understand organizations *in* their biophysical environment, theorize about the interconnectedness between both, and bring the substantive material and energy flows of nature's organization into the study of human organizations.

We start by introducing recent strategic initiatives of corporate ecosystem management. To allow us to place such business initiatives into the context of the vibrant and rapidly growing knowledge domains related to ecology and society (e.g., Cardinale et al., 2012; Levin, 2009), we next discuss the meanings of ecosystems, biodiversity, ecosystem services, and ecological resilience in some detail. We chose these four concepts to both raise management scholars' interest in and provide a coherent introduction to critical advances in those domains, fully aware that a more comprehensive treatment of such an expansive knowledge domain is impossible within the scope of an article. Last, linking these concepts back to business, we explore implications for management theory and practice and close with suggestions for future research.

Biodiversity and Ecosystem Conservation: The New Strategic Business Issue?

In 1999, Paul Hawken, Amory Lovins, and L. Hunter Lovins published their book *Natural Capitalism*, summarized in the *Harvard Business Review* article "A Roadmap for Natural Capitalism" (Lovins, Lovins, & Hawken, 1999). Linking "capital," a core concept for economics and business, with "nature," this groundbreaking article offered a new way of thinking to environmental management: A host of examples illustrated that simple changes in how companies run their business can improve competitiveness and profits while not only reducing harm to the environment but also actually preserving and even restoring natural resources. The authors called this approach natural capitalism, "because it's what capitalism might become if its largest category of capital—the 'natural capital' of ecosystem services—were properly valued" (p. 146).

The promise that was encapsulated in such radical new thinking, however, has yet to be fulfilled. Clearly, attention to ecosystems and ecosystem services has increased tremendously over the past decade, fuelled especially by advances in the new interdisciplinary field of ecological economics (Farber, Costanza & Wilson, 2002; Gómez-Baggethun, de Groot, Lomas, & Montes, 2010; Norgaard, 2010) and by high-visibility efforts to systematically measure and assess the state of ecosystems globally (MEA, 2005).

And yet troubling trends in habitat destruction, freshwater decline, biodiversity loss, and other forms of eroding natural capital continue to accelerate (Kumar & Martinez-Alier, 2011; MEA, 2005; TEEB, 2011). The critical importance of biodiversity and well-functioning ecosystems for social and economic well-being is now routinely acknowledged and examined by articles in scientific journals (e.g., Cardinale et al., 2012; Crutzen, 2002; Rockström et al., 2009), but this debate has remained largely outside the scholarly work on business organizations and management.

The language of sustainability and greening has certainly become an integral part of business across a wide range of industries, and many firms have developed environmental innovations, products, and processes, while also incorporating sustainability into their missions and strategies (Hall & Vredenburg, 2003; Marcus & Fremeth, 2009; Nidumolu, Prahalad, & Rangaswami, 2009). The strategies and operations of many firms reflect a growing awareness of environmental sustainability, whether through eco-efficiency, life cycle thinking, "green" product lines, or other eco-innovations seen as opportunities for company growth, product differentiation, and competitiveness (e.g., M. E. Porter & Kramer, 2011; Willard, 2002).

Despite the many types of corporate greening activities, biodiversity and ecosystem preservation have until recently remained largely peripheral to mainstream business strategies and investment decisions driven by companies' corporate sustainability and environmental departments. This is not too surprising since (apart from pioneering efforts by organizations like The Nature Conservancy [TNC] or the WBCSD, see below) business leaders generally show only limited awareness of the potential business risks posed by biodiversity loss and damage to ecosystem functionality (PriceWaterhouseCoopers, 2010). The past few years have witnessed a shift, however, as nature conservation and ecosystem protection appeared as new features of interest for a number of leading firms, business organizations, nongovernmental organizations (NGOs), and international agencies (Bishop, Kapila, Hicks, Mitchell, & Vorhies, 2008; WBCSD, 2011; WRI et al., 2008).

TNC, a global NGO focused on nature conservation, provides an example. During the 2012 Rio+20 Summit, the Rio de Janeiro United Nations Conference on Sustainable Development, the TNC unveiled the results of a groundbreaking initiative on business and ecosystem protection involving 24 pioneer companies with more than $500 billion in combined revenues (including Alcoa, Coca-Cola, Dell, Dow Chemical, Duke Energy, Marriott International, Nike, Patagonia, Unilever, The Walt Disney Company, Xerox, and others). The report shows that these companies engage in a number of initiatives to protect forests and safeguard freshwater and marine ecosystems. The individual case studies suggest that protecting nature and biodiversity is becoming recognized as a corporate imperative since it is essential to long-term business continuity across many industries (TNC, 2012).

The WBCSD also played a leading role in promoting attention toward an understanding of company–ecosystems relations. In 2007, this CEO-led association of international companies established a specific Ecosystem Focus Area, publishing several guidelines and handbooks in order to inform companies about risks related to ecosystem degradation and calling for a collective response from the business community to address the scale of environmental change taking place. The first publication, "Business and Ecosystems: Issue Brief: Ecosystems Challenges and Business Implications," was released in November 2006 jointly with three leading NGOs specializing in the area of environmental protection and sustainable development: the Earthwatch Institute, the WRI, and the World Conservation Union. This document marked a watershed development. It introduced business to a new way of perceiving its relations with the natural environment, acknowledging that firms not only use and have an impact on ecosystems and their services but, crucially, also rely on these services to generate long-term value. This report was followed by several publications looking in more detail at the business case for biodiversity and ecosystems protection (TEEB, 2011; WBCSD & World Conservation Union, 2007), providing guidelines and tool kits for corporate ecosystem evaluation (WBCSD, 2009, 2011) along with illustrative case studies of companies involved in ecosystem service protection.

In order to check the breadth and relevance of this phenomenon and to better understand the type of initiatives that companies are undertaking, we conducted a preliminary scan of the top

100 companies in the global *Fortune* 500 ranking. We matched this data set of corporate initiatives with two other sources of information, the TNC (2012) report and the WBCSD case study database on ecosystem and biodiversity (http://www.wbcsd.org/publications-and-tools.aspx). The result is surprising. More than 70 firms are involved in over 100 specific initiatives across a broad range of sectors. Participants are both from industries that *directly* interact with ecosystems (e.g., agriculture, food and beverages, water services, tourism, mining, forestry, and paper) and from industries relating only *indirectly* to the ecological services provisioned by nature (e.g., retail, health care, financial services, manufacturing). Four examples will illustrate the range and diversity of these new corporate ecosystem services initiatives (see Table 1).

The first example, AcelorMittal, is one of the world's leading firms in the steel and mining industry with over 20 mines in operation worldwide. The firm implemented a biodiversity compensation program to minimize the impact of its iron mining activity in Liberia's Nimba Mountain, one of the few remaining West African rainforests and considered one of the top biodiversity hot spots on the continent. The second, Unilever, branded itself as the "Sustainable Living" company and developed a specific action program directed at its farmers around the world to educate and train them on the business case for biodiversity protection. The company's initiatives include the supply chains of some of Unilever's leading brands, such as Lipton, Knorr, or Dove. The third, Syngenta, a Swiss-based agribusiness specializing in seed and pesticides markets, developed a conservation program with the goal of increasing farm productivity by reversing ecosystem services decline. As part of the program, the company has launched a specific initiative called Operation Pollination with the goal of restoring native pollinators in agricultural landscapes and affecting growers in 15 European countries and the United States. The last example, Veolia Environnement, a global environmental services company focusing on water, waste, and energy solutions for public and private clients, engaged actively with experts and NGOs to maintain and restore the ecological heritage of the area from which the city of Lyon in France draws its water supply.

These initiatives differ widely in terms of aim and scope, including the reduction of operational risks, the control of the quality and quantity of critical resource inputs, or improvement of company reputation. We also note the importance of strategic partnerships in such initiatives. Several large food and agriculture companies are increasingly involved in promoting and buying certified products. Prominent initiatives include Chiquita, Kraft Foods, Unilever, or Nestlé, which purchase bananas, coffee, or cocoa certified by the Rainforest Alliance, a global NGO promoting the conservation of biodiversity and sustainable management practice of forest resources through market-based certification programs. Similarly, the retail company IKEA has partnered with the World Wildlife Fund (WWF) since 2002 to promote responsible forest management in order to increase the amount of purchased wood certified by the Forest Stewardship Council. Since 2005, it has sought to reduce the environmental and social impacts of conventional cotton production in countries like India and Pakistan.

We also find initiatives in the financial services sector, an industry with less direct connections to ecosystems or biodiversity conservation than those industries whose supply chains and operations depend directly on raw materials such as food or fiber. In 2002, for example, HSBC launched the conservation program called Investing in Nature in partnership with the WWF. Ten years later, the British multinational banking and services provider started the Water Program, a new initiative with the goal of protecting some of the world's most important rivers, investing $100 million in partnership with the WWF, Earthwatch Institute, and Water Aid, three leading environmental and development NGOs.

Our preliminary review highlights the sheer scale, breadth, and depth of corporate initiatives engaging directly with nature. It suggests not only that biodiversity conservation and ecosystem restoration have drawn the attention of corporations at strategic levels (Hoffman & Ocasio, 2001) but also that firms see business opportunities in doing so. The ecosystem services resulting from

Table 1. Business Initiatives in Ecosystems Management.

Firm	Industry	Ecosystems dependence and management	Specific initiative	The business case
Acelor Mittal	Steel and mining	Extracting operations have a profound impact on local ecosystems and biodiversity Several initiatives include site restorations and mitigation of effects on ecosystems during the on-site operations Multiple stakeholders involved	Commissioned major environmental study in 2005 and implemented a biodiversity compensation program in the Nimba Mountains, Liberia, close to the mine site; this region represents one of the few remaining West African wet-zone forests and a hot spot for many endemic species of flora and fauna, including chimpanzees	Improve stakeholder relations (government, UNESCO, nongovernmental organization [NGOs]); keep license to operate in the region; positive impact on local communities
Syngenta	Agriculture, seeds, and pesticides	Depending on the region and type of crops, the business relies on ecosystem services like freshwater availability, water regulation, pollination, and natural nutrient cycles Several initiatives aim to protect ecosystems and mainstream best management practice among farmers in countries like India and United States and in Europe Involves agricultural experts, NGOs, farmers, and academia, from 13 European Union countries and the United States	In 2009, launched program "Operation Pollinator" aiming to restore native pollinators (e.g., bees) in agriculture by creating suitable habitats near the farmland; program includes growing of vegetables, melons, and blueberries	Increase long-term agricultural productivity and soil fertility, positive impact on communities of farmers; positive effects on reputation
Unilever	Consumer goods	Strong dependence on the quality and availability of raw materials coming from agriculture (tea, vegetables) and forest (palm oil) Several initiatives aim to preserve natural resources from overexploitation and climate change effects through better agricultural practice and reforestation; involves suppliers, farmers, NGOs, local authorities, and others	In 2006, started project with the Kenya Tea Agency to support the diffusion of sustainable practices among Kenyan smallholder tea growers. In 2007, Unilever started to certify its Kenya producers with Rainforest Alliance standard to promote improved environmental, social, and economic conditions. Farmers learn to reduce pesticide use, eliminate waste, and introduce better farming techniques. The overall project helps protect the biodiversity in the farmland area	Improve productivity, reduce costs, and enable growers to obtain higher prices for their tea Increase product quality Positive impact on Lipton brand and market opportunities
Veolia Environnement	Environment and water services	Highly dependent on ecosystem functioning for both availability and quality of water resources; sites often located near biodiversity sensitive areas	The water supply of the Lyon metropolitan area in France is managed by Veolià Waters and depends on the Crépieux-Charmy water withdrawal site	Preserve quality of critical resource—water, enhance site management efficiency, and strengthen positive relation with local authorities
		Several initiatives to regulate water abstraction from rivers and basins and to protect habitats and biodiversity (e.g., through flora and fauna inventories) Collaboration with local stakeholders, including city and conservation groups	Since 1996, a team of environmental technicians with experts from local NGOS and government authorities has worked to maintain and restore the well field and to monitor the area's ecological heritage	Return of species that had previously disappeared from the site

biodiversity, ecosystem conservation, and sustainable use initiatives appear to be increasingly recognized for the direct benefits they provide to firms that depend on such natural capital in their products and services and for the indirect benefits via offsetting emissions (e.g., in the case of voluntary programs for offsetting greenhouse gases through forestation in developing countries) or enhanced reputational benefits.

We also note that the initiatives introduced here encompass a wide variety of actions on and engagement with ecosystems ranging from the protection of forest and soil to the conservation of biodiversity, freshwater, and fisheries; the restoration of contaminated areas; and the diffusion of sustainable management practices with farmers and suppliers. Drivers for such corporate engagement in and deliberate management of nature's functions are likely varied, ranging from recognizing the strategic dependencies on the quantity and quality of goods and services provided by ecosystems to reducing both regulatory and reputational risks through more symbolic actions of nature protection (Delmas & Toffel, 2008; Ramus & Montiel, 2005). Whatever the motives, such corporate initiatives point to a growing attention to and deliberate engagement with nature, and this new attention by business toward ecosystems and their functioning offers intriguing research directions for investigating both the biophysical dimensions of impact–dependence linkages between organizations and the natural environment as well as cognitive and management dimensions of these linkages.

While much of the field of organization and the natural environment has pointed to reducing negative impacts by business activity on ecosystem functioning, it has paid little attention to the dependence of business on critical provisioning services like freshwater, fiber, or food and to regulatory services like the climate regulation, flood control, water purification, or waste treatment that ecosystems provide.

As mentioned earlier, nature and nature's functioning have not yet been sufficiently integrated into organization and natural environment (ONE) literature or into broader organization theory, despite the promise of pathbreaking articles in the *Academy of Management Review*'s October 1995 issue and apart from some noteworthy exceptions (King, 1995; Marshall & Toffel, 2005; T. B. Porter, 2006; Whiteman et al., 2013). The fundamental interconnectedness between organizational (business) life and ecosystems has been examined only occasionally, for example, by linking industrial ecology more directly to organization studies (Hoffman, 2003), using coevolutionary concepts to generate a metatheory linking natural organization and human organization (T. B. Porter, 2006; Stead & Stead, 2009), linking the resilience of communities to their relationship with nature (King, 1995), and offering a metatheoretical framework cognizant of planetary boundaries (Rockström et al., 2009) to corporate practice and management research (Whiteman et al., 2013. Concepts like biodiversity, ecosystem functioning, ecosystem services, and natural capital have rarely entered the work of management and organization scholars in a substantive manner, as several scholars have pointed out (Bansal & Gao, 2006; Etzion, 2007; Kallio & Nordberg, 2006; Starik, 2006; Starik & Kanashiro, 2013).

There are organizational theories that appear to link organizations to nature, such as the literature on population ecology (Hannan & Freeman, 1977, 1984) or on coevolution (e.g., Baum, 1996; Lewin & Volberda, 1999). Such similarity is deceptive, however. There is a fundamental difference between using concepts and principles from ecology as an analogy or interpretative lens (Oswick et al., 2011) and using them in a substantive, even "literal," manner for studying organizations and nature such that the biophysical foundations of organizational life become part of organizational theorizing.

Heeding the calls from the founding years of the field, which implored management scholars to acknowledge the embeddedness of organizations in the natural environment and to expand and enrich management studies with concepts recognizing that embeddedness (Gladwin, Kennelly, & Krause, 1995; Jennings & Zandbergen, 1995; Shrivastava, 1994; Starik & Rands, 1995), we argue that the practical and widespread initiatives we observe in business practice open up new opportunities for research in just that direction. If, as Starik and Kanashiro (2013) recently called for, the field were to advance a theory of sustainability management, any such theory would have to both incorporate the complexity of and interconnectedness between ecosystems and organizations and provide a solid framework for a managerial decision making respectful of the biophysical constraints of natural capital and opportunities resulting from more proactive approaches.

Toward a Deeper Understanding of Nature's Functioning

A first step in that direction is to introduce core concepts and insights from research typically considered to be external to our own field of organizations and management. Our intent is to expand the vocabulary and conceptual arsenal of management studies toward a deeper understanding of ecosystems functioning and the role of biodiversity, toward more focused research into the emerging phenomenon of businesses deliberately managing their impacts on ecosystem on which they depend, and toward a stronger foundation for future sustainability management theories.

We focus on those concepts that played a particularly important role in prompting major breakthroughs in the understanding of relationships between human organizations and the natural environment. We start by introducing the foundational concept of the ecosystem, then we discuss biodiversity, ecosystem services, and ecosystem resilience and how they interrelate (Costanza et al., 1997; Levin, 1998, 2009). Research on these concepts emerged from disciplines like biology and ecology and their subdisciplines evolutionary ecology, conservation ecology, and ecosystem science. Under the umbrella of the new and multidisciplinary field of ecological economics, knowledge in this area has grown dramatically in the past 20 years (Abel & Stepp, 2003; Cardinale et al., 2012; Holling, 1998).

Since the 1992 Earth Summit in Rio de Janeiro especially, hundreds of studies and major joint research initiatives around the world have generated vibrant debates and fertile ground for new theories and knowledge creation. The Global Biodiversity Assessment commissioned by United Nations Environment Program in the 1990s played a major role in focusing research attention on biodiversity and ecosystem functioning. In parallel, work on biodiversity and ecosystem services, which are "built on the idea that ecosystems provide essential services to humanity," expanded equally rapidly (Cardinale et al., 2012, p. 59).

These new ideas and frameworks not only galvanized growing scientific momentum but also drew significant political and public attention with the publication of the MEA in 2005. Launched by the United Nations Secretary-General Kofi Annan in 2000, the scope of this research project was truly global, involving 1,360 experts, 95 countries, and 850 reviewers (MEA, 2005).

It is important to stress that the concepts of ecosystems, biodiversity, ecosystem services, and ecosystem resilience themselves emerged from a number of different scientific fields, with the result that—despite growing consensus in some areas—there is no unanimous agreement on their interpretative capacity, relevance, or even utility. Like many concepts that populate organization and management studies (e.g., strategy, organization, institutions, or management), the meanings of ecosystems, biodiversity, ecosystem services, and ecological resilience are complex, interrelated, and subject both to multiple interpretations and criticism. Norgaard (2010) points out that many ecologists view ecosystem services as a weak theoretical construct and refuse to interpret ecosystems using a stock flow framework or to attribute nature a value—yet these are two key aspects underlying the concept of ecosystem services. There is much discussion about definitions and classifications, and "perhaps we should accept that no final classification can capture the myriad of ways in which ecosystems support human life and contribute to human well-being" (TEEB, 2011, p. 10).

Nevertheless, these concepts and the growing knowledge base around them provide powerful heuristics and foundations for theorizing nature's functioning in organization and management

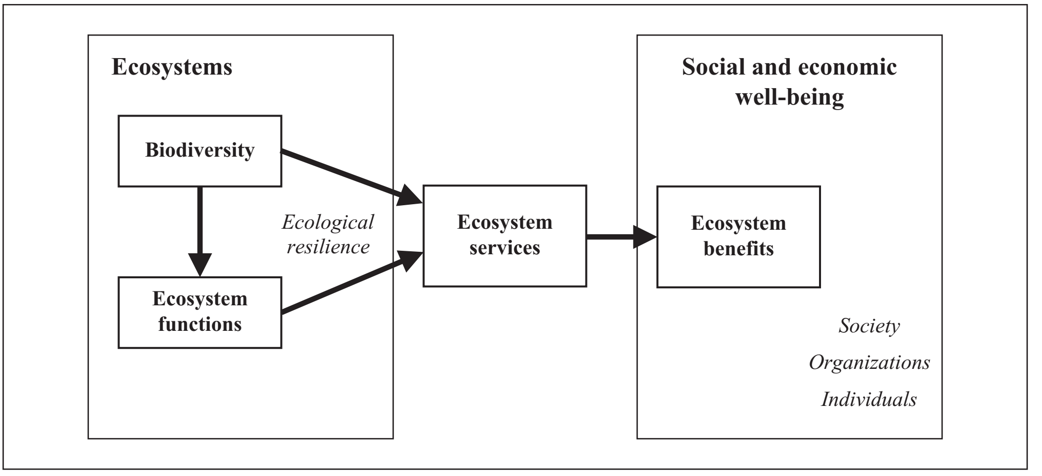

Figure 1. Linking ecosystems to social and economic well-being.

studies. In this article, we do not attempt to reduce these distances or smooth out differences that likely stem as much from divergent ontological and epistemological assumptions of different disciplines as from the youth of these fields. Instead, we think that, treated as heuristics, these concepts can help scholars of organizations and the natural environment build a stronger understanding of the interconnectedness between nature and organizations, and that they offer promising perspectives from which to advance theory in this domain. Recognizing the complexities and challenges for corporations to more effectively manage their respective relationships with the ecosystems on which they depend, these constructs provide foundations for new research directions and implications for organization theory and strategy.

Next, we examine ecosystems, biodiversity, ecosystem services, and ecological resilience and their relationship to human social and economic well-being. To provide an overview and guide for our readers, Figure 1 attempts to visually map these biophysical foundations and focuses specifically on the organizational (and implied institutional) levels of analysis.[2]

Ecosystems

An ecosystem is

> a natural unit consisting of all the plants, animals, and microorganisms (biotic) factors in a given area, interacting with all of the nonliving physical and chemical (abiotic) factors of this environment. An ecosystem can range in scale from an ephemeral pond to the entire globe, but the term most often refers to a landscape scale system characterized by one or a specified range of community types (e.g., a grassland ecosystem). (Levin, 2009, p. 779)

The term *ecosystem* identifies perhaps one of the most fundamental, widely used, and successful concepts theorized in ecology. Far from being simple and straightforward, the ecosystem is a subtle and complex concept with multiple layers of meanings and use (Pickett & Cadenasso, 2002). The concept and its meaning have evolved over the years, as ecosystem science itself evolved into a significant body of both small-scale experimental studies and large-scale (landscape-scale) correlational research and practical applications.

The first use of the term in print is attributed to the British ecologist Sir Arthur Tansley (1935), although the term was probably coined in the early 1930s by Roy Clapham. Then a young biologist at Oxford University's Department of Biology, Clapham was asked by Tansley if he could think of "a suitable word to denote the physical and biological components of an environment considered in relation to each other as a unit" (Tansley, 1935, cited in Willis, 1997, p. 268). Tansley provided the first definition of an ecosystem as a biotic community and its associated physical environment located in a specific place. He was also the first scientist who noted the importance of relations between inorganic factors and organisms, thereby highlighting the existence of a constant interchange of materials between biotic and abiotic systems or biogeochemical systems.

Two decades later, Eugene P. Odum, often considered the father of modern ecology, popularized the concept through his research and findings. In the book *Fundamentals of Ecology*, he described the ecosystem as "any entity or natural unit that includes living and nonliving parts interacting to produce a stable system in which the exchange of materials between the living and nonliving parts follows a circular path" (E. P. Odum, 1953; cited in Purser et al., 1995, p. 1070). The book's second edition, published in collaboration with his brother Howard T. Odum, promoted the view of ecology as a science of systems (E. P. Odum & Odum, 1959). An important aspect of E. P. Odum's ecosystem formulation is its flexibility. An ecosystem can exist at any level and size as long as organisms and the physical environment interact within it. As mentioned above, the concept of ecosystem is scale independent. Ecosystems can be a small lake, an estuary, the rainforest, the entire biosphere, or even the digestive flora and fauna of an individual human; boundaries are not fixed in objective ways. Similarly, ecosystems may be simple and in existence for only a very short time or extremely complex and persisting over time.

Another important feature introduced by E. P. Odum's research is the recognition that human beings are a key part of ecosystems and that ecosystem science must incorporate the study of human-generated activities and processes. His younger brother H. T. Odum, a maverick and innovator, further contributed to the development of ecology as a systems discipline, taking a holistic approach to the study of ecosystems (H. T. Odum, 1983) and focusing attention on the links between ecosystem ecology, energetics, and thermodynamics. The Odum brothers' work was fundamental for the development of ecosystem science and interdisciplinary fields like ecological economics (Gunderson, Folke, Lee, & Holling, 2002).

The 1970s and 1980s witnessed heavy criticism on the linear mechanical assumptions used to explain ecosystem dynamics. At the same time, theoretical advances in ecosystem ecology, fruitful cross-fertilization with other scientific disciplines (e.g., biology, geochemistry, physics, sociology, anthropology), and growing scholarly interest in complex adaptive systems prompted a break from earlier directions and, in the 1990s, resulted in the formation of the "new ecology." Modernized and revitalized, this new system science addressed the dynamics of ecosystems as complex systems (Abel & Stepp, 2003) and was quickly accepted by the academic society and disseminated among scholars via new and popular journals, such as *Ecosystem* and *Conservation Ecology* (now *Ecology & Society*). Meanwhile, the rapid growth and global scope of the ecological crisis, biodiversity loss, and climate change has stoked widespread, public concern for environmental issues.

Modern ecosystem studies are grounded in Tansley's and Odum's early seminal works (Pickett & Cadenasso, 2002), which offered a clear, inclusive, and remarkably current account of the concept and functioning of ecosystems. In contrast to the earlier works, however, they de-emphasize notions of stability, unique equilibria, normative states, and deterministic approaches, focusing instead on complex system characteristics. Ecosystems are defined as "prototypical examples of complex adaptive systems in which macroscopic system properties, such as trophic structure, diversity-productivity relationships, and patterns of nutrient flux emerge from interactions among components and may feed back to influence the subsequent development of those interactions" (Levin, 1998, p. 431). In this view, an ecosystem consists of many heterogeneous components that interact in parallel and have a range of basic properties associated with any complex adaptive system (Levin, 1998). *Aggregation* refers to the way scientists group individuals in populations, populations into species, and species into functional groups. *Nonlinearity* denotes that transformations occur through complex paths primarily governed by reinforcing stochastic events, nonlinear causation, and path dependency. *Diversity* refers to the variety of species present in the ecosystem and the generation and maintenance of this diversity. Finally, the notion of *flow* suggests that any ecosystem is based on a range of different nutrient, energy, material, information, and other flows, which interconnect the single parts in a web of relations.

This transition of ecosystem science into new theoretical and practical domains has generated two conflicting streams of study (De Leo & Levin, 1997; Holling, 1998). The earlier approach, rooted in experimental science with a focus on small spatial scales and short time frames, is reductionist and highly analytical. Emphasizing structural aspects of ecosystems, it focuses on processes that influence specific variables (e.g., population dynamics of species, levels of nutrients, and flux of materials). The more recent approach with its macro-level and functional perspectives is inherently holistic and integrative. Analyzing ecosystem dynamics with a broad and exploratory perspective, this field employs simulation models to observe large spatial and temporal scale changes that are impossible to study through experiments. Holling (1998) observes the tensions between these two domains, suggesting that the latter acknowledges that ecosystems are inherently uncertain, unknowable, and unpredictable. Here, uncertainty is seen as a system property that needs to be managed, whereas the former emphasizes the need to reduce uncertainty.[3] Rather than being mutually exclusive, both perspectives contribute to the understanding of ecosystem dynamics and the management of ecological problems at local and global scales.

The functions of ecosystems are the result of interactions between structures and processes and of biodiversity (see below). Considered "ecological processes that control the fluxes of energy, nutrients and organic matter through an environment" (Cardinale et al., 2012, p. 60), ecosystem functions refer to processes like primary production (the conversion of sunlight into organic matter by plants), nutrient cycling (the process through which nutrients such as nitrogen, phosphorus, sulfur, or calcium are cycled back and forth between biotic and abiotic entities like plants, animals, microbes, soil, air, and precipitation), or decomposition (the breaking down and recycling of organic waste). These processes are, in part, influenced by biodiversity.

Biodiversity

The United Nations Convention on Biological Diversity in its Article 2 defines biodiversity as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (1992, p. 3). A shorter definition refers to it as "the variety of life, including variation among species and functional traits" (Cardinale et al., 2012, p. 60).

As the anthropogenic transformation of the planet has intensified (Steffen, Grinevald, Crutzen, & McNeill, 2011; "Welcome to the Anthropocene," 2011), research on ecosystem processes and functioning has grown rapidly. At the same time, attention to biodiversity and specifically to biodiversity loss has increased dramatically in the past two decades. United Nations–supported assessments, initiatives, and conventions of global scale (e.g., Convention on Biological Diversity, 1992; MEA, 2005) have prompted extensive reports and journal publications. Results highlight that the distribution and abundance of species have been reduced dramatically due to massive transformation of land use, natural capital overexploitation, global transportation networks, human-induced environmental changes such as climate change, and increasing levels of pollution (MEA, 2005; Peterson, Allen, & Holling, 1998; TEEB 2011). Rockström et al. (2009) conclude that "today, the rate of extinction of species is estimated to be 100 to 1,000 times more than what could be considered natural" (p. 474).

The Living Planet Index—an indicator of the state of the global biological diversity based on the dynamics in the vertebrate populations provided by the WWF for nature in collaboration with Zoological Society of London—suggests that the populations of vertebrates (birds, mammals, amphibians, reptiles, and fish) declined about 28% between 1970 and 2008 (WWF, 2012). This decline has been particularly severe in tropical areas and freshwater ecosystems. Similarly, the World Conservation Union reports that by 2009, of the over 47,677 species assessed, 36% were threatened with extinction; plant species reached an alarming 70% (Secretariat of the Convention on Biological Diversity, 2012). The implications of this "great extinction" of species (Brown, 2008) are equally dire for humans, considering, for example, the imminent threats to one crucial ecosystem service: the supply of food (with 75% of global fish stocks either fully or partially overexploited, the collapse of a number of global fisheries appears imminent).

Biodiversity loss is occurring at global, regional, *and* local levels (e.g., European Environment Agency, 2009; Federal, Provincial and Territorial Governments of Canada, 2010). According to "The Economics of Ecosystems and Biodiversity" report (TEEB, 2011), a "business as usual" scenario will lead to a continued or accelerated loss of biodiversity, affecting the provisioning of ecosystem services (discussed below) and seriously affecting human well-being, however unevenly, at a global scale (Nordhaus, Shellenberger, & Blomqvist, 2012).

The term *biological diversity* has been used widely since the 19th century, although its first formal appearance in a publication is attributed to the sociobiologist E. O. Wilson as recently as 1988 (Colwell, 2009). Among ecologists, biodiversity is often defined as "the genetic, taxonomic, and functional diversity of life on Earth including temporal and spatial variability" (Naeem, 2009, p. 584). In other words, it consists of "communities of living organisms interacting with the abiotic components that comprise, and characterize, ecosystems" (TEEB, 2011, Chap. 2, p. 5). Together, these definitions capture several important aspects.

First, the concept of biodiversity captures far more than just the number of species. It is a multilevel construct applied at different organizational scales (genes, individuals, populations, species, communities, ecosystems, and biomes) and to different perspectives, including evolutionary (phylogenetic) and ecological (functional). The term *biodiversity* may apply to biological populations explaining genetic variation among individuals and lineages; ecologists and conservation biologists largely use the term at the species level, which is probably the meaning most commonly associated with this concept. Species richness, for example, is the number of species in a specific taxon (e.g., birds, mammals) in a particular ecosystem type (e.g., the savannah). At macro scales—landscapes, marinescapes, or regions—biodiversity can apply to the number, relative frequency, and spatial organization of ecosystem types, or ecosystem diversity.

A second important aspect is the difference between functional (Lawton & Brown, 1994) and response diversity (Elmqvist et al., 2003). Both can range from low to high, but while functional diversity refers to the number of species that fulfill different ecological functions in an ecosystem (e.g., pollination or nitrogen), response diversity refers to the number of different ways in which a specific function, such as pollination, may be performed (e.g., by insects and birds; Colwell, 2009; Vold & Buffett, 2008). In any community of organisms, each functional group (e.g., pollinators) primarily participates in a specific process and, in doing so, contributes to the functioning of the overall system (TEEB, 2011). Biodiversity thus also captures the interconnectedness and functioning of ecosystems, and species diversity is positively associated to higher ecosystem productivity.

Response diversity also refers to the diversity of responses to environmental change among species contributing to the same ecological function. Species that perform the same function may respond in different ways to transformations in the ecosystem. Hence, response diversity can be a proxy for the adaptive capacity in a world of complex systems, uncertainty, and human influence and thus relates to the concept of ecosystem resilience (Elmqvist et al., 2003) discussed below. Although some uncertainty remains about the mechanisms that link biological diversity to ecosystem structure and processes (Peterson et al., 1998; TEEB, 2011), the relevance of biodiversity stems also from the fact that species richness generally increases the capacity of ecosystems to self-organize, absorb disturbance, and regenerate after disturbance (Folke, Carpenter, & Walker, 2004). In other words, biodiversity loss affects ecosystem functionality since it reduces the capacity of ecosystems to regenerate or reorganize after a perturbation, while a high level of biodiversity (response diversity) can buffer and help revitalize the system without tipping it irreversibly into an undesirable state (i.e., the former dynamic equilibrium is not recoverable, leading to "ecological surprise"). We will return to these relationships and to the theoretical and practical implications for management in a later section of this article.

Ecosystem Services

The notion of ecosystem services links the study of ecosystems firmly to "the province of humanity" (Kinzig, 2009), introducing a fundamentally different aspect—namely, that humans derive essential benefits from ecosystem functioning and from biodiversity. Ecosystem services are commonly defined as "the benefits that humans obtain from ecosystems, and they are produced by interactions within the ecosystem" (MEA, 2005, p. 3). Ecosystems like forests or wetlands provide services such as food, timber, fibers, water purification, climate regulation, genetic diversity, and medicines that support our well-being. As mentioned, one widely accepted classification groups these services into four types: supporting services (which maintain all other services), provisioning, regulating, and cultural services system (MEA, 2005).

Ecosystem services have increasingly attracted the interest of at least two broad scientific communities in recent decades—ecologists and economists—helping describe the relation between humans and nature and underline the societal dependence on the life support systems of the environment (Gómez-Baggethun et al., 2010). The concept originated in the late 1970s (Westman, 1977) or early 1980s (Ehrlich & Ehrlich, 1981), but it was in the 1990s that ecosystem services entered the mainstream literature. The concept rapidly, even exponentially (Fisher et al., 2009, p. 644), diffused into articles and books (Costanza & Daly, 1992; Costanza et al., 1997; De Groot, Wilson, & Boemans, 2002) offering a powerful framework for thinking about sustainable development as well as designing and supporting decision-making processes (United Nations Environment Programme, 2008; World Bank, 2009). The multiyear MEA (2005) served as another major factor in the diffusion of this concept, inspiring natural and social scientists to engage in theoretical and empirical research on the topic while also placing ecosystem services squarely on the public agenda (Fisher et al., 2009).

We mentioned that ecosystem *structure and processes* (e.g., the primary production or nutrient cycles) are at the heart of providing *functions* (e.g., water purification). The *services* that individuals, organizations, and society obtain from these functions (e.g., food and clean water) contribute to human welfare and generate benefits that range from nutrition and water to satisfying cultural needs, such as aesthetics. At the same time, through its multiscale organizational components and attributes, biodiversity (e.g., species richness or functional diversity) influences ecosystem functioning and the provisioning of ecosystem services. Table 2 provides some illustrative examples of the links among biodiversity, ecosystem functions, ecosystem services and benefits, both in general terms (MEA, 2005) and with regard to business organizations.

The concepts of *ecosystem services* and *benefits* fundamentally rest on humans utilizing ecosystems and their functions, whereas ecosystem functions exist even if humans are not using them as services (e.g., Fisher et al., 2009). The distinction between services and benefits highlights that the same service can generate multiple and different benefits and points to the potential for conflicts between different human values and uses. Trees (the service) in a forest (the ecosystem) may offer an aesthetic pleasure and can provide outdoor experiences for ecotourism, wood

Table 2. Biodiversity, Ecosystem Functions, Ecosystem Services, and Benefits: Examples.

Specific aspect of biodiversity	Example of ecosystem functions	Examples of ecosystem services	Example of benefits	Benefits for organizations and businesses
Genetic diversity	Source of unique biological materials and products	Medicine and agricultural products	Control of disease; health from use of medicines; nutrition; individual pleasure from enjoying variety in food	Pharmaceutical and agro-food companies rely on genetic biodiversity to find new drugs or seeds
Population size and biomass	Primary production extractable as food	Food from crops, fisheries, or timber	Health and human material well-being, energy for comfortable temperature control, quality of life, recreational value, etc.	Consumer goods and retail companies benefit from higher productivity rates and improved quality (e.g., Unilever, IKEA)
Interaction between organisms and their abiotic environment	Recovery of mobile nutrients and removal or breakdown of excess nutrients and compounds	Water purification	Clean and safe drinking water, avoidance of disease, recreational value, etc.	Water management companies benefit from higher efficiency and increased quality (e.g., Veolia Waters)
Interaction between organisms and species	Movement of floral gametes (reproductive cells)	Pollination	Health, adequate food production, recreational value, etc.	Companies in the agriculture industry benefit from increased land productivity (e.g., Syngenta)

Source. Adapted from Costanza et al. (1997), Millenium Ecosystem Assessment (2005), and TEEB (2011).

for paper or furniture, protection from floods or storms, or improved living conditions through climate regulation and carbon dioxide sequestration.

The following quote helps further explore linkages among biodiversity, ecosystem functioning, and ecosystem services (and resulting benefits for humans):

> The biological activities of plants, animals, and microorganisms influence the chemical and physical processes of their surroundings, and if one were to modify the distribution and abundance [and diversity] of these organisms, ecosystem functioning, or biogeochemical activity, would change. For example, trees in a forest sequester atmospheric carbon dioxide and locally enhance evaporation; invertebrates in a marine ecosystem mix and aerate sediments; and microorganisms in an aquatic ecosystem decompose organic matter. Reduce the number or mass of these organisms, and ecosystem functions, such as primary production in the forest, the rates of sediment aeration in the marine ecosystem, and rates of decomposition in the aquatic ecosystem, are likely to be altered. If ecosystem functions are altered, then it stands to reason that ecosystem services, which are ecosystem functions that benefit humans, are also likely to be altered. (Naeem, 2009, p. 584)

Table 2 offers a number of examples for further illustration.

The concept of ecosystem services thus highlights those ecosystem functions that are particularly relevant for humans. It is often combined with manufactured or human-made types of capital, put in place to more deliberately or more intensively extract benefits. It is this latter aspect that effectively establishes ecosystem services as a social-ecological concept. Humans can, for example, benefit from the service of constant water flow for producing energy by building a dam;

fishing or boating similarly relies on human-made capital to access ecosystem services of food provision or recreation (Fisher et al., 2009).

Another aspect of the relationship between services and benefits deserving further attention is that ecosystem services can result in multiple benefits or "joint production" (Fisher et al., 2009), depending on the way people use the services. For example, clean water can be used for drinking and also for washing or swimming; the services provided by a regulated stream of water can include irrigation and recreational opportunities. A regulated stream can also reduce the risks of flood and increase safety for people (a short-term benefit), while reducing biodiversity along the river banks over the long term.

Not surprisingly, benefits obtained from the same service can cause conflict, for example, when timber generated by a forest in a tropical area can be extracted and sold or be valued for climate regulation or for its contribution to the cleaning of water.

A distinction between functions, services, and benefits (including acknowledging joint production and trade-offs) is critical for economic valuation purposes, and "the issue of valuation is inseparable from the choices and decisions we have to make about ecological systems" (Costanza et al., 1997, p. 255). Therefore, the concept of ecosystem services must lend itself to a solid interpretative framework if it is to better support social decisions with regard to the protection and management of ecosystems and biodiversity as well as make our dependence on nature more clear—be that at individual, organizational, or societal levels.

At the same time, the critical importance of ecosystem services for business, both in terms of risks and opportunities, calls for a valuation method that can inform and support strategic and operational decisions (WBCSD, 2009). According to several scholars (Fisher et al., 2009; TEEB, 2011) and despite offering an excellent and intuitive heuristic, the classification proposed by the MEA (2005) is not suitable for economic ecosystem service evaluation since it does not address issues such as risks of double counting or trade-offs, nor does it account for those benefits that are indirect or not formally valued, such as intrinsic appreciation (TEEB, 2011). Much research needs to be done to properly capture the myriad of ways that ecosystems services contribute to our well-being and to integrate them in our decision-making processes.

The spatial and temporal scales of services provided, and whether they serve as rival or excludible goods further affects the relationship between organizations and ecosystems. Rival and excludible goods have been broadly investigated by economists, management scholars, and by colleagues in the ONE field (Ostrom & Ostrom, 1977; Prakash & Kollman, 2004). Typically, public goods like air or national public defense are considered nonexcludible in economic theory in the sense that it is not possible to exclude people from consuming them. They are also nonrival, which means that the consumption by one consumer does not prevent others from doing so. Ecosystem services provide benefits that can be characterized along a continuum from rival to nonrival and from excludible to nonexcludible (Fisher et al., 2009).

Typically, timber or fibers are rival and excludible while the benefits from the service of climate regulations provided by ecosystems like forests are nonrival and nonexcludible. Without entering into the discussion about the classification of the multitude of bundled services and joint production of benefits that we derive from nature, this distinction has important implications when it comes to excluding others from the consumption of ecosystem services or when services become scarce, generating problems of trade-offs and conflict between rivaling beneficiaries. Deep-sea fisheries, when abundant, are usually considered typical public goods since they are nonexcludible and nonrival (the abundance of species such as cod meant it was not in discussion until the fishery collapsed a few years ago). When scarcity increases, however, goods can suddenly become rival; when specific barriers like fishing quotas or monitoring systems are introduced, they become excludible.

Also important are spatial and temporal scales of services and benefits (Levin, 1992; Scholes, 2009). Ecosystem services, in fact, provide benefits that can be spatially and temporally contingent on or separated from the ecosystems production area. The benefits of soil formation are typically in situ, while pollination or carbon sequestration benefits extend to an area around their production place. In the case of a forest, the water purification service can generate benefits to communities living downstream and far away from the woodland (different spatial scale) many weeks after the service is provisioned (different time scale; Fisher et al., 2009; MEA, 2005; Scholes, 2009). Scale, therefore, comes into play in many ways in assessing and managing ecosystem services, raising questions on how organizations can manage and govern these dynamics (Kinzig, 2009).

To conclude, ecosystem services have acquired relevance both as an interpretative scheme of the interdependencies between humans and nature and as a framework to include nature more fully in our social and economic decision making. Before we discuss the management implications for research and for business, we turn our attention to another important concept that is closely linked to ecosystems and biodiversity: ecological resilience.

Ecological Resilience

Resilience has been investigated by a number of disciplines and from diverse theoretical perspectives, including management and organization science (e.g., Sheffi, 2005; Sutcliffe, Sitkin, & Browning, 1997), psychology (Luthar, Cicchetti, & Becker, 2000), system analysis (Holling, 2001), and economy and sociology (see Folke, 2006, for an extensive review). In this article, we focus on *ecological resilience* as a specific quality of ecosystems (an exploration of the relationship between ecological resilience and organizational resilience, while relevant, goes beyond the scope of this article). We define resilience as the capacity of a system (e.g., an ecosystem) to cope with disturbances without shifting into a qualitatively different state (Gunderson & Holling, 2002). A clear understanding of the concept of ecological resilience appears paramount in the context of this article, because it is considered an essential factor underlying the capacity of ecosystems to continue the production of services in complex systems coping with disturbance and uncertainty.

When ecosystems are stressed persistently and cumulative effects reach a certain threshold, they may undergo sudden and dramatic changes. This can shift the ecosystem to another state with large and unpredictable effects on the capacity to provision services. Examples are eutrophication (the overenrichment of water with nutrients and subsequent excessive plant growth) of lakes, a reduction of fish stocks, or the breakdown of the coral reef. When ecosystems have accumulated stress, they become more fragile, and even small perturbation can trigger their capacity to maintain structure and functionality. For example, the loss of response diversity in the case of human-made disturbances in specific terrestrial or aquatic ecosystems reduces their resilience along with the system's capacity to remain within a specific state. Several papers and publications show that ecosystems increasingly shift between states as a consequence of human actions that affect and weaken resilience (Gunderson & Holling, 2002; MEA, 2005; TEEB, 2011).

The resilience perspective has emerged in ecology in the late 1960s and early 1970s in parallel with the previously discussed transformation of the discipline from being deterministic and single-equilibrium steady-state based to a discipline of complex adaptive systems with multiple equilibria and feedbacks among multiple scales that allow self-organizing processes (Folke, 2006; Holling, 2001; Levin, 1998). *Ecological resilience* is defined as "the capacity of a system [an ecosystem, a community or society, addition by authors] to absorb and re-organize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks" (Folke, 2006, p. 259). This definition encompasses three different but complementary features.

The first is the capacity to absorb or buffer shocks while maintaining structure and function. This aspect is often called *persistence*. Here, resilience can be considered as a measure or a threshold, and although difficult to determine, it plays a substantial role in managing ecosystems in order to maintain ecosystem functionality and the provisioning of services (Brand, 2009). Flips or state changes in ecosystem functions may prompt a sudden reduction of biological productivity, with direct consequences on the ecosystem's capacity to support human well-being and human life.

The second is the potential of the system to recombine structure and processes and to reorganize and renovate itself. Ecological resilience, therefore, is also an indicator of the capacity of an ecosystem to allow for its dynamic development, its *transformability*. A resilient ecosystem, for example, can turn disturbances into opportunities to innovate, change, and improve its capacity to provide services. In the case of weak resilience, even small turbulences can determine dramatic social and ecological consequences.

The third feature, *adaptability*, refers to the capacity of an ecosystem to adapt and learn. Recognizing that humans, their activities, and their organizations are deeply embedded in and part of ecosystems points to the broader conception of social-ecological systems. In this sense, resilience has become a perspective and interpretative lens that supports ecologists and social scientists in the analysis of social-ecological systems.

Extending these concepts to our domain of studies, we next examine their implications for core assumptions and future directions of organization theory and strategy. We know that this is a complex exercise, but we argue that the development and maturation of our field requires a bold move toward a new reconceptualization of the discipline, breaking its merely social boundaries to the outside world.

Linking Two Knowledge Domains: Challenges and Implications

A number of organization scholars have called for transdisciplinary cross-fertilization as an important method to build powerful new theory and models (Corley & Gioia, 2011; Oswick & al., 2011; Suddaby, Hardy, & Huy, 2011; Zahra & Newey, 2009). Similarly, ONE scholars have for two decades highlighted the need for looking outside our disciplinary boundaries and at the natural sciences in particular (Gladwin, Kennelly, & Krause, 1995; Kallio & Nordberg, 2006; T. B. Porter, 2006; Shrivastava, 1994; Starik & Kanashiro, 2013; Starik & Rands, 1995; Whiteman et al., 2013) to bring relevant concepts, perspectives, and models of the biophysical foundations to the study of the organization–natural environment relationship.

In this article, we have discussed critical contributions provided by disciplines outside the domain of organization and management studies, namely, ecology and ecological economics, to offer our readers a better understanding of nature's functioning principles and to begin to sketch the myriad interconnections between ecosystems and human, and thus organizational, life. We also offered examples of companies implementing initiatives intended to manage ecosystems and biodiversity, thus acknowledging the interconnectedness of their organizational models with the natural capital from which they draw. Our reviews of ecosystems and biodiversity, ecosystem services, and ecological resilience required profound immersion into other sciences in order to capture their ontological and epistemological underpinnings, language, dominant interpretative frameworks, and experimental practices (Abel & Stepp, 2003; Braat & de Groot, 2012; Costanza, 1989; Holling, 1998).

Investigating both ecology and ecological economics for this article, we observe an intense commitment in those fields to the conservation of nature as a fundamental tenet underpinning the way these disciplines build their models and tools. A quote by Levin (2009) in the preface to the *Princeton Guide to Ecology* illustrates this point:

> Just as we are beginning to appreciate not only the beauty of natural systems but also their essential role in providing an infinite range of goods and services on which humanity depends, we are reluctantly also learning that we are destroying those life-support systems and threatening the sustainability of the biosphere as we know it. Ecology, the unifying science in integrating knowledge of life on our planet, has become the essential science in learning how to preserve it. (p. vii)

At the same time, a large branch of ecological economics research is dedicated to study market mechanisms such as "pay per ecosystem services" and refine methods like "cost–-benefit analysis" to effectively and efficiently incorporate ecosystems' services into our decision-making processes with the ultimate goal to preserve nature (Farber et al., 2002; Farley & Costanza, 2010).

Underlying this commitment is a growing realization that society appears to be maneuvering itself to the outer side of "a safe operating space for humanity" (Rockström et al., 2009) and that exceeding the safe boundaries of a number of planetary system changes such as the global climate change, biodiversity loss, or ocean acidification may prompt unprecedented and disruptive global environmental change—along with associated social change and upheaval. While not uncontested (Nordhaus et al., 2012), Rockström et al. (2009) cite evidence for their conclusion that boundaries have already been exceeded in three such systems—biodiversity, nitrogen cycles, and climate change.

Looking back at the organizational and management domain, we raise questions around the role of ONE scholars in contributing to (or detracting from) the conservation of nature. Arguing that a significant part of responsibility for the ecosystems and biodiversity crises—as well the search for solutions—falls to organizations (in addition to individuals, institutions, and society at large), we take the liberty to pose some pointed questions.

To what degree has our discipline been able to provide useful lenses to analyze the transformations that are occurring in our society? Have we raised the right questions to prompt a profound rethinking in the management discipline outside the discourse in the ONE subfield? Are we providing the interpretative frameworks capable of favoring or supporting the conservation of our fragile ecosystems? As management scholars, are we jointly responsible for or complicit in nature's progressive degradation, or is this outside our boundaries of responsibility?

As theorists trained to study organizations, and as members of organizations immersed in a biophysical world, we share the view of our colleagues in the fields of ecology and society and think that our branch of social science must actively contribute to protecting nature—particularly since the absence of doing so implies contributing to nature's decline.

If we acknowledge the mutual influence—or interconnectedness—of organizations and ecosystems, what are the implications for organization theory? In Figure 2, we graphically represent this relationship: On the one hand, humans—whether as individuals, through business organizations (our main focus here), or through any form of organizing (including institutional arrangements and entire societies)—affect ecosystem functioning and stress ecological resilience through the overconsumption of services (be that overexploitation of natural resources, emissions of pollutants, or other wastes at rates above the recovery capacity of natural systems).

On the other hand, organizations fundamentally depend on the services provided and are vulnerable to shortages in the availability of these services: depletion of fish stocks threatens global fisheries and companies operating in the food industry; growing pressure on water resources affects both the supply and the quality of water and undermines businesses' continuity in sectors such as agriculture, forestry, beverages, or energy. We refer to this mutual relationship of impact and dependence as *organizational ecosystem embeddedness*.

What is new in this representation is the focus on dependence as a constitutive part of the ecosystem–organization relationship. Future research should consider not only the effect of

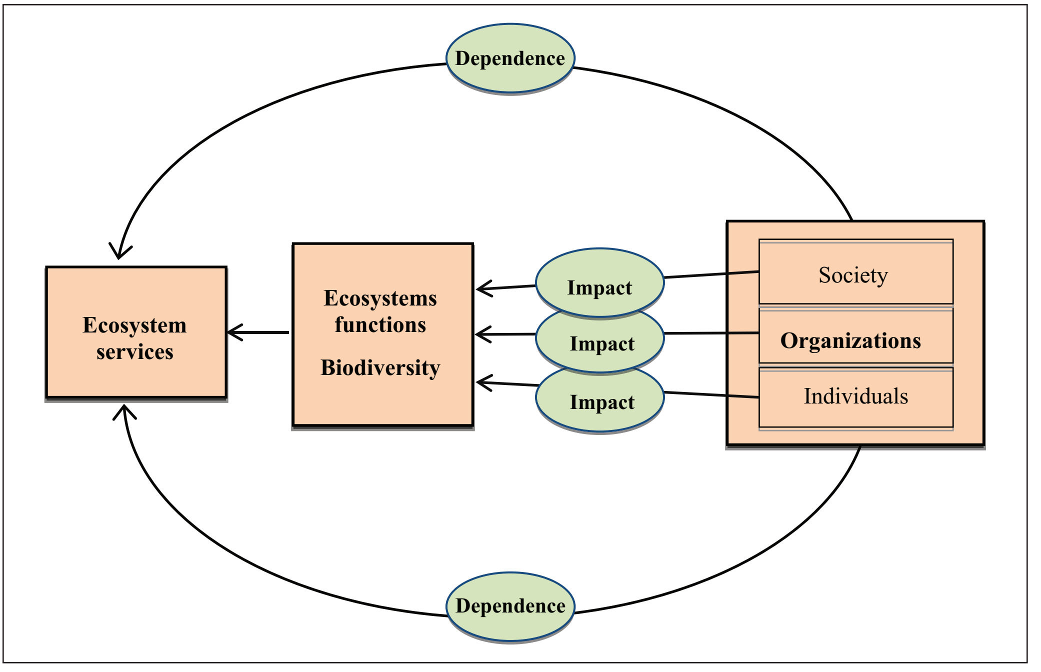

Figure 2. Theoretical model of organizational ecosystem embeddedness.

organizational impact on nature but also the effect of nature's transformation on organizations, since changes in ecosystems and ecosystem services can dramatically affect firms and entire business models. Climate change provides a good example. Strategies aimed at reducing a firm's impact on the climate system (by reducing carbon emissions) are increasingly accompanied by strategies aimed at increasing the firm's resilience to the heightened risk of extreme weather events (by preparing for floods or droughts; Kolk, Pinkse, & Van Houten, 2010; Winn, Kirchgeorg, Griffiths, Linnenluecke, & Günther, 2011).

As mentioned above, the concept of organizational ecosystem embeddedness relies on *dependence* and *impact* as two constitutive aspects of the relationships between ecosystems and organizations. This effectively establishes business organizations as social-ecological systems—something that has not been closely examined in organizational studies before.

Implications for Research on Organizations and Strategic Management

New attention by business toward ecosystems and their functioning offers intriguing research directions for investigating both the biophysical dimensions of impact–dependence linkages between organizations and the natural environment, as well as cognitive and management dimensions of these linkages.

Earlier, we discussed ecosystems as complex adaptive systems. If organizations are also forms of complex adaptive systems that jointly form social-ecological systems, then scholarly research needs to investigate more specifically how the *interconnectedness* between them is structured and how it might change in a context of rapid mutation of ecosystems' capacity to provide services. This raises a number of questions. Which theories—organizational and other—deal with interconnectedness and can provide solid conceptual models to examine the ecosystem–organization relationship and its potential joint or coevolution (T. B. Porter, 2006)? Can theories anchored in knowledge domains of human and social organization (e.g., coevolution, industrial ecology, or population ecology) be adapted or expanded to include the material aspects of nature and ecosystem functioning and deepen knowledge of organization–nature interconnections? What are the conditions that increase or mitigate impact and dependence? How much can and do institutional contexts influence these organization–ecosystem interconnections? An example is the new market mechanisms intended to protect ecosystem services, such as tradable permits, increasingly popular in sectors like fisheries or water system management; scholars are also looking at biodiversity as a new area to experiment with tradable rights (United Nations Environment Programme Finance Initiative, 2008). Research is needed to understand how such institutional innovations can, for example, incentivize private investment in conservation initiatives aimed at enhancing ecosystem services (e.g., by protecting and restoring fisheries or water systems).

Ecological resilience, furthermore, is crucial for maintaining ecosystem functionality and to avoid flips to other states with unpredictable consequences for society. Global fisheries serve as an example: Having proven resilient through extended and extensive overfishing and wide-scale destruction of marine ecosystems, once pushed into collapse, result in massive reductions in food sources, livelihoods, and global business. Important questions to ask include the following: What are the barriers that keep organization theory from expanding more fully into examining the mismatch between spatial and temporal scales at ecosystem levels and those at organizational levels? Indeed, why are ecological scales not or very rarely (e.g., Bansal & Knox-Hayes, 2013) even considered? How can social and organizational systems and their functioning be linked to ecosystems and their functioning, such that impacts and dependence are accurately represented?

Strategy and Risk: Nature as the New Corporate Reality

Earlier, we discussed how a number of multinational companies are addressing ecosystems and biodiversity conservation by implementing a range of initiatives. Future research will need to provide a full review of current initiatives and build a comprehensive framework to interpret and classify them. In the context of this article, a closer look at how ecosystem interconnectedness affects and, perhaps, inspires management strategy does open fruitful directions for future research.

One important set of questions relates to *business risk*. As awareness and understanding of the strategic dependencies of firms on specific ecosystem services grow, firms will want to reduce both direct operational risks and secondary regulatory and reputational risks. In recent years, some industry associations (e.g., the WBCSD), NGOs (e.g., the WRI), and consulting companies (e.g., PriceWaterhouseCoopers for the World Economic Forum) have explored the relationship between ecosystem degradation and risks from a business perspective and identified multiple areas of impact on companies' strategies and operations (PriceWaterhouseCoopers, 2010; WRI et al., 2008). Still, methodological rigor is required to investigate how the degradation of ecosystem services and loss of ecological resilience affect organizational risk and risk perceptions, and how the type of industry, type of firm, and operational activities affect both. What kind of new business risks are emerging as a consequence of the degradation and transformation of ecosystems? What is the nature of such risks? Which industries and organizations are more exposed and why? Are risks of a reputational or regulatory type, or do they undermine core strategies of companies, directly affecting the sustainability of the business model by threatening availability of and access to critical resources? We expect that entire research agendas can be built around the question of how such risks affect the competitive advantage of firms.

Another important area of investigation involves the *strategic responses* of companies. The following questions map possible future directions: Facing changes in and deterioration of ecosystems services, how are companies transforming associated business risks into opportunities to reshape their strategies and to innovate? What factors prompt firms to adapt only reactively to such changes, what factors contribute to building anticipatory capacity, and what contributes to transformational changes that lead to sustainability management? Which types of firms undergo changes in their core strategy and why? What are the emergent strategies to address ecosystem service scarcity and loss of ecological resilience (e.g., bio-mimicry and other approaches that increase the efficiency of using ecosystem service), and what innovations lead to viable ecosystem services substitutes (e.g., the use of water filtration and treatment techniques to purify water; implications of replacing wood fiber with bamboo fiber for supply chains, production technologies, and marketing strategies)? How can ecosystem and biodiversity conservation strategies contribute to reducing the corporation's negative impact on ecosystems? To increasing its sustainability management on both environmental and social dimensions? How robust is such engagement when competitive pressure goes up, how much proves to be only symbolic or greenwashing?

Engaging actively in ecosystem management is likely to have ripple effects through firms' entire supply chains thus placing new demands (as well as opportunities) on innovations in *supply chain management* and related literature. Clearly, this also places new demands on developing (or tapping into) relevant firm competencies and dynamic capabilities. Here, a theoretical anchor for new research might be the natural resource–based view of the firm (Hart & Dowell, 2011), as well as the rich body of research on dynamic capabilities (e.g., Aragón-Correa & Sharma, 2003; Teece, Pisano, & Shuen, 1997). Questions include the following: What competencies and dynamic capabilities are needed to address and learn from changes in ecosystem service availability? Can such capabilities reside narrowly in expert knowledge in the firm or do they require broader cultural shifts throughout the entire organization, similar to the quality revolution, or even more transformative change? Are more fundamental organizational systems needed, and if so, what kind? More specifically, how can companies manage the protection and restoration of relevant ecosystems in light of their complexity, varied spatial and temporal scales of ecosystem services, and competing uses and users? Potentially conflicting demands will likely require new forms of partnerships with local, regional, and international partners and across market, regulatory, and civic sectors. What theoretical advances might this area offer to the natural resource–based view and resource-based theory in general?

Competition, Cooperation, Conflict

As corporations learn (and are even called on) to actively manage their relationship with and ideally restore and even strengthen ecosystems, they are bound to encounter conflicts (internal and external) and governance challenges that stem from private sector organizations managing the commons. Difficult organizational and governance challenges include finding mutually acceptable forms of joint engagement among a range of different stakeholders, principled with transparency and accountability, and taking into account perceptions of fairness and justice in light of differential endowments of power (e.g., voluntary self-regulating approaches; Berchicci & King, 2007). Linking the intra- and interorganizational challenges of cross-sector partnerships to the complexities of different temporal and spatial aspects of ecosystem functioning places considerable strain on businesses to innovate and to find models that allow them to cooperate on the ground, while retaining their competitive advantage vis-à-vis competitors in other areas, such as their cost structure, branding, and so on. This is not entirely new ground: The Marine Stewardship Council, Roundtable for Sustainable Palm Oil, and Rainforest Alliance provide additional examples to those mentioned earlier and will serve as an important empirical base for in-depth case studies and rigorous investigation of different aspects of these challenges.

Value and Values

New decision-making tools (e.g., ecosystem evaluation tools, software programs, etc.) will need to be developed that both permit the difficult task of monetizing ecosystem services (and the ecosystem functions that lie behind them) and capture the divergent, and often conflicting, "values" held by different stakeholders. To use the example of AccelorMital's initiative cited in Table 1: Retaining healthy chimpanzee populations in the Nimba Mountains may or may not be crucial for the integrity of ecosystem functioning, but it is clearly an important aspect of the UNESCO effort and vital to environmental NGOs (and their supporters), who view chimpanzees as having intrinsic value in their own right. Discussions around the loss of species and biodiversity must necessarily tap into both scientific knowledge and personal, cultural, and societal values. The literature on conflict and multiple-stakeholder management may have important contributions to make for both scholarly purposes and practice.

Nurturing Multidisciplinary Perspectives

As a concluding observation, we argue that the bridging of knowledge domains (as aimed for in this article) and the development of effective new approaches to ecosystem management and corporate involvement absolutely require cultivating of cross-disciplinary discourse, nurturing of multidisciplinary perspectives, and drawing on the innovative capabilities of the many practitioners developing new approaches on the ground. To the degree that sustaining the biophysical foundations of business is recognized as essential to long-term business continuity, new perspectives, decision approaches, and methodologies are required. We observe hopeful signs of new partnerships and forms of interactions that support a fruitful discourse and a search for rigorous, scientifically based collaborations among scientists (natural and social), civil society leaders (e.g., TNC, WWF), business pioneers (e.g., WBCSD), and governmental/intergovernmental efforts. Organization scholars have an important contribution to offer.

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Notes

1. In this article, we use the term *ecosystem management, strategic ecosystem management*, or *ecosystem services management* to refer to the range of emerging efforts by firms either to deliberately design their operations such that the sustainability of affected ecosystem functions is enhanced or to restore and enhance ecosystems and ecosystem functions. The term *managing ecosystems* refers to managing processes; it does not imply an inherent ability to control complex ecosystems any more than the term *human resource management* refers to controlling people.

2. Future work, outside the scope of this article, needs to examine the relationships between individual, organizational, institutional, and societal levels in order to expand our understanding of the social dimension of sustainability within the broader framework of the biophysical dimensions mapped here.
3. As indicated earlier, the use of the term *ecosystem management* refers to deliberately managing and improving organizational processes toward achieving more sustainable relationships between the organization and ecosystems; any such efforts must be cognizant of the uncertainties inherent in interacting complex adaptive systems.

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