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Survey

Understanding changes in business strategies regarding biodiversity and ecosystem services

Joël Houdet [a,*], Michel Trommetter [b], Jacques Weber [c]

[a] A@L Integrated Sustainability Services, 25 Melville Road, Hyde Park Ext. 2, Sandton, Johannesburg, South Africa, Association Synergiz, 69 rue de Rochechouart, 75009, Paris, France
[b] INRA, UMR GAEL INRA — UPMF, BP 47, 38040, Grenoble Cedex 9, France. Department of Economics, Ecole Polytechnique, Palaiseau, France
[c] CIRAD, Unité de recherche Ressources forestières et politiques publiques, 42 rue Scheffer, 75116 Paris, France

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ABSTRACT

Business activities play a major role in biodiversity loss so that firms are under increasing pressures from stakeholders to mitigate their negative impacts on ecosystems. As business attitudes, policies and behaviors regarding biodiversity and ecosystem services (BES) progressively change, a better understanding of how business strategies may be framed and implemented is required. In the first part of this paper, we discuss how biodiversity is usually understood as an external environmental constraint on business activities, and how this perception influences arbitrages. We then discuss how assessing BES interdependencies (impacts and dependencies) may bring about new business strategies and needs: we explore the opportunities and challenges of emerging mechanisms of payments for ecosystem services and expose the need for standardized sets of indicators at different scales for the effective management of their BES dependencies and impacts.

1. Introduction

During the past few decades, firms have been under increasing pressures from stakeholders to reduce their impacts on ecosystems so that environmental issues have progressively become key strategic variables for them (climate change, water, pollutions), notably in terms of disclosures (Cho and Patten, 2006; Cormier et al., 1993) now mandatory in many countries (e.g. New Economic Regulation law for France from 2001). Bellini (2003) argues that companies have progressively taken such issues into account under the impulsion of three types of arbitrage: legislative or normative, economic and technical.

Because biodiversity was, up to recently, at best an emerging issue among others for most firms, the business community has been officially asked to contribute to the objectives of the Convention on Biological Diversity (CBD) in March 2006 in Curitiba (CoP 8): decision VIII/17 emphasized the need for firms to adopt best practices for integrating biodiversity concerns into their strategies and decision-making processes. As business attitudes, policies, and behaviors progressively change worldwide (Houdet, 2008a,b; TEEB for business 2010), a better understanding of how corporate strategies pertaining to BES may be framed is needed.

Our analysis of business strategies regarding biodiversity seeks to be complementary to mechanisms and measures for biodiversity conservation. In this paper, we do not discuss corporate responsibility towards nature[1] but seek to analyze how different business perceptions regarding biodiversity may influence strategies and behaviors. First, we discuss the implications of perceiving biodiversity as an external environmental constraint on business activities: this widespread way of understanding interactions between business and biodiversity, which falls within the traditional competitiveness versus environment debate (Section 2), typically leads to business or project legitimization strategies through (a) negotiations with stakeholders throughout decision-making processes (Section 3.1), (b) BES valuation for cost–benefit analyses (Section 3.2) and (c) negotiated impact mitigation measures (Section 3.3). We then explore how assessing a firm's interdependencies with biodiversity may bring about new business strategies and practices (Section 4.1), highlighting the opportunities and challenges linked to emerging markets for ecosystem services (Section 4.2) as well as the need for standardized measurement protocols so as to help

Abbreviations: BES, biodiversity and ecosystem services; ES, ecosystem services; CBA, cost–benefit analysis; CEA, cost–efficiency analysis.

* Corresponding author. Tel.: +27 73 446 2671.
E-mail address: jhoudet@synergiz.fr (J. Houdet).

[1] See Bazin (2009) for a recent analysis of associated theoretical paradigms.

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business better manage their BES impacts and dependencies at different scales (Section 4.3).

2. Setting the Scene: The Competitiveness — Environment Debate

With water, soil and air quality, and more recently climate change, at the heart of stakeholders' concerns, most (past and) current business efforts at internalizing their negative environmental externalities (have) target(ed) indirect drivers of ecosystem — and hence biodiversity — change, that is their diverse polluting outputs (waste, emissions); and this frequently independently from one another in response to changes in stakeholders' demands and priorities. In this context, firms generally perceive biodiversity as an additional form of external environmental pressure: the mandatory or negotiated implementation of tools for internalizing their BES externalities hence falls within the traditional competitiveness versus environment controversy (Boiral and Jolly, 1992; Walley and Whitehead, 1994).

Within this debate, two positions have been regularly opposed. On the one hand, a win–lose perspective (Boyd and McCelland, 1999) considers that, with increasing regulatory and societal pressures, firms cannot ignore anymore their negative environmental externalities without risking losing their legitimacy or license to operate (Boiral and Jolly, 1992). The resulting costs they incur, seen as proportional to the intensity of external pressures, cannot be easily avoided, and far outweigh the environmental benefits. Environmental issues, through notably industrial and regulatory norms, are considered as external constraints which often necessitate substantial investments with minimal or negative returns, notwithstanding the associated reductions in productivity (Walley and Whitehead, 1994). On the other hand, a win–win approach, also known as the Porter Hypothesis, has attempted to demonstrate the advantages of environmental actions undertaken by firms, hence questioning the orthodoxy of negative causality between competitiveness and the internalization of environmental concerns (Porter and Van der Linde, 1995). Advantages commonly put forward include reductions in energy and material consumption, improvement of corporate image, access to new markets as well as technological and organizational innovations.

The origin of the controversy lies both in the complexity of environmental problems and the arbitrariness of cost–benefit analyses (CBA) and/or cost–efficiency analyses (CEA) undertaken by firms so as to guide decision-making (Boiral 2005). Arbitrage between various options (e.g. different environmental technologies) depends on factors which are both contingent and contextual of each situation or firm. Accordingly, various variables need to be taken into account, including:

(a) The role of industrial and business excellence in environmental performance: environmental initiatives are often inseparable from the ordinary routines, methods and organization of the workplace designed to improve productivity and competitiveness (Shrivastava 1995). For instance, measures favorable to biodiversity (e.g. specific bird species) may be intrinsically linked to specific farming practices (e.g. timing of mowing practices; McLaughlin and Mineau, 1995; Muller 2002).

(b) The distinction between preventive and corrective action (Boiral 2005; Jasch 2008): corrective action corresponds to measures undertaken after opening an industrial plant, such as process redesign to control or reduce pollution. Research supporting the win–lose hypothesis is typically based on comparative analysis of this type of investment (water pollution remediation systems, particulate filters), because it relies on parameters (environmental costs) which can easily be isolated. Preventive action, in contrast, refers to technical and organizational innovations integrated into production methods before the start of their life cycle, at the initial design stage. They are often indistinguishable from measures aimed at improved productivity and efficiency. While corrective actions generally require expensive investment with a minimal increase in profitability or competitiveness, preventive actions may be both economically and environmentally attractive in certain circumstances.

(c) The marginal decrease in the effectiveness of environmental actions: the costs and efficiency of environmental action, whether preventive or corrective, depend directly on the level of pollution remediation projected by the business. Beyond certain thresholds, the costs can turn out to be quite prohibitive (Salamitou 1989), while the results can be uncertain.

(d) The duration or life cycle of assets: an asset is said to be specific when its use-value would be lower in uses other than that for which it is intended in the initial investment (Williamson 1981). Riordan and Williamson (1985) argue that there are five categories of specific assets: localized assets, physical assets, intangible assets, human resources and dedicated assets (no demand for them apart from the transaction that led to their acquisition). According to Godard and Hommel (2001), there is a continuum of levels of asset engagement. At the one end, the absence of sunk costs allows for an engagement that is reversible at will, in the short term, in a perfectly contestable market. At the other end, the business is engaged indefinitely in markets which are not fully contestable owing to the presence of sunk costs so that environmental efforts may be very costly (e.g. modifications of productions tools or processes). In other words, the more specific their assets are, the more firms should be willing to engage with stakeholders pertaining to their externalities so as maintain their license to operate.

(e) The dependence of CBAs/CEAs on the modes of regulation, incentives and property rights in force: if sources of pollution fall under clearly established property rights, it is socially optimal to make the polluters pay (Coase 1960). Inversely, if pollution sources are diffuse and associated with an unclear property rights regime, it will be socially optimal to make society pay. Similarly, if a premium is put on deforestation combined with the growing of export crops (e.g. agrofuels, soya), it is understandable that refraining from exploiting an old-growth forest so as to convert it to a lucrative monoculture is equivalent to an opportunity cost for the company concerned.

Acknowledging the reductionism of clear-cut positions (win–win, win–lose), research is striving towards a better understanding of the conditions which would make internalizing negative environmental externalities profitable for concerned firms or industries.[2] To that end, Jaffe and Palmer (1997) have proposed three variants of the Porter Hypothesis (supported by some empirical studies; e.g. Lanoie et al., 2007): (1) environmental regulation stimulates certain kinds of environmental innovation (weak version); (2) flexible environmental policy regimes give firms greater incentive to innovate than prescriptive regulations, such as technology-based standards (narrow version) and (3) properly designed regulation may induce cost-saving innovation that more than compensates for the costs of compliance (strong version).

From the perspective of the business community, the critical importance of negotiations with stakeholders throughout decision-making processes thus needs to be emphasized: firms would seek to legitimize their activity or project under stakeholder scrutiny at the lowest possible cost. This means optimizing their behavior given the

[2] Based on a bibliographical review, Wagner (2003) suggests that positive relationships between competitiveness and environmental regulation should arise under the following conditions: (a) implementation of economically-efficient regulations, (b) favorable market structures (e.g. demand for differentiated environmental goods ensured by sufficient number of consumers), and (c) availability of unused and more efficient technologies.

rules which are imposed on their operations (Stigler 1971), and potentially manipulating laws to their own advantage (Regulatory Capture Theory; strategic lobbying: e.g. Viardot 1993; Roy and Whelan, 1992). Yet, what does negotiating with stakeholders regarding BES externalities entail for firms?

3. Biodiversity Understood as an Additional Constraint on Business

3.1. BES Externalities: Negotiating with Stakeholders for Cost-efficient Outcomes

Taking BES externalities into account is fundamentally contingent to negotiations with stakeholders (often governments) with respect to (1) where (e.g. rights of access) and (2) how (e.g. fish and wood harvesting quotas) firms can operate. From this perspective, biodiversity may be divided into (a) remarkable biodiversity,[3] to which existence values are attached and/or for which some sort of protection status exists, and (b) *ordinary biodiversity*, which contributes to varying degrees to ecosystem functioning and ES and for which no direct protection is offered (Chevassus-au-Louis et al., 2009). This leads us to propose three distinct business — BES negotiation interfaces:

1. No or extremely limited economic opportunity or activity allowed for (a) specific species or resources protected from trade, exploitation and/or destruction and (b) areas harboring remarkable biodiversity elements (e.g. national parks).
2. Areas containing both ordinary and remarkable biodiversity, where business opportunities, development models and choices, as well as the use of and access to renewable and exhaustible resources, are negotiated with stakeholders so as to ensure ecosystem viability (e.g. Natura 2000 sites in Europe, UNESCO's biosphere reserves network).
3. Other areas which do not have any protection status and where impacts on ordinary biodiversity are addressed (often indirectly) through complementary regulations such as mandatory Environmental Impact Assessments, statutory norms for pollutions (waste, air/water emissions), and legislative frameworks pertaining to the prevention and offsetting of environmental damage (e.g. EU's Directive 2004/35 on environmental liability).

In other words, different decision-making processes would apply whether the (proposed) business activity threatens ordinary biodiversity or biodiversity elements which are important to stakeholders (e.g. protected by law). Conventional business strategy would essentially amount to assessing and mitigating the impacts of business activities, projects or ventures on biodiversity components' key to legitimate[4] stakeholders (e.g. Tucker 2006). For pre-existing activities, firms would at best adopt a cost-effectiveness approach (CEA) with respect to new negotiated or mandatory ecological goals requiring changes in production processes; for instance seeking compensation payments for costs incurred due to compulsory conservation constraints imposed by governments (e.g. Hackl et al., 2007). For new projects under public scrutiny, firms would seek approval from important stakeholders at the lowest possible cost; most often by making use of (a) CBA justifying their desired alternative(s) (ideally inclusive of BES loss and gain; Section 3.2) and (b) negotiated impact mitigation measures (Section 3.3).

3.2. BES Valuation for CBA/CEA: Principles and Limitations

CBA are instrumental to calculate optimal pollution or damage levels, for instance for alternative infrastructure or plant design scenarios (Boiral 2005; Vivien 1994). Taking BES into account within CBA/CEA requires the pricing of their economic value(s) and, more precisely, capturing their marginal economic value for trade-off purposes (Braat and ten Brink, 2008). As argued by Ruhl et al. (2007), "failure to refine our understanding of their value, and the consequent inability to account for those values in regulatory and market settings and, more important, in the public mind, is unlikely to promote their conservation" (business case for biodiversity; TEEB for Business 2010). In other words, coupling CBA or CEA with BES valuation would allow firms and stakeholders to account for BES degradation or loss towards the full cost assessment of proposed projects (Turner and Daily, 2008). As put by Perrings et al. (2009), "maximizing societal welfare calls for understanding the tradeoffs between the net benefits from consumptive and non-consumptive use of ecosystem services, and the costs that these uses create in the form of biodiversity externalities that can diminish future ecosystem services."

To that end, the total economic value of biodiversity, inclusive of that of ecosystem services (Kettunen et al., 2009), is traditionally divided into its use values (direct use value, indirect use value, option value) and non-use values (existence value and bequest value), with a gradient of decreasing tangibility as one moves from direct use values to existence values (Barbier 1989; Freeman 1993; Pearce and Turner, 1990). Accordingly, despite numerous efforts (e.g. Azqueta and Sotelsek, 2007; Costanza et al., 2007; Curtis 2004; Howarth and Farber, 2002; Turner et al., 2003; Wilson and Hoehn, 2006), BES may not easily be valued economically, that is translated into a monetary proxy for market internalization and put into aggregate boxes such as capital, goods or services (Dasgupta 2001; Farber et al., 2002; Heal 1998; Wallace 2007). Major components of BES do not give rise to market transactions (e.g. many regulation services), which means relying on non-market valuation techniques for CBA[5]; each having its own set of methodological limitations. For instance, concerns with contingent valuation relate to the reproduction of protocols and the comparative analysis of results across time and space (Bonnieux 1998; Kumar and Kumar, 2008; Weber 2002). Biases are also associated with benefit transfer techniques applied to the results of studies based on one or more valuation techniques (e.g. Costanza et al., 1997; Troy and Wilson, 2006; Turner et al., 2007; Wilson and Hoehn, 2006). As argued by Nelson et al. (2009), benefit transfer approaches often incorrectly assume that "every hectare of a given habitat type is of equal value — regardless of its quality, rarity, spatial configuration, size, proximity to population centers, or the prevailing social practices and values".

Beyond methodological limitations, the economic valuation of BES is an anthropocentric approach grounded on weak sustainability: i.e. the substitutability between different forms of capital (Godard 1995; Pearce et al., 1990). Depending on the aims and context of the study (e.g. questions asked to interviewees) and the methodological assumptions of the model used (e.g. chosen discount rate), the marginal economic value of an additional BES unit would vary considerably, and in some circumstance be particularly low (e.g. Simpson et al., 1996[6]). This would hold even truer within the context of most CBA of highly lucrative industrial projects, so that many stakeholders — and even some firms — argue that the total economic value of biodiversity, though useful for expressing previously ignored values of non-marketed BES within collective or public decision-making processes,

[3] One might question whether this is the appropriate terminology. Given the contingent nature of remarkable biodiversity, we would argue that it might be nothing more than biodiversity elements *noticed* by law and/or specific human communities/professional groups.

[4] Legitimacy is the key value of corporate social responsibility (Capron and Quairel-Lanoizelée, 2007; Schuman, 1995).

[5] Valuation techniques for BES may be grouped into four types (de Groot et al., 2002): (a) direct market valuation, (b) indirect market valuation (avoided cost, replacement cost, factor income, travel cost, hedonic pricing), (c) contingent valuation and (d) group valuation.

[6] The high substitutability between genetic resources underpinning this study has been criticized by Sarr et al., 2008.

is not sufficient in itself for arbitrage. Indeed, the social acceptability or legitimacy of a business activity is contingent to stakeholders' perceptions of the interactions between the (proposed) activity and specific BES components, in reference to a wide variety of value systems and social needs (Gobert 2008; e.g. empowerment strategies — Bacqué 2005; environmental justice — Schlosberg 2005). This is why Chevassus-au-Louis et al. (2009) argue that monetary values should be subordinates to others within debates pertaining to biodiversity conservation, notably when designing impact mitigation measures.[7]

3.3. Mitigating BES Loss: Options and Challenges

A no-net-loss five-stage approach is being promoted worldwide for impact mitigation, notably by the International Association for Impact Assessment (IAIA 2005) and the Business and Biodiversity Offsets Program (2009). It involves: (a) avoiding irreversible biodiversity loss (preventive action), (b) seeking alternative solutions to minimize loss, (c) restoring what can be restored or has been temporally degraded, (d) compensating for residual, unavoidable loss by providing substitutes of at least similar biodiversity value, and (e) seeking opportunities for enhancement of biodiversity values on-site and/or in areas nearby.

From this perspective, Trommetter et al. (2008) argue that three alternatives are available to firms for mitigating BES loss: (1) avoided or minimized mitigation, (2) self-realized mitigation and (3) externalized mitigation. Though this would depend on the country and its regulatory framework, any business could theoretically be subject to mitigation measures when proposing a project subject to environmental impact assessment; hence its need to arbitrate between the three aforementioned options, most likely according to the risks and costs contingent to each situation:

1. Avoided mitigation relates to operations carried out with no impact on biodiversity and ecosystem services used by other agents; which includes the option of project withdrawal. Minimized compensation relates to projects with impacts as minimal as possible on BES.
2. In the case of self-realized mitigation of unavoidable residual impacts, the firm may (a) buy land assets ecologically equivalent to what its project has destroyed, or (b) restore land assets, previously owned or specially acquired for that purpose, so as to meet ecological goals negotiated with stakeholders (generally public authorities).
3. Lastly, externalized mitigation relates to the demand for restored land assets under state regulation. The company may either (a) acquire ecologically equivalent areas restored by other organizations, (b) purchase BES units from a mitigation market according to the number of units required for mitigating its BES loss or (c) make a financial contribution — i.e. the calculated cost of purchasing and managing adequate BES offsets — to an appropriate (normally accredited) organization whose core mandate is BES conservation, management or restoration.

The third option — i.e. mitigation contracts between credit sellers and buyers within regulated markets — is potentially the most uncertain for business (Hallwood 2006):

> Actual/projected market price for mitigation credits may not be sufficient to cover production costs and secure a healthy margin/return on investment for potential mitigation bank investors and operators, while some firms may find (or perceive) performing avoided, minimized or self-realized mitigation less costly than buying credits on the market (Trommetter et al., 2008);
>
> There may be unexpected penalties or extra costs, for instance in case of mitigation site failure (Matthews and Endress, 2008);
>
> High transactions costs may result from burdensome administrative processes (Goldman et al., 2007);
>
> The lack of clarity/transparency as regards to the methods and indicators used for measuring ecological equivalency ratios and mitigation performance may prevent the rigorous assessment of net BES loss or gain, so that stakeholders might question mitigation measures (Fennessy et al., 2007).

Nonetheless, various market mitigation mechanisms have been implemented worldwide, for instance Wetland Mitigation Banks in the USA (Clean Water Act of 1972) and the Bush Broker Program in Australia (Madsen et al., 2010). Such initiatives hold several important implications for firms. First, they put a potentially prohibitive cost on BES destruction. This sends very important signals to firms and may encourage them to maximize avoided or minimized mitigation at the project design stage (preventive approach); for instance by seeking technological innovations which secure ecological continuities for linear infrastructure projects. Secondly, lands with high ecological (potential) values may become much more attractive than under normal circumstances: firms operating within mitigation markets may secure their long-term ecological viability through active management. Thirdly, economies of scale would push firms to restore habitats over large connected areas rather than on isolated sites, so that mitigation markets may allow the private sector to contribute to biodiversity conservation programs coordinated by public authorities over entire bioregions or watersheds (Latimer and Hill, 2007; Madsen et al., 2010; e.g. in France, CDC Biodiversité is restoring habitats for threatened species on land assets connected to pre-existing state conservation areas[8] so as to sell biodiversity credits to developers).

Expanding mitigation mechanisms to a wide variety of ES (beyond remarkable biodiversity elements) may become a standard for environmental policy worldwide. It would probably involve the supply of various BES units from the same land assets, also known as credit stacking (e.g. Willamette Partnership 2009). Although this could become a powerful tool for ensuring the financial viability of mitigation projects/banks, methodologies for ensuring the ecological additionality of stacked payments will need to be developed so as to avoid double counting (Bianco et al., 2009; Cooley and Olander, 2011). Indeed, to become scientifically and socially-accepted worldwide (e.g. US wetland mitigation banking has failed to ensure the no-net-loss of wetlands[9]; Matthews and Endress, 2008; Burgin 2010) and, hence, a secure mitigation option for firms, market mitigation mechanisms need to incorporate:

> Institutions and regulation mechanisms as independent (from both administrations and market operators) and objective (e.g. for validating equivalency ratios and compliance control) as possible (Chevassus-au-Louis et al., 2009);
>
> Consensual and publically-available methodologies for equivalency ratios (BES offsets/BES loss) which (aim to) secure the spatiotemporal efficacy of mitigation measures[10] (Burgin 2008; Dunford et al., 2004; Faber-Langendoen et al., 2008; Fennessy et al., 2007; Llewellyn 2008; Quétier and Lavorel, 2011; Roach and Wade, 2006).

In effect, the business community is facing increasing risks worldwide with respect to their BES impacts. Mitigating them is becoming relevant to (a) an increasing number of business activities and (b) over a much wider scope than that of standard environmental impact

[7] According to Bas and Gaubert (2010), there are two distinct approaches for assessing the spatiotemporal dimensions of mitigation sites: (a) methodologies based on equivalencies (service–service and resource–resource approaches) and (b) those based on values (the value–value approach, which can include both monetary and non-monetary values; and the value–cost approach, using exclusively monetary information).

[8] http://www.cdc-biodiversite.fr/files/Plaquette_Cossure.pdf.

[9] Wetland mitigation banking would need to better take wetland complexity and heterogeneity into account (Holl et al., 2003; Raffini and Robertson, 2005; Zedler and Callaway 1999).

[10] Equivalency ratios need to be based on the probability of success of effective ecological restoration (Moilanen et al., 2009; Robb 2002).

Table 1
Business strategic challenges regarding their dependencies and impacts on biodiversity and ecosystem services (BES).

Business dependencies on BES		Business impacts on BES	
Managing BES sources, delivery channels, timing of delivery and benefits to business		Managing stakeholders' concerns, from liability avoidance, legal compliance to voluntary action	
Challenge 1: securing BES benefits contributing to production processes/sales	*Challenge 2*: avoiding BES dis-services and associated costs	*Challenge 3*: assessing and managing legal responsibilities regarding BES (e.g. Nagoya Protocol on access and benefits-sharing for genetic resources)	*Challenge 4*: mitigating impacts on BES components of cultural and/or economic significance to stakeholders

assessments. This is partially because current impact mitigation strategies do not cover all business impacts on BES (Hanson et al., 2008; Houdet, 2008a,b; TEEB for Business 2010): stakeholder pressures increasingly target indirect impacts linked to supply chains or clients (e.g. retailers, financial services industry, Mulder and Koellner, 2011). What's more, business strategies regarding BES are not limited to the management of stakeholders' concerns as regards to business-induced biodiversity loss. For instance, various business initiatives attempt to address access and benefit-sharing issues (Nagoya Protocol) related to genetic resources (e.g. SECO 2007). In other words, firms are starting to understand that ecosystem services are the benefits they derive from ecosystems, which brings about new risks and opportunities.

4. Interdependencies between Business and Biodiversity: Emerging Strategies and Research Needs

4.1. Business also Depend on BES: What This Means for Risks and Opportunity Analysis

Many studies have tried to identify and classify biodiversity risks and opportunities (ISIS 2004; Mulder 2007; Tucker 2006), essentially in terms of regulations (liability, taxation), industrial standards and norms, stakeholders' pressures and expectations, corporate image or reputation, evolution of customers' needs and wants (market risk), operations management (accidents, availability and costs of resources) and cost of capital (financing, insurance and investment risks; UNEP FI 2008). More recently, various organizations have attempted to help companies understand the importance of biodiversity by making them aware of their dependencies on healthy ecosystems and specific ecosystem services. For instance, a step-by-step, a procedural methodology for identifying business risks and opportunities with respect to ecosystem change has been recently developed by the World Business Council on Sustainable Development, the Meridian Institute and the World Resources Institute (Hanson et al., 2008). It helps business assess its dependencies and impacts on priority ecosystem services so as to help the firm develop new strategies, gain competitive advantage or reduce/avoid costs.

Business perceptions, attitudes, behaviors and strategies regarding BES are hence progressively changing, as further illustrated by the European Platform Biodiversity Research Strategy (EPBRS) meeting and e-conference on 'Biodiversity and Industry' in October–November 2008 (Grant et al., 2008) and the work undertaken by the *Orée* — Institut Francais de la Biodiversité[11] Working Group on business and biodiversity (about 20 case studies on interdependencies between business & BES available in Houdet, 2008a,b; business and biodiversity interdependency indicator — Houdet 2008b). Firms can no longer exclusively consider biodiversity as an external constraint on their activities (impact mitigation approach; Section 3). They are becoming increasingly aware that they are managing (or that they need to manage) the ecosystem services which influence their activities: i.e. managing dependencies on BES is embedded into their organizational routines (Table 1). On the one hand, they seek to secure benefits (quantity, quality, delivery timing, costs) contingent to desired ES (e.g. raw biological materials with unusual attributes in the cosmetics industry, water with specific mineral content for mineral water producers), by managing the spatial and temporal dimensions of their availability (sources/origins, diffusion modes — trajectories, distance). On the other hand, firms would seek to avoid any form of negative impacts (e.g. damages to assets — climatic event, disruptions to production processes via the decrease in the quantity and/or quality in ES benefits effectively) linked to the changes in ecosystem functions and processes affecting their activities («*ecosystem dis-services*»; Zhang et al., 2010).

Thinking in terms of interdependencies with BES allows firm to better assess their internal (e.g. critical success factors) and external (e.g. opportunities, constraints/pressures, market positioning) strategic diagnosis. This would help them to identify their *ecological infrastructure* — i.e. all their interactions with BES — so as to precisely target key links which need to be closely managed or developed towards maintaining or improving their competitive advantage.

However, for firms to fully internalize negative BES externalities, we need to emphasize the critical importance of tangible monetary flows (expenses, revenues, investments, liabilities and contingent liabilities) so as to influence decision-making. The economic valuation of BES via aforementioned methods (Section 3.2) would thus often fail to generate required changes in corporate behavior because they do not to directly influence critical success factors such as specific product pricing requirements (i.e. no monetary inflows or outflows): firms would merely seek assess the return on investment of investment/project alternatives, making sure (at best) that the maintenance of specific BES components (legal compliance, voluntary actions targeting legitimate stakeholders) would not affect the viability of their venture (e.g. minimizing costs of impact mitigation measures). In other words, for business to systematically and rigorously integrate BES concerns into their strategies and operations, (a) BES degradation/loss needs to imply immediate and tangible costs while (b) changes in business practices required for biodiversity conservation and sustainable uses of ES need to become financially viable (accounting for opportunity costs).

Without robust, clear and socially equitable institutions for managing interactions between agents (firms, consumers, states) regarding BES (dependencies/uses, impacts), only pressures from stakeholders (e.g. local communities, NGOs) would likely be able to influence business practices to some extent (e.g. emergence of corporate leaders, creation of niche markets). This is why payments for ecosystem services present both opportunities and challenges for the business community (Section 4.2), while appropriate sets of indicators at different scales are warranted for the effective management of their BES dependencies and impacts (Section 4.3).

4.2. Payments for Ecosystem Services: Opportunities and Challenges

As previously argued (Section 3.3), mitigation measures may lead to the remuneration of the supply of ecosystem services within regulated markets. This may be correlated to relatively recent research and schemes with respect to remunerating economic agents for practices linked to the delivery of specific ecosystem services, including those

[11] Now Fondation pour la Recherche sur la Biodiversité.

Table 2
Market mechanism options for biodiversity and ecosystem services (adapted from Parker and Cranford, 2010).

	Beneficiaries pay	Polluters pay
Ecosystem services	Direct PES Beneficiary pays for ES that flow to them. ES are not wholly public, but can be captured to some degree by paying beneficiaries (bilateral arrangements — e.g. payments for watershed services) Indirect PES Consumers of final goods and services pay a premium for the sustainable ecosystem management practices up in the supply chains (e.g. organic food)	ES markets Polluter pays for damage they have done by buying an offset/credit. The beneficiaries are the population that receive the ES and are usually different from the population that is paying (bilateral/market arrangement — e.g. water quality trading, forest carbon)
Biodiversity	User fees Beneficiary pays for access to/use of in situ biodiversity. Direct use biodiversity benefits accrue to those who pay for access (single payments — e.g. eco-tourism, hunting licenses)	Mitigation markets Developer pays for damages they have done to biodiversity (habitats, species) by buying an offset/credit (bilateral/market arrangement e.g. biodiversity offsets/banks, tradable fishery quotas)

that contribute directly to another business activity (Barbault 2006; Perrot-Maître 2006) and those which are linked to the provision of public goods (biodiversity conservation, CO_2 sequestration) (Table 2). Provided ecosystem services are identified and their benefits to economic agents evaluated, the focus would be on measuring their maintenance costs and the associated financing mechanisms; the latter including at least three (potentially complementary) options: (a) payments by public authorities, (b) payments by direct beneficiaries of BES and (c) payments by consumers of final goods and services (Trommetter et al., 2008).

Direct compensation payments have been proposed with respect to *in-situ* agro-biodiversity conservation (Boody et al., 2005; Hackl et al., 2007; Pascual and Perrings, 2007; Perrings et al., 2009). When a farmer shifts to non-productive land uses which may be favorable to biodiversity (at least to certain functional groups; Burel et al., 2008), several options do exist for financing these changes:

1. State intervention, through subsidies, is justified on the ground that BES are undersupplied public goods. This is particularly relevant within the context of the multi-functionality of European agriculture and the reform of the Common Agricultural Policy and somewhat akin to conservation easements in the USA where the focus is on preventing economic agents from doing something (e.g. change in land use) through contractual agreements (Gustanski and Squires, 2000; Merenlender et al., 2004).
2. A complementary mechanism may see consumers paying a premium for goods and services which are produced according to practices or standards which protect or restore BES, as (supposedly) in the case of organic farming and eco-tourism (e.g. labeling and certification schemes; Angeon and Caron 2008). In such a context, BES maintenance (supply) costs are internalized into the prices of goods and services, though it remains unclear (a) under which institutional conditions business practices favorable to biodiversity may or may not be more costly than practices leading to biodiversity loss[12] and (b) whether consumers would accept to pay for such (potentially more expansive) goods and services (demand uncertainty).
3. Similarly, certain business transactions between firms can be understood as payments for ecosystem services: firms may undertake practices (action or inaction) which deliver specific (levels of) ecosystem services and be paid by beneficiaries. In the case of Vittel (a mineral water firm in France; Déprés et al., 2008; Perrot-Maître 2006), the company pays farmers for practices which go beyond legal requirements in terms of water quality, as excessive nitrate concentrations due to fertilizer use could lead to the (temporary or definite) closure of its water bottling plant. This approach is allegedly valid up to the point it becomes more expensive for the firm than an artificial alternative which would substitute the ecosystem service in question: e.g. a water treatment plant in the case of Vittel so as to capture nitrate particles (which is impossible because it is illegal to sell treated water in France…).

The generalization of payments for ecosystem services (PES) seems highly appealing. Combining[13] strategies for mitigating BES loss (Polluter or Impacter Pays Principle — OECD 1975; SLWRMC 1999) and remunerating BES supply (Beneficiary Pays Principle — Aretino et al., 2001; Hackl et al., 2007; Pascual and Perrings, 2007; linked to some extent to the Victim Pays Principle — Siebert 1992) opens the door to new forms of arbitrage with respect to land use and development, as well as core business processes and practices. This approach sees BES provision becoming an integral part of the business plan of the firm, first as a strategic core variable among others for decision-making and management (beyond impact mitigation) and, perhaps more importantly, as a source of (a) new assets and liabilities (BES trading rights and/or contractual agreements), (b) new skills or competencies (e.g. biodiversity skills in the Finnish forest industry; Wolf and Primmer, 2006), as well as (c) technological (e.g. using living systems as ecosystem engineers; Byers et al., 2006; Hastings et al., 2007) and organizational innovations. The development of markets for BES may hence lead to major changes in business routines, practices, intra- and inter-organizational norms and organization of the workplace.

However, for firms to fully embrace markets for BES, numerous uncertainties will need to be resolved. For an efficient sharing of BES advantages (Perrings et al., 2009; Pascual et al., 2010), we would need to clarify the level of excludability and rivalry of such ES by beneficiaries and providers, to make sure there would be sufficient demand or willingness to pay for such services by the beneficiaries, to delineate and enforce clear regimes of rights surrounding land use and ecosystem services and invest in social capital to foster collective action and cohesion between the providers and beneficiaries of ecosystem services. To those challenges, we may add those relating to defining ecosystem boundaries, including spatial and temporal relationships across different scales between economic agents as regards to dependencies and impacts on BES: several ecosystems may exist within a larger one and their boundaries may expand and contract over time in response to various drivers of change, including anthropogenic influences. What's more, the precise tracing — if ever possible — of ES from their source (s), which may be discrete, ambient or variable, to their ultimate user (s) (point, diffuse, or spotty) is likely to be required in many circumstance, and may further necessitate identifying service provision timing, delivery channels, distance delivery, and delivery timing (Ruhl et al., 2007). That that end, further research into the vertical and temporal stacking of payments for ecosystem services (Bianco et al., 2009; Cooley and Olander, 2011) as well as pro-biodiversity incentive design (Zabel and Roe, 2009) may provide some clues on how to make such mechanisms work from an ecological, social and economic perspective.

[12] When comparing the evolution of labor costs with input costs, organic farming could be economically more efficient under certain conditions (Roger-Estrade et al., 2008).

[13] Iftikhar et al. (2007) provide some preliminary thoughts on inter-linkages among and between Compensation and Rewards for Ecosystem Services (CRES) and human well-being, with a special focus on its implications for poor communities.

4.3. Towards Standardized Sets of Indicators for Managing BES Dependencies and Impacts

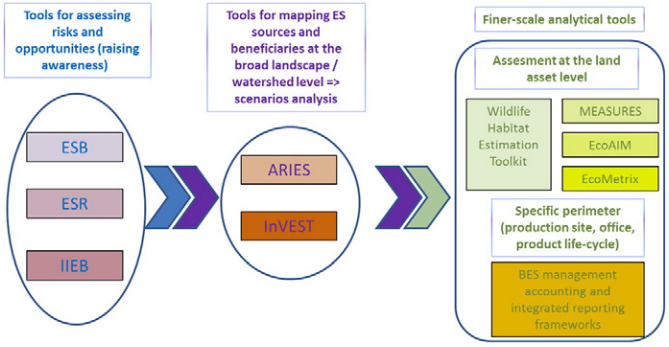
Managing ecosystems for specific ecosystem services, especially those which generate higher returns on investment, may lead to unforeseen ecosystem change, degradation or even collapse. For instance, managing biomass and productivity of tree plantations to maximize CO_2 sequestration leads to diminished stream flows, increased soil salinization and acidification (Jackson et al., 2002). Though recent efforts have focused on designing institutional mechanisms which would remunerate the provision of various ES (CO_2 storage essentially) while conserving biodiversity (e.g. REDD/REDD + proposals; Gibbs et al., 2007; Miles and Kapos, 2008; Mollicone et al., 2007; Swingland 2002), one may argue that such situations (i.e. relatively unexploited tropical forests) are more the exception than the rule. In other words, the key challenge lies in developing cost-effective BES market mechanisms in areas where business activities are relatively diverse and intensive; while ensuring that the underlying objective clearly remains ecosystem health maintenance or restoration (e.g. ensuring the ecological additionality of stacked payments for ES; Bianco et al., 2009; Cooley and Olander, 2011). From this perspective, BES market mechanisms are unlikely to cover the complete spectrum of interactions between businesses and BES (impacts and dependencies), hence the need to promote research on the development of standardized sets of indicators/measurement protocols for BES impacts and dependencies at all relevant scales.[14]

Houdet (2010) exposes that two complementary approaches are being currently explored to that end. On the one hand, existing environmental or sustainability tools are being improved at the production, organizational (information systems for decision-making) and institutional (tools for engaging external stakeholder) levels. These include impact assessment procedures and offset measures (Briand 2010; Köllner 2000; BBOP case studies: Anglo Platinum 2009, Solid Energy New Zealand Limited 2009), environmental management systems (e.g. case studies in Houdet, 2008a,b), life-cycle assessment methodologies (e.g. supply chain impacts of food products — Jeanneret et al., 2008), product labels or certification schemes (e.g. BES criteria for the Forest Stewardship Council), and sustainability reporting guidelines (GRI 2006; Houdet, 2008a,b; Houdet et al., 2010; Jones, 2003; Jones and Matthews, 2000). On the other hand, various organizations have been developing tools directly addressing BES issues[15] (Table 3). These comprise:

(a) tools for raising BES awareness (e.g. ESB — Ecosystem Services Benchmark, ESR — Ecosystem Services Review, BBII — Business & Biodiversity Interdependency Indicator),
(b) tools for mapping ES at the broad landscape level for scenario analysis purposes (e.g. ARIES — ARtificial Intelligence for Ecosystem Services, InVEST — Integrated Valuation of Ecosystem Services and Tradeoffs) and
(c) tools used for finer-scale assessments at the land asset level (e.g. EcoAIM — Ecological Asset Information Management; EcoMetrix; MEASURES — Model Ecosystem Services Credit Calculator; Wildlife Habitat Benefits Estimation Toolkit) or for specific business perimeters (e.g. BES management accounting framework — Gonzalez and Houdet, 2009; Houdet, 2010; Houdet et al., 2009; integrated BES — financial reporting framework for external stakeholders — Houdet, 2010; Houdet et al., 2010).

While these various types of BES tools may be complementary for firms to gradually incorporate BES concerns within their activities, most are in various stages of development (with limited external assessment of their effectiveness) and cannot be easily imbedded into business decision-making tools and processes (Waage et al., 2010). Besides, they do not constitute standardized and widely-recognized tools for measuring BES impacts and dependencies (e.g. some focus exclusively on ES valuation for trade-off purposes such as InVEST or EcoMetrix) (Houdet, 2010). From the perspective of working towards standardized measurement protocols for the latter, developing (1) a BES management accounting framework — which builds upon conventional environmental management accounting guidelines (targeting internal stakeholders for decision-making) — and (2) a BES — financial integrated reporting framework — which builds upon both financial accounting and sustainability/integrated reporting standards (accountability to external stakeholders) — represent exciting challenges. Indeed, they target core business information systems.

Table 3
The different types of BES tools for business (adapted from Houdet, 2010; Waage et al., 2008, 2010).



5. Conclusion

Biodiversity is usually understood as a new, additional form of external environmental constraint on business activity within the context of the environment — competitiveness debate. It is linked essentially to regulatory frameworks overseeing where and how businesses can operate, chiefly through the appraisal of new projects. Conventional business strategy amounts essentially to minimizing the costs of identifying, assessing, monitoring and mitigating their BES impacts, especially on their components protected by law or those important to legitimate stakeholders. From this perspective, capturing the marginal economic value of biodiversity and ecosystem services has been argued to be critical for cost–benefit analyses (trade-off purposes). Yet, despite numerous efforts, BES may not easily be translated into monetary proxies: stakeholders increasingly argue that the total economic value of biodiversity, though useful, is not sufficient for arbitrage. This is why mitigation mechanisms based on a no-net-loss approach are actively being promoted worldwide, with research highlighting the need for clarifying methods for measuring ecological equivalency ratios and offset performance so as to be able to effectively assess net BES loss or gain.

While impact mitigation mechanisms are central to business strategies regarding BES, they tend to restrict business perceptions of its interactions with ecosystems to the costs of managing their negative BES impacts. This is why various organizations have recently attempted to help companies understand the importance of biodiversity by making them aware of the risks and opportunities linked to their dependencies on healthy ecosystems and specific ecosystem services. As a result, business attitudes, behaviors and strategies regarding biodiversity are progressively changing: biodiversity is increasingly associated to key raw materials, products sold or sources of new technologies. This suggests

[14] Decision X/21 on Business Engagement at CoP 10 of the CBD highlighted the need to encourage the establishment of a forum of dialogue among parties so as to increase the awareness of existing BES tools, develop new ones, monitor their effects and learn from business experiences.
[15] This does not include general business guidelines for using economic valuation methodologies for trade-off purposes (e.g. WBCSD et al., 2011).

the emergence of business strategies and practices which could go beyond impact mitigation and the search of a compromise between development and conservation. Combining strategies for mitigating BES loss (Polluter Pays Principle) and remunerating BES supply (Beneficiary Pays Principle) opens the door to new forms of arbitrage with respect to land use and development, as well as core business processes. This approach may see BES maintenance or provision becoming an integral part of the business plan of the firm, as a core variable among others for decision-making and management and as a source of new assets, liabilities, skills, technological and organizational innovations. Provided that regime of rights regarding BES are clearly defined and enforced, the development of markets for BES may lead to major changes in business methods, routines, intra-organizational norms and organization of the workplace.

Yet, compensating, subsidizing or paying for specific BES delivery is unlikely to cover the complete spectrum of interactions between businesses and BES. Besides, ecological and social risks associated with managing ecosystems exclusively for a single ecosystem service should be taken systematically into account when designing markets for BES, hence the need for standardized sets of measurement protocols for BES impacts and dependencies at different scales. Recent research on designing BES tools for business is promising but more research is warranted, especially with respect to embedding BES indicators into core decision-making processes of companies, such as their accounting information systems.

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