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Biodiversity loss and financial stability: a new frontier for central banks and financial supervisors?

Central banks (in particular the Banque de France and the European Central Bank) have played a leading role in taking into account the economic and financial issues of climate change. In addition to climate-related issues, the scientific community is also sounding the alarm about the impact of human activities on biodiversity and is speaking of a dangerous and accelerating decline. The losses of ecosystem services resulting from this collapse and the socio-economic changes required in response could generate major economic and financial risks. However, less headway has been made in understanding these risks than in the case of climate change. A framework and methodology therefore need to be established to analyse the risks associated with biodiversity loss. Recent studies estimating the financial system's dependencies on ecosystem services and its biodiversity footprint are first steps in this direction. However, new conceptual and methodological approaches are still needed.

Mathilde Salin, Romain Svartzman, Lisa Biermann, Renaud Concordet*, Léa Grisey and Erlan Le Calvar
Financial Stability Directorate
Climate Change Centre (CCC)

* At the CCC at the time of writing.

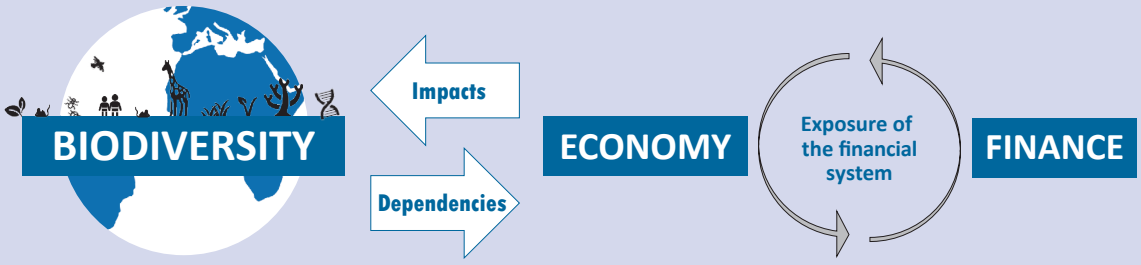
JEL Codes
D81, Q51, Q57

42%

the share of the value of securities held by French financial institutions issued by companies that are deemed highly or very highly dependent on at least one ecosystem service
▸ Dependency

The securities considered in the paper by Svartzman et al. (2021) include bonds and equities issued by non-financial corporations and held by French financial institutions, chiefly investment funds, insurers and banks.

Dependencies on ecosystem services and biodiversity impacts – a first step towards assessing biodiversity-related risks for the financial system



Source: Svartzman et al., 2021.
Note: Ecosystem services are defined as the direct and indirect services that humans obtain from nature.

1 Biodiversity loss is still relatively poorly acknowledged but represents a challenge to our socioeconomic systems

Accelerated decline in biodiversity due to human activity

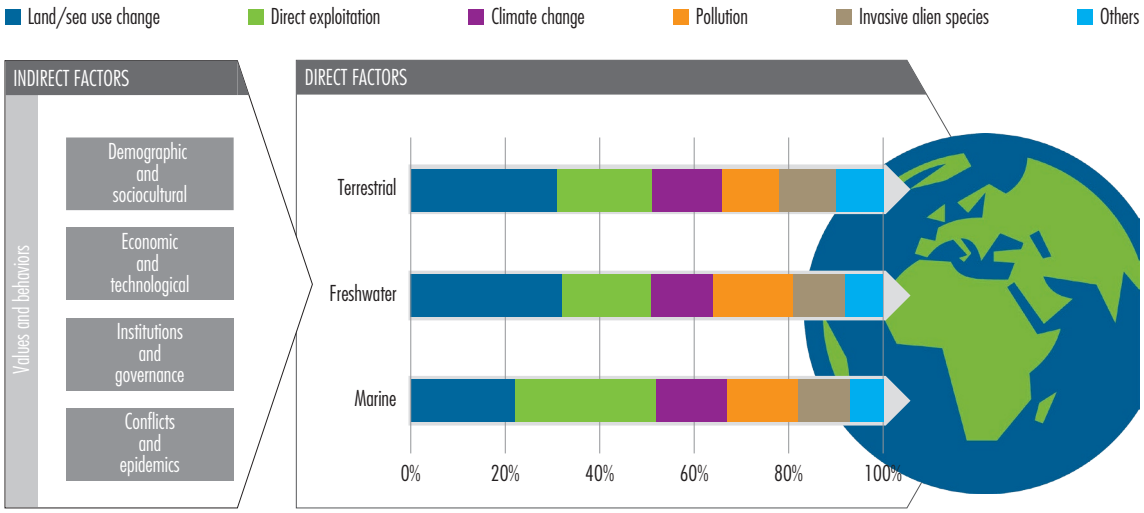
Biodiversity is the living fabric of our planet. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2019) defines biological diversity as "the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part. This includes diversity within species, between species and of ecosystems".

Human activity is causing a rapid loss of biodiversity (IPBES, 2019), which is threatening "Earth's ability to support complex life" (Bradshaw et al., 2021). The global rate of species extinction is already between tens to hundreds of times higher than it has averaged over the past ten million years and is accelerating (IPBES, 2019). Biologists believe that we are currently entering Earth's sixth mass extinction. The last one occurred 65 million years ago (Ceballos et al., 2015). Ecosystem and habitat diversity has also been severely affected. Old-growth forests, insular ecosystems and wetlands are particularly at risk (IPBES, 2019).

Human activity is directly and indirectly responsible for the collapse in biodiversity. Globally, there are five main direct drivers of change. Starting with those with greatest impact, they include changes in land and sea use, direct exploitation of organisms, climate change, pollution, and invasion of alien species (see Diagram 1). These direct drivers result from an array of indirect drivers that include consumption, production and trade patterns as well as technological innovations.

As a result, though it has received less attention than climate change, biodiversity loss is starting to feature more prominently on the international policy agenda. The next major event is the 15th meeting of the Conference of the Parties (COP 15) to the Convention on Biological Diversity, which will be held in April-May 2022 in Kunming, China. The gathering is expected to adopt a global biodiversity framework for the 2021-2030 period, with targets set in three broad areas: (i) reduce the threats to biodiversity, notably by protecting at least 30% of land, freshwater and marine areas by 2030; (ii) ensure that biodiversity benefits are used in a

D1 Direct and indirect drivers of biodiversity loss



Source: IPBES (2019), adapted by authors (images: icons8).

sustainable and shared way to meet people's needs; and (iii) put in place operational tools and solutions and promote biodiversity mainstreaming.

Biodiversity loss creates socioeconomic risks: the standard economics approach

The risks posed by biodiversity loss to human societies could be at least as significant as those posed by climate change and might also interact with those risks (IPBES and IPCC, 2021 – see also Appendix 1). The pressures that mankind is bringing to bear on biodiversity have already begun to affect the ability of nature and ecosystems to provide many services. Crop yields are declining owing to biodiversity loss (IPBES, 2019), while human health is being affected at numerous levels by worsening water and air quality, and by more frequent and intense flooding and fires (Bradshaw et al., 2021).

These effects are set to grow, with many hard-to-measure indirect impacts potentially entering into play. Scientists are warning of an increased likelihood that future pandemics will "emerge more often, spread more rapidly, kill more people, and affect the global economy with more devastating impact than ever before", owing to "human activities and the impacts of these activities on the environment" (IPBES, 2020).

Under the standard economics approach to biodiversity, there is considered to be a stock of "natural capital" that produces flows of "ecosystem services". Biodiversity, which is a characteristic of natural capital, is treated as an enabling asset, i.e. an asset that confers value to natural capital (Dasgupta, 2021). Ecosystem services are grouped into three main types: (i) provisioning services, such as food, fuel and drinking water; (ii) regulating and maintenance services, such as pollination, climate stability, air quality and erosion control; and (iii) cultural services, such as tourism and spiritual values linked to nature. These services are maintained by basic ecological functions, such as material cycles (e.g. water and carbon cycles), photosynthesis, soil formation, and ecological interactions within ecosystems.

Under this approach, the value of the stock of natural capital or of ecosystem service flows may be estimated from a utilitarian perspective and converted into monetary units using a variety of valuation methods. For example, in their update of a well-known paper, Costanza et al. (2014) estimate the global value of ecosystem services at USD 125 trillion/year, or approximately 1.5 times larger than global GDP at the time when the paper was written. Integrated economy/ecosystem services models have also begun to emerge recently and could give rise to macroeconomic analyses of the importance of biodiversity.

Yet despite this, identifying the economic losses linked to biodiversity loss, and hence the related financial risks, remains a tricky task. This is especially true for extreme risks (such as a loss of ecosystem services), which could have dramatic consequences given the vital and irreplaceable nature of the services in question.

2 Biodiversity loss: financial risks and the methodological challenges involved in measuring them

Recent and rapidly growing awareness

The financial community has recently begun looking at the economic and financial consequences of biodiversity loss, particularly in the wake of a series of studies prepared by the public and international sector (OECD, 2019), civil society (Finance Watch, 2019) and the private sector (Finance for Biodiversity, 2021), or through collaborations among these sectors, as in the case of the Taskforce on Nature-related Financial Disclosures (TNFD – see Appendix 2). The academic community has also stressed the serious financial risks connected with biodiversity loss. The Dasgupta Review on the Economics of Biodiversity, for instance, devotes a chapter to the topic (Dasgupta, 2021).

Central banks are talking about the issue as well, including within the Central Banks and Supervisors Network for Greening the Financial System (NGFS), which set up a study group to look at the potential implications of biodiversity loss for financial stability.

BOX 1

Enhanced extra-financial reporting for investors: Article 29 of the Energy and Climate Act

Building on Article 173-VI of the Energy Transition Act of 17 August 2015, Article 29 of France's Energy and Climate Act No. 2019-1147 of 8 November 2019 increased financial institutions' environmental risk reporting obligations. In particular, Article 29 extended climate risk reporting requirements to include biodiversity-related risks.

The implementing legislation for this article was published on 27 May 2021 and enters into effect in 2022 for reporting in respect of fiscal year 2021. In addition, and pursuant to the treaties under the Convention on Biological Diversity, investors will be required to align their investment strategies with long-term biodiversity targets, in particular with reference to a new indicator, namely the biodiversity footprint. An example of such an indicator is presented in Part 3, which details the biodiversity impact (footprint) linked to the bonds and equities of non-financial corporations held by French financial institutions.

This group published a Vision Paper (NGFS and INSPIRE, 2021a) and an Interim Report[1] (NGFS and INSPIRE, 2021b) that set out the rationale for its work and key methodological issues. It will publish a final report in early 2022.

Some central banks have begun exploring the financial risks linked to biodiversity loss. In June 2020, De Nederlandsche Bank (DNB) published a report (van Toor et al., 2020) that provided an overview of the potential exposure of Dutch financial institutions to these risks. The report called on regulators to develop consistent measurement and reporting standards in this area. France, meanwhile, recently adopted novel regulatory provisions on reporting the financial risks linked to biodiversity loss with the publication of the implementing legislation for Article 29 of the Energy and Climate Act (see Box 1).

A framework for analysing the financial risks linked to biodiversity

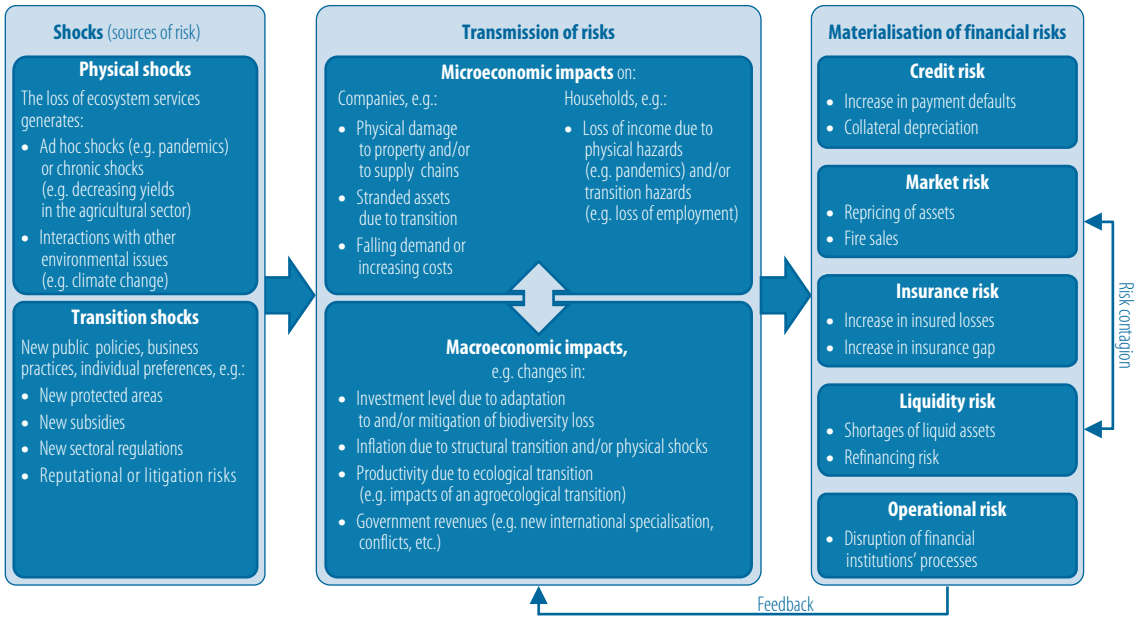
Just like climate-related financial risks, the financial risks linked to biodiversity can be organised into two categories (see Diagram 2 below): physical risks and transition risks (NGFS and INSPIRE, 2021a). Physical risks can be chronic (e.g. gradual decline in pollinators resulting in reduced crop yields) or acute (e.g. deforestation causes a zoonotic disease to emerge and develop into a pandemic). At scale, they can create geopolitical risks (notably through migration and conflict) that also represent threats to financial stability. Transition risks may be triggered when corporate assets and strategies are incompatible with policy or regulatory changes, such as a phase-out of subsidies that are harmful to biodiversity. They can also be caused by other factors, such as shifts in consumer preferences (e.g. changing diets) or the development of new technologies (e.g. that make it possible to replace products that are bad for the environment). Depending on their magnitude, the risks to which companies are exposed may translate into risks for their creditors and investors.

Methodological challenges involved in measuring the financial risks linked to biodiversity loss

To gain a better grasp of the economic consequences of biodiversity loss, it is necessary to understand how ecosystems work and how they interact with the economic system. A major difficulty lies in the complexity of the processes at work (Kedward et al., 2020), which the models and approaches described in the previous section fail to tackle adequately. One aspect of this complexity consists of the fact that, unlike in the case of climate change, where a common measurement unit

1 These two documents are occasional papers. They contribute to the work of the NGFS, but do not formally commit its members.

D2 Theoretical framework to analyse the financial risks linked to biodiversity



Source: Svartzman et al., 2021.

(ton of CO_2 equivalent) can be used to summarise effects, "it is illusory to hope that biodiversity might be described using a single indicator" (Chevassus-au-Louis et al., 2009). Another issue involves the non-linearity of these effects and the uncertainty associated with them; while there is a consensus that crossing critical ecological thresholds may lead to catastrophic and irreversible results, it is hard to predict exactly where these tipping points lie (Hillebrand et al., 2020). Dasgupta (2021) stresses the point that these dynamics could give rise to "green swans", i.e. potentially systemically important financial risks triggered by socioecological dynamics (Bolton et al., 2020a and 2020b; Svartzman et al., 2020).

Another challenge when assessing biodiversity/economy linkages concerns the substitutability of ecosystem services. Most biodiversity/economy models do not factor in the non-substitutability of natural capital and take a "weak sustainability" approach (Dietz and Neumayer, 2007): here, all that matters is whether overall capital (measured in monetary terms) increases; loss of natural capital is significant only insofar as it threatens the accumulation of physical and human capital. Conversely, under a strong sustainability approach (Dietz and Neumayer, 2007), an increase in manufactured or human capital cannot – or can only very partially – replenish existing stocks of natural capital. Put another way, the depletion of natural capital and ecosystem services in a world where biodiversity is collapsing cannot be offset by increased revenue, or if so only to a very limited degree: "If the biosphere was to be destroyed, life would cease to exist" (Dasgupta, 2021).

3 Estimating biodiversity-related financial risks: France's example

Estimating the financial system's dependencies and impacts: a necessary first step towards risk analysis

The methodological challenges described above underline the difficulties in predicting future shocks and their transmission to economic agents, yet this is an essential step in measuring new environmental risks (that are thus not reflected in historical data). Against this backdrop, researchers from the Banque de France, the French Office for Biodiversity (OFB), the French Development

Agency (AFD) and CDC Biodiversité (Svartzman et al., 2021) employed two DNB methodologies (van Toor et al., 2020):

- To approximate physical risks, the authors measure the dependencies on different ecosystem services (see Diagram 3) of companies whose securities are held by French financial institutions. These dependencies constitute an indicator of exposure to a potential physical "shock" linked to biodiversity, assuming that the more a firm's output depends on certain ecosystem services, the greater the likelihood that this production will be affected if the provision of these services is disrupted (physical shock). It follows from this that a portfolio containing securities issued by companies exposed to physical risk is itself exposed to physical risk;

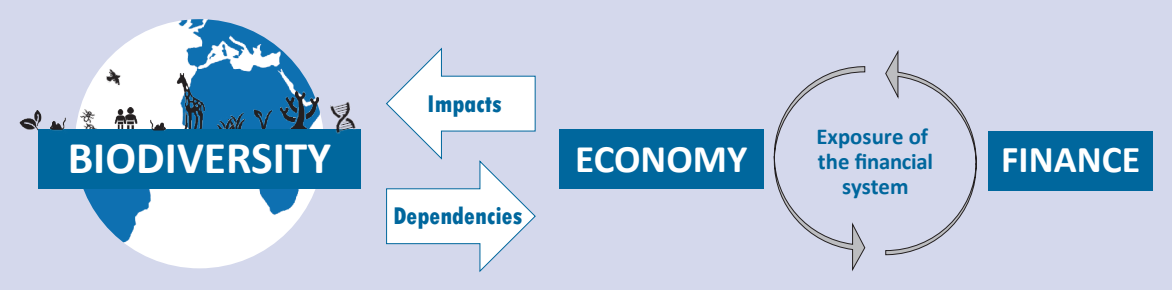
- To approximate transition risks, the authors measure the biodiversity impact (or footprint) of companies whose securities are held by French financial institutions through their direct activities or their upstream value chains (see Diagram 3). The more a company's negative impact on biodiversity increases, the more likely it is that the firm will be affected by measures to protect biodiversity (transition shock). It follows from this that as the biodiversity impact of a securities portfolio increases, so the portfolio's exposure to transition risk also goes up.

The research work, whose initial findings are summarised below, was presented in a working paper (Svartzman et al. [2021], "A 'silent spring' for the financial system? Exploring biodiversity-related financial risks in France", *Working Paper*, No. 826, Banque de France, August). This work seeks to assess the dependencies on ecosystem services and the biodiversity footprint of securities (equities and bonds) issued by and bonds) issued by companies and held[2] by French financial institutions at end-2019. The dependency and impact metrics are described in Box 2.

Ecosystem service dependencies in the portfolio of French financial institutions

When looking at direct (scope 1) business dependencies,[3] Svartzman et al. (2021) found that 42% of the value of the securities held at end-2019 by French financial institutions (chiefly funds, insurers and, to a lesser extent, banks) came from issuers that were highly or very highly dependent on at least one ecosystem service. This finding is consistent with the results obtained by van Toor et al. (2020) in their analysis of the Netherlands financial system. Meanwhile, 9% of securities held were issued by companies that were very highly dependent on at least one ecosystem service. The main ecosystem services involved were water supply (surface and ground) and regulatory services, such as erosion control, flood and storm protection and climate regulation.

D3 Analysis of dependencies on ecosystem services and biodiversity impacts



Source: Svartzman et al., 2021 (images: icons8).
Note: Ecosystem services are defined as the direct and indirect services that humans obtain from nature.

2 Amounts taken from the European Central Bank's Securities Holdings Statistics by Sector (SHSS).

3 Scope 1 refers to the impacts or dependencies of companies' direct operations, i.e. those related to their actual production, without including the impacts or dependencies of their suppliers or customers.

BOX 2

Dependency and impact metrics

Dependency on ecosystem services

The direct dependencies of 86 business processes[1] on 21 ecosystem services available in the ENCORE[2] database are described by level of dependency, which ranges from "very low" to "very high". For example, the "large scale arable crops" business process is highly dependent on the "water supply" ecosystem service (among others). Dependencies are converted into scores ranging from 0% (not dependent) to 100% (extremely dependent).

Biodiversity impact

The model used (BIA-GBS, developed by CDC Biodiversité and Carbon4 Finance) assesses the biodiversity footprint (or impact) using a simple metric: MSA.km². Mean species abundance (MSA) describes the mean abundance of species in a given ecosystem relative to their abundance in the same ecosystem that is not disturbed by human activity. It ranges from 0% (completely destroyed ecosystem) to 100% (pristine ecosystem). MSA.km² integrates MSA with the surface area and is read as follows: *x* MSA/km² is comparable to the loss of *x* km² of pristine nature.

1 Processes defined in the ENCORE database (see next footnote) for the primary, secondary and tertiary sectors.

2 Database developed by the Natural Capital Finance Alliance and the UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC).

However, Svartzman et al. (2021) point out, with reference to the scientific literature, that all economic activities are dependent in one way or another on ecosystem services. Examining dependencies on ecosystem services stemming from the value chain (upstream)[4] they found that all companies in the portfolios under review were at least weakly dependent on all ecosystem services. Considering both scope 1 and upstream dependencies, the authors found that companies whose business was based directly or indirectly on agricultural production (e.g. in the agrifood sector) tended to depend on many ecosystem services.

Biodiversity footprint of French financial institutions

Svartzman et al. (2021) estimate that, through the companies financed, the terrestrial biodiversity footprint cumulated over time[5] of the equity and bond portfolio of French financial institutions at end-2019 was comparable to the loss of at least 130,000 km² of pristine nature, which corresponds to the complete artificialisation of 24% of the surface area of metropolitan France. On average, EUR 1 million of securities from the portfolio has a biodiversity footprint that is comparable to the complete artificialisation of 0.13 km² of pristine nature (equivalent to 16 football pitches). This result is close to that obtained by the DNB (van Toor et al. [2020] who obtain an artificialisation of 0.18 km² per million euros). However, as discussed in more detail in Svartzman et al. (2021), due to the differences in the methodologies used and in the scope of the analysis, the results of each study need to be put into context in order to compare them in a meaningful way.

Land use is the main factor of biodiversity pressure accounting for these results. Various economic sectors contribute to this footprint, including chemicals and gas production, manufacturing of dairy products and food products processing. Their impact stems primarily from scope 3 (upstream) dependencies, with relatively little impact from scope 1 (direct) dependencies.

In addition to the cumulative (or static) impact, the portfolio of securities analysed has, through the constituent companies, an additional annual (or dynamic) terrestrial biodiversity impact comparable to the loss of 4,800 km² of pristine nature, corresponding to the complete artificialisation of an area 48 times greater than that of Paris. These results are primarily attributable to the pressure exerted by

4 Upstream refers to the value chain upstream of the company's production, i.e. the impacts or dependencies of suppliers. This includes what is known as scope 2, which relates to direct energy suppliers, and scope 3 upstream, which relates to suppliers of non-energy inputs, whether direct or indirect (suppliers of suppliers). Upstream is to be distinguished from downstream, which covers the impacts or dependencies of the company's customers, located downstream in the value chain. The latter are not covered by the study by Svartzman et al. (2021).

5 This footprint is called "static", as opposed to the "dynamic" footprint described below.

climate change on biodiversity. Various sectors contribute to this footprint, including chemicals production and oil refining.

4 Possible next assessment steps for central banks and financial supervisors

Ways forward to improve understanding of biodiversity-related financial risks

There are a number of potential avenues that could be developed to refine the assumptions and findings presented so that they can be expressed as financial risks. NGFS and INSPIRE (2021b) and Svartzman et al. (2021) sketch out a number of these avenues. They would consist in: (i) developing tailored scenarios to identify potential shocks and transmission channels more effectively; (ii) using methodologies that more effectively capture the limited substitutability of ecosystem services and the non-linearity of ecosystems, and especially how biodiversity-related shocks can spread between economic sectors and between financial institutions; and (iii) adopting an approach that captures the "double materiality" of risk,[6] in particular by developing tools to track the alignment of financial institutions with biodiversity protection goals, as required by the implementing legislation for Article 29 of the Energy and Climate Act – see Box 1.

The need for a more in-depth discussion on interactions between humans, animals and the environment

Understanding ecological risks also requires detailed analytical work to be done on interactions between biosphere components. In this regard, the "One Health" concept has received renewed attention in the context of the Covid-19 pandemic and provides a collaborative, multisector, transdisciplinary approach aimed at achieving positive health outcomes while recognising interactions between humans, animals, plants and their environment. International organisations in charge of human health (WHO), animal health (OIE), food (FAO – see FAO et al., 2008) and the environment (UNEP) have endorsed this concept, which was previously used during the zoonotic SARS and H5N1 flu epidemics of the 2000s.

However, it remains to be determined how central banks, supervisors and international financial institutions should go about recognising the risks linked to these issues. The approach taken could rely on interactions and similarities between these risks and the environmental risks that are already monitored by these institutions. For example, work by the European Insurance and Occupational Pensions Authority (EIOPA) recognises that private insurance solutions are inadequate to deal with pandemic risk and proposes coordination between private and public sectors, risk-sharing with the private sector and support for prevention and adaptation measures (EIOPA, 2020). EIOPA has also highlighted the benefits of a taxonomy of economic activities with a harmful health impact, owing to the transition risk created by regulations adopted for health and environmental reasons, particularly regarding pesticides (EIOPA, 2019).

Financial risks and "transformative changes"

This article stresses the relevance of considering the risks that may arise from biodiversity loss (physical risks) and the potentially profound socioeconomic changes (transition risks) linked to protecting biodiversity; the IPBES (2019) talks about "transformative changes". Central banks and supervisors could take on this issue by making progress in research into the nature and location of these risks, interactions with other risks (including climate-related risks), and their impact on financial stability. The complexity of ecosystems and the uncertainties facing us make it challenging to capture these risks, but approaches such as those described in his article show that progress may be possible.

6 Under this concept, companies are not only exposed to environmental risk (outside-in materiality), but also contribute to it through their activities (inside-out materiality). The latter approach may be relevant in measuring contingent transition risk.

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Appendix 1
IPBES and IPCC co-sponsored report on biodiversity and climate change

This report was the first co-sponsored publication by the IPBES and the IPCC (2021).[1] It marks a major milestone and may signal the beginning of increased collaboration between the climate and biodiversity scientific communities. The main message of the report is that shared management of the climate and biodiversity crises is vital, but also that accelerated social, technological and structural changes are needed to tackle these crises.

The report highlights the fact that climate change and biodiversity loss can feedback on one another to alter the location of tipping points. For example, negative climate impacts on biodiversity, particularly in ecosystems that are already close to their tipping points, can diminish carbon storage potential, in turn undermining nature's capacity to mitigate climate change. Exceeding tipping points could trigger ecological and social catastrophes, such as food crises caused by reduced crop yields.

Biodiversity protection measures have extensive climate benefits. For instance, the report indicates that reducing deforestation and forest degradation can contribute to lowering greenhouse gas emissions by an estimated 0.4–5.8 $GtCO_2e$ per year. It recommends that 30% to 50% of ocean and land surface areas should be protected (as compared with 7.5% and 15% respectively at present) and that certain environments should get priority protection, notably within the framework of interactions with climate goals. Particularly vital environments identified in this regard include forests, wetlands, peatlands, grasslands and savannahs.

Conversely, biodiversity may be harmed by certain climate mitigation or adaptation measures, such as tree planting in the wrong places or mining activities to support the development of renewable energy. The annual bioenergy CO_2 uptake rates by 2050 projected by some climate scenarios may be unattainable owing to the land area required. Moreover, current scenarios used by the IPCC do not differentiate between natural forest regrowth, reforestation with plantations, and afforestation of land not previously tree-covered, which makes assessment of biodiversity impacts difficult and is a knowledge gap that needs to be addressed.

The report therefore calls for climate and biodiversity scenarios to be used in combination, while pointing out that the former are more advanced, possibly owing to the complexity of ecosystems and their responses and dynamics.

1 IPBES, Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services; IPCC, Intergovernmental Panel on Climate Change. *IPBES-IPCC Co-Sponsored Workshop Report on Biodiversity and Climate Change – Scientific Outcome*, June 2021: *download link*.

Appendix 2
Taskforce on Nature-related Financial Disclosures (TNFD)

The TNFD was set up in 2020 by the United Nations Development Programme (UNDP), the United Nations Environment Programme Finance Initiative (UNEP FI) and non-governmental organisations Global Canopy and the World Wide Fund for Nature (WWF). It is backed by over 70 major corporations, financial institutions, think tanks, consortiums and governments around the world, with particularly strong support from the French government and the Paris financial community. Formally launched in June 2021 with the publication of two reports (TNFD, 2021a and 2021b), this initiative seeks to develop a framework to enable companies and financial institutions to report on nature-related risks in their market disclosures, with a view to encouraging global financial flows to be redirected towards projects that are beneficial to nature.

It thus follows the lead of the Taskforce on Climate-related Financial Disclosures (TCFD) set up by the Financial Stability Board (FSB), which quickly established a central place in climate-related financial risk disclosures. However, the TNFD is intended to take a broader view extending beyond the climate and the most immediate financial risks to capture nature-related impacts, particularly in terms of the related transition risks.

The TNFD is set to continue working through to 2023 at least, when implementation of the framework for measuring and acting on evolving nature-related risks is scheduled to begin. Initially, the TNFD will concentrate on devising a draft framework, relying initially on companies and financial institutions, in partnership with other participants, such as standard-setters, regulators, data providers, non-governmental organisations and research institutes. The draft will then be tested, in collaboration with financial regulators, by a diverse group of entities from emerging economies and developed capital markets. This test phase is intended to be used to revise the draft, which will then be put out to consultation, including by financial regulators. The TNFD framework is then scheduled to be launched in the second half of 2023. The TNFD is expected to continue its work beyond 2023, notably with a view to providing greater detail for its recommendations. Specific work is planned to determine methods for using scenario analyses as a risk assessment method. This will be done in conjunction with partners, as the TNFD has no plans to develop these types of scenarios itself.

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Gilles Vaysset

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Céline Mistretta-Belna

Editor
Didier Névonnic

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