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Allianz Research

The new risk frontier in finance: biodiversity loss

Concepts, challenges and a first quantitative case study on pollination

Executive Summary

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- **Biodiversity matters for the finance sector.** Financial institutions may face financial, market, reputational and legal risks when they invest in economic activities that cause adverse effects on biodiversity or are highly dependent on natural capital. Protecting biodiversity, on the other hand, provides huge opportunities for investments: The financing gap to restore biodiversity until 2030 is estimated at USD711bn per year. As a first step, this study focuses on the risk aspect.

- **Measuring biodiversity loss is challenging, to put it mildly.** There is a plethora of different methods and indicators, but no consensus. The highly local nature of biodiversity adds another layer of complication. In contrast to climate change, where local emissions have global consequences, impacts on biodiversity stay mainly local, leading to a very heterogenous map of biodiversity losses and resulting risks.

- **The assessments of biodiversity loss in finance are so far limited to qualitative and exposure-based metrics. This report provides a quantitative approach that measures actual impact, focusing on the risk of reduced pollination.** As a result, rather than simply categorizing economic activity into low, medium or high risk, we can concretely establish, for example, that a -20% loss in pollination activity would cut US agricultural production by -1.3%.

- **A complete elimination of pollination would cut agricultural output by between -2.0% in the UK to -7.9% in Belgium.** We estimate this would reduce annual gross domestic product by between -0.04% (the UK) to -0.4% (Portugal). In absolute terms, this would be equivalent to between USD1bn (Portugal) and USD28bn (US) annually.

- **On the other hand, the industrial and services sector could indirectly benefit.** Reduced pollination can increase the production of sectors that benefit from the land, capital and labor released by the contracting agricultural sector, notably the industrial and services sector. In France and Italy, for instance, the positive impact could exceed USD4bn per year.

- **These monetary results go a long way in helping the financial sector to quantify possible portfolio impacts of biodiversity loss.** Furthermore, they set the frame for a cost-benefit analysis of abatement measures and their financing mechanism. Such detailed analysis forms the foundation for the battle for a nature-positive economy as it can stir the financial sector into action. In that respect, the present report is just the first step of a long journey.

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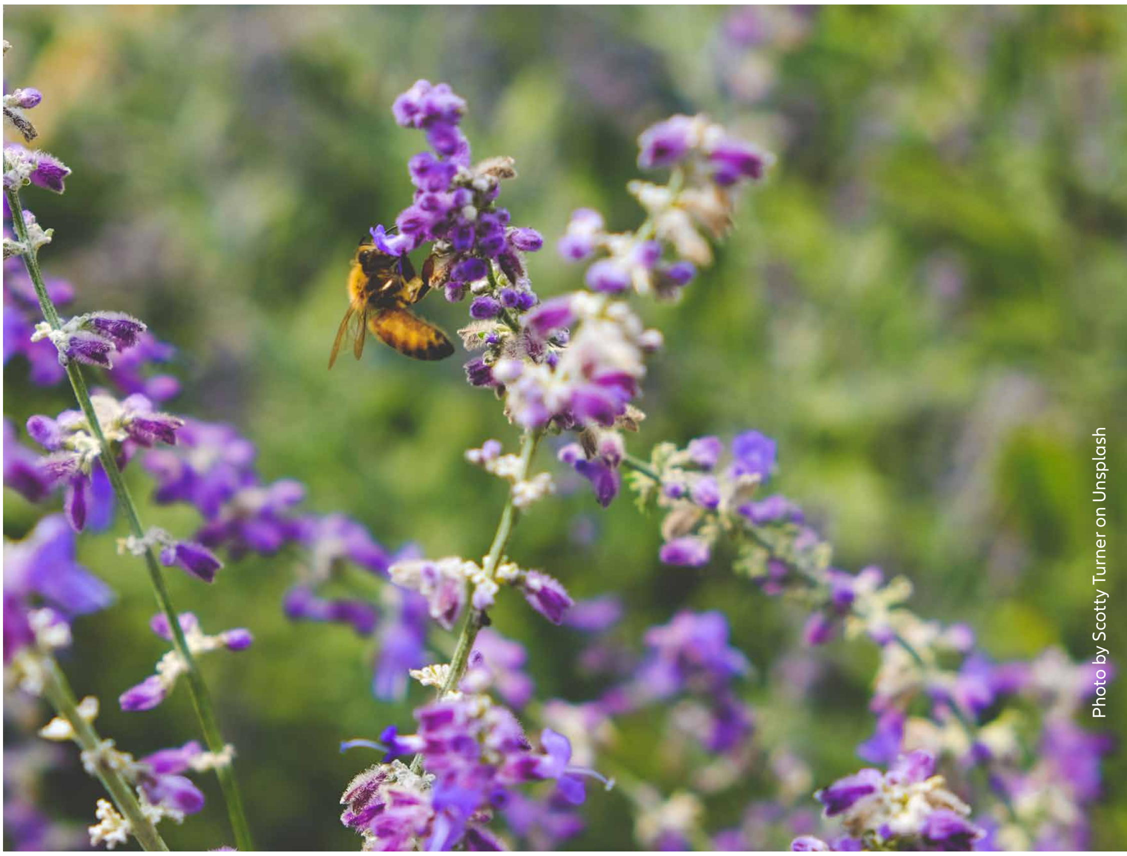
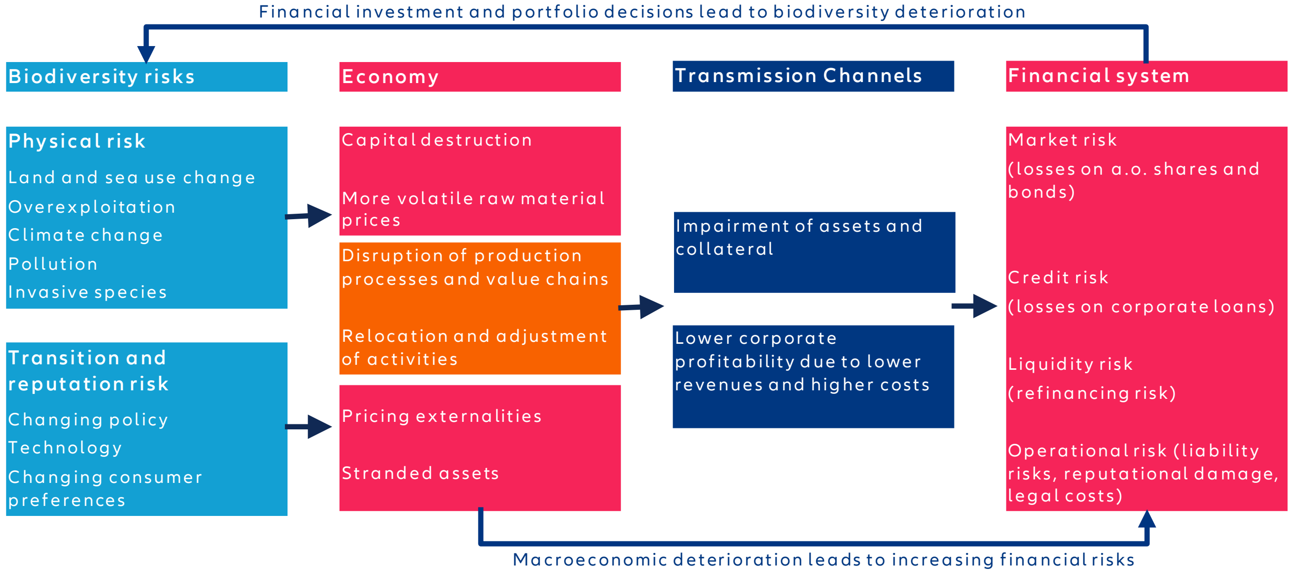


Biodiversity and the financial sector: the framework

Biodiversity loss is a risk to the financial sector. 55% of the global economy depends on well-functioning biodiversity and ecosystem services (Swiss Re Institute, 2020), yet increased economic activity may adversely affect biodiversity. Financial institutions could face financial, market, reputational and legal risks when they invest in economic activities that cause adverse effects on biodiversity or are highly dependent on natural capital (Figure 1). Understanding and evaluating these associated risks (and opportunities) is vital for the financial sector's performance, and disclosing these risks is the core of the EU's evolving Corporate Sustainability Reporting Directive (CSRD).

Figure 1: How biodiversity risks impact the financial sector



Source: Allianz Research

At the same time, protecting biodiversity provides huge opportunities for investments that will benefit long-term economic development and bring new business opportunities for the financial sector. The financing gap to restore biodiversity until 2030 is estimated to be USD711bn per year; as of 2019, just USD143bn (16% of the total need) was invested.[1] The majority (55%) of that finance was domestic budget spending and tax policies, and only 5% was green financial products, nature-based solutions and carbon-market products that the financial sector can provide.[2] Cutting environmentally harmful agricultural, forestry and fishery subsidies that amount to USD542bn and reusing them in a biodiversity positive way would already cover 76% of the gap.[3] The financial sector could contribute to financing the rest through new investment and insurance products. This particularly includes insurance products covering the resilient restoration of natural habitats that are harmed by wildfires, floods, storms, droughts or pollution accidents such as oil spills. Developing and emerging economies in particular often lack the institutional capacity to implement adequate restoration activities. In this context, public-private partnerships with the insurance sector provide an opportunity to close the gaps in building the necessary financial buffers, and offer access to the necessary competences and resources for restoration. Markets for nature-based solutions similar to carbon markets provide another scalable, yet neglected solution to mobilize large financial flows.

[1]This paragraph is mainly based on findings from Deutz et al., (2020).
[2]57% domestic budgets and tax policy, 20% natural infrastructure, 6% biodiversity offsets, 5% official development assistance, 5% sustainable supply chains, 4% green financial products, 2% philanthropy, conservation NGOs and 1% nature-based solutions and carbon markets.
[3]For instance, according to the estimates from Deutz et al. (2020), USD30.9bn-USD92.5bn in green finance could be used to finance biodiversity from 2020 to 2030.

What we talk about when we talk about biodiversity

The set of renewable and non-renewable resources that benefit people are understood as natural capital assets (NCAs) and they support ecosystem services that economic activities rely upon (Guerry et al., 2015; Leach et al., 2019). Ecosystem services (ES) are widely defined as services that nature provides to humans; these services can be varied and some economic activities such as agriculture, livestock and forestry benefit from them. They are usually categorized as either provisioning, regulating, supporting or cultural services. Some examples include water and food, pollination, habitat for species, recreation and mental and physical health, respectively (FAO, 2022). An ecosystem needs to function properly so that it is able to provide such services. A delicate balance of species interacting among each other and with their natural environment will allow an adequate ecosystem functioning and thus enable the provision of ecosystem services (Vos et al., 2014). The two main causes of ecosystem disruption are climate change and biodiversity loss (BDL). The latter is evidenced whenever species are reduced in an ecosystem. This loss can negatively influence the balance in that ecosystem and disrupt or impede the provision of the ecosystem's services. For example, the loss of pollinators, such as species of bees or moths, affects the ecosystem service of pollination. At the same time, this can affect the production of several crops and bring economic loss (Potts et al., 2016).

The numbers are staggering. Ecosystem services provide societal benefits worth up to USD140trn per year, equal to one and a half times the total of global GDP (OECD, 2019), including food production, medicines, carbon sequestering, protection against natural disasters and disease control (De Nederlandsche Bank, 2020). Yet, there has been considerable losses over the past decades: natural ecosystems declined by -47% (Ngo et al., 2019). If the world economy functions as usual and continues losing essential ecosystem services, it will also lose 0.67% of global GDP per year (equivalent to about USD479bn per year) until 2050 (Johnson et al., 2020).

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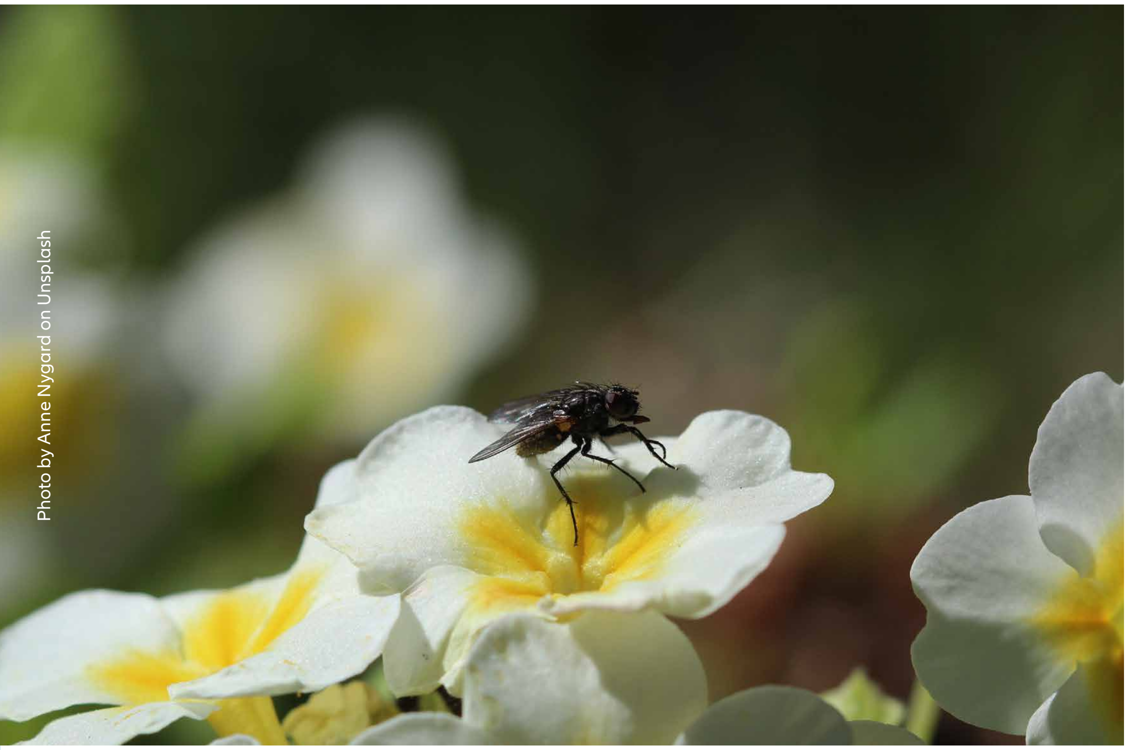
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The challenges in measuring biodiversity loss: there is no price tag (so far)

Indicators to measure biodiversity loss are still in their infancy. Unlike greenhouse-gas emissions, biodiversity is a complex topic because of its relation to ecosystems, biomes and its inherent local nature. As a result, setting specific numerical targets is complicated and controversial: a plethora of different methods and indicators exists, with no consensus in sight (see appendix 1) The EU, for instance, still needs several indicators in its biodiversity strategy at a regional level.[4]

The local nature of biodiversity is another challenge when estimating an investment portfolio's impact on biodiversity. The biodiversity-related impact of investments is geographically very heterogeneous. For instance, there is a huge range of variation between the economic values for ecosystem services in non-protected areas in Germany, France, Italy, the UK and the Netherlands. Table 1 shows each country's minimum, median, average and maximum value of ecosystem services in 2020 US dollars per hectare.[5] For instance, while the average value of ecosystem services is about USD75,000 per hectare in Italy and USD17,000 per hectare in France, it is about USD4000 in Germany, the UK and the Netherlands. The variations within countries are even wider. This implies that ecological harm stemming from a specific business activity in one area differs from the environmental damage it would create in another region. It depends on the activity, the presence of the type of ecosystem services and the values of those services.

[4]Please see EU Biodiversity Strategy Dashboard for detailed information.
[5]Estimates use the Ecosystem Services Valuation Database, a public database including standardized monetary values of ecosystem services in a specific geographic area, based on 900 peer-reviewed studies evaluating the value of ecosystem services for different regions in different years.

Table 1: Labor market vacancies per unemployed persons

Method	Min	Mean	Max
France	0.21	17,298	545,709
Germany	117	4,313	30,878
Italy	0.04	74,829	2,301,802
UK	0.02	4,101	100,391
Netherlands	0.01	3,992	235,133

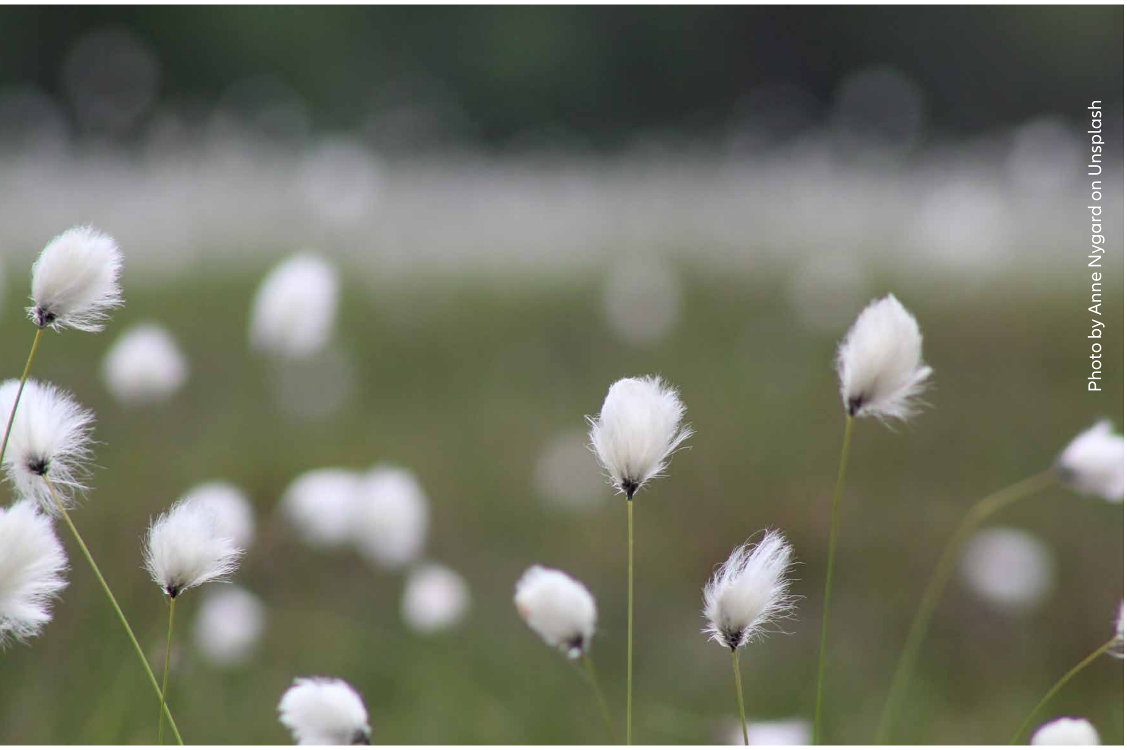
Source: Allianz Research

Given these limitations, most studies on biodiversity-related risks are scoping studies that shed some light on the high-risk sectors and provide a qualitative ranking among them by their qualitative exposure. For instance, a study by the Swiss Re Institute, 2020, shows that agriculture, forestry, fishing, manufacturing, accommodation and food services have the highest dependency on ecosystem services. Furthermore, six industries – chemicals and materials; aviation, travel and tourism; real estate; mining and metals; supply chain and transport; retail, consumer goods and lifestyle – have low direct dependencies on ecosystem services; however, they are highly dependent on them through their supply chains (World Economic Forum, 2020).

In contrast, this study aims at identifying the economic effects of biodiversity loss on financial sector portfolios at the country and sector level in monetary terms. To achieve this objective, we present a conceptual framework that links biodiversity and ecosystem-services loss with business activity. The framework is then applied to the case of pollination-services loss in Western Europe and the US to showcase the potential economic effects. The case of pollination is chosen for its high relevance among the ecosystem services and its increasing vulnerability (see box).

The economic relevance and vulnerability of pollination services

Around 75% of cultivated crop types such as fruits, nuts and highly valued commodities such as coffee and cocoa depend on pollinators (Potts et al., 2016). The global economic value added of pollination services is estimated to be between USD235bn and USD577bn (in 2015 US dollars, IPBES, 2016). Declines in pollinators have been documented mostly at regional or national levels, and a global study found that the number of bee species was 25% lower from 2006 to 2015 than before 1990 (Zattara & Aizen, 2021). While pollinators continue to decline, at the European level for example, around 40% of bee and butterfly species are highly threatened, with national numbers in European countries reaching 50% of highly threatened species (IPBES, 2016). Trends in species abundance and diversity in European agricultural landscapes are worrisome as a consequence of agricultural intensification, a limited number of cultivated species as well as land abandonment (EEA, 2021; Lécuyer et al., 2021; Mupepele et al., 2021).

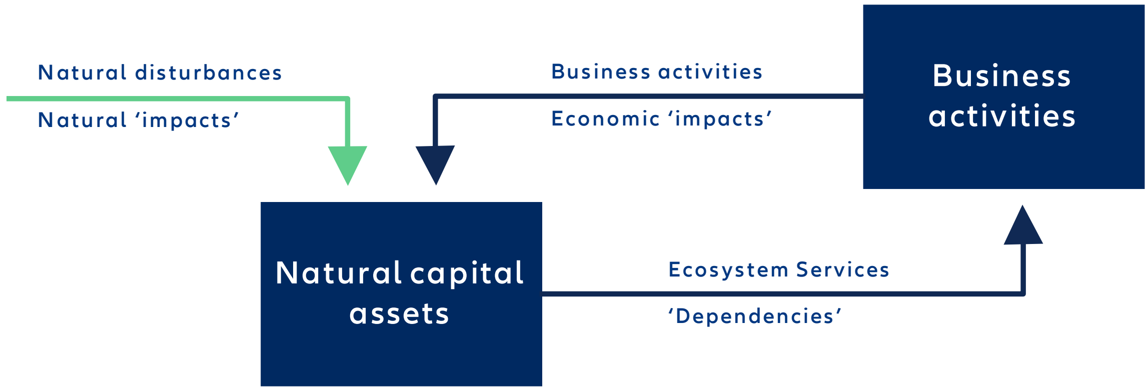


The pilot study on pollination-service loss: first quantitative results[6]

The framework of this study is based on the concept of dual materiality. Business activities depend on ecosystem services (ESs) supplied by natural capital assets (NCAs), but at the same time business activities can also impact NCAs adversely (Figure 2). Biodiversity – the variety of species and habitats – is part of diverse NCAs[7] that provide ESs[8] such as water, soil quality, dilution, pollination, pest control and flood protection. A decline in biodiversity and loss of habitats and species causes a reduction in the ability of NCAs to provide ESs essential for the economy and decreases the productivity of businesses (measured by the value of output obtained with one unit of economic input) dependent on ecosystem services.

[6] These calculations are based on WUR (2023).
[7] Classified according to UNEP-WCMC and explained in Leach et al. (2019).
[8] Classified according to CICES: Structure of CICES.

Figure 2: Relationship between natural capital assets, ecosystem services, and business activities.

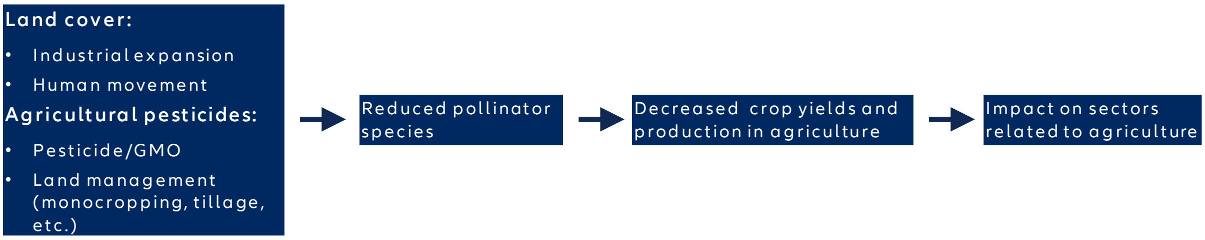


Sources: Generated by WUR researchers using ENCORE framework, Allianz Research

To identify the impact of biodiversity loss on the financial sector, the economic impact for the case of pollination-services loss is estimated by using the MAGNET global general equilibrium model. The results are economic effects estimates at the country-sector level. The financial sector can use these estimates to assess their portfolios' biodiversity-related risk exposure by weighing the estimated sector-country level economic losses by the share of financial assets in those sectors and countries. Annex II gives a detailed explanation of the methodology.

Pollination-services loss (PSL) affects overall business activity in the agriculture sector, where pollination is essential (Figure 3). Pollination is necessary for food production and human nutrition. Most of the producing plants of nuts, fruits and seeds in the human diet depend on pollinators to reproduce. Pollinators, such as diverse species of bees, moths, butterflies and other insects, play a key role in flowering plant reproduction, mobilizing pollen from one plant to another, enabling fruit production. PSL can directly and adversely affect agricultural production activities through decreased crop production yields and production, which in turn impacts other sectors dependent on agricultural inputs.

Figure 3: Impact pathway of pollination loss

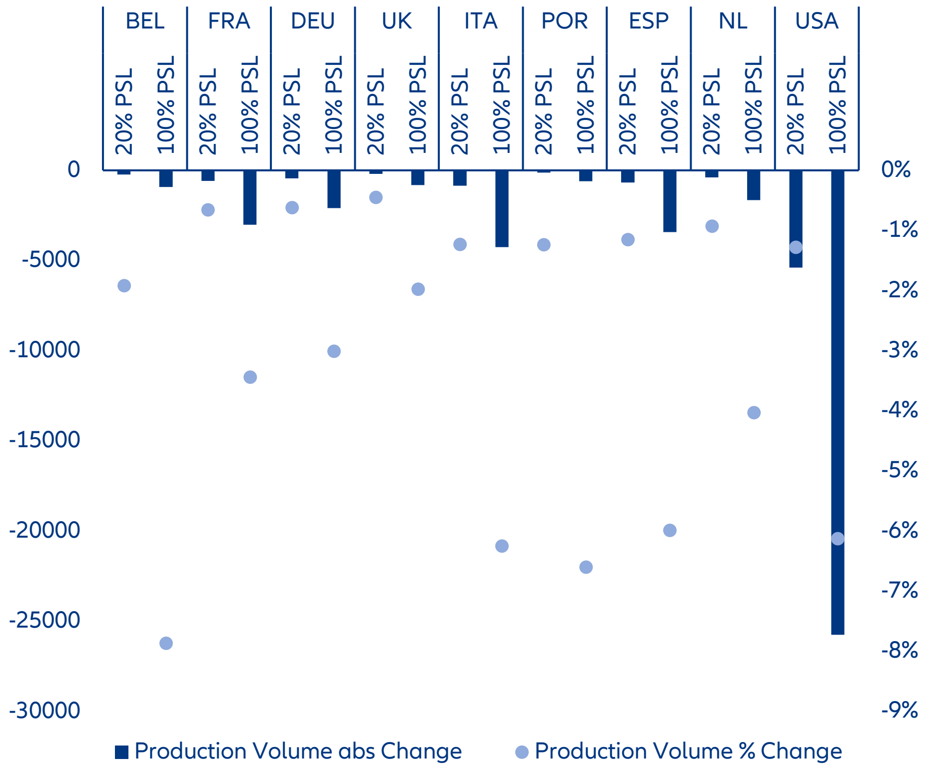


Sources: Generated by WUR researchers using ENCORE framework, Allianz Research

In this study, we estimate the economic effects of different PSL shock scenarios in Western Europe and United States.[9] The main results are presented for the complete PSL (100% pollinator loss), which is a common scenario in other studies in the literature[10] to show the importance of pollination services for economic activity and also for the 20% PSL scenario to demonstrate how the estimated effect changes by the level of the loss.

PSL decreases agriculture output. The level of the loss of production varies by the extent of countries' dependency on pollination services (e.g. type of crops) and the level of PSL. Figure 4 shows the impact (in percentage and absolute levels) of the 20% and 100% PSL shock scenarios on agricultural production. A complete loss of pollination services (100% PSL loss) decreases the agricultural output by between -1.98% in the UK and -7.87% in Belgium. In monetary value, the production loss is between USD0.6bn in Portugal to USD26bn in the US. The production losses are smaller (between 0.45% and 1.92%) for the 20% loss scenario. Compared to pre-shock agricultural production levels, farm production decreases more in countries such as Belgium, Italy, Portugal, Spain and the US, which specialize in heavily pollination-dependent crops such as apples, pears and nuts.

Figure 4: PSL effect on agricultural production in countries experiencing hypothetical PSL shock, 100% and 20% PSL scenarios, % change and absolute change USD mn



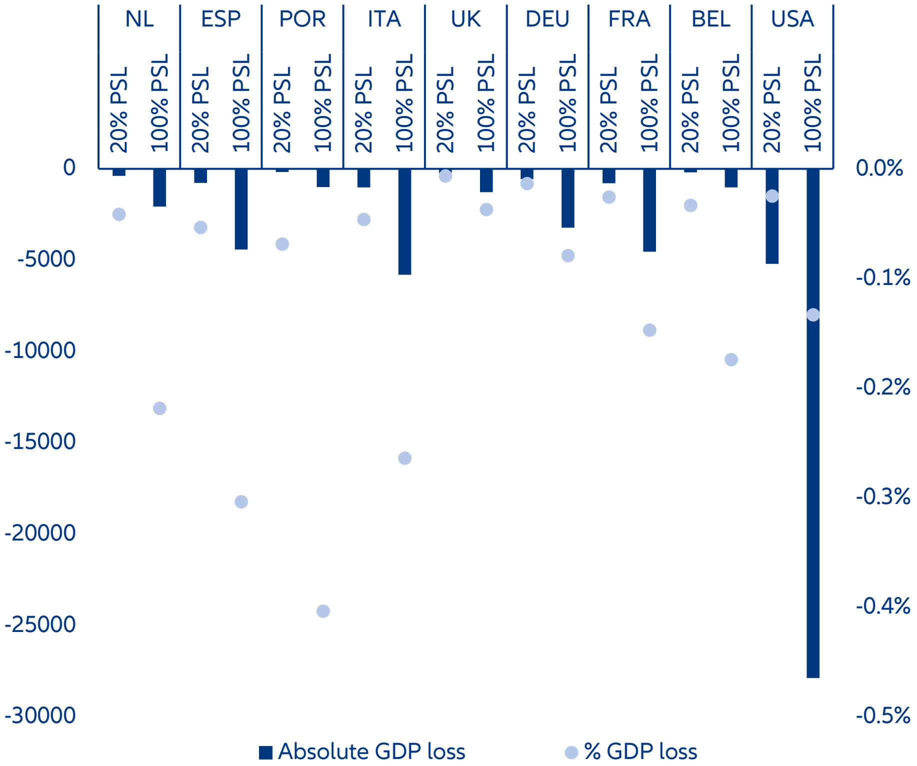
Source: Allianz Research

The level of the agricultural production loss due to PSL and the importance of agriculture and agriculture-related sectors in the economy determine the extent of total macroeconomic losses due to PSL (Figure 5). Our model shows that when the indirect effect of decreased crop yields due to PSL are taken into account, annual gross domestic product is estimated to be reduced by between 0.04% (the UK) to 0.4% (Portugal), and in absolute levels between USD1bn (Portugal) and USD28bn (US) annually. Compared to pre-PSL GDP levels, this loss is highest in Portugal, Italy, Spain and the Netherlands, where PSL directly affects agricultural production and agriculture, and agriculture-related sectors such as food processing

[9]In our study, countries that experience PSL shock are Belgium, France, Germany, Great Britain, Italy, Portugal, Spain, United States, the Netherlands.
[10]Such as the Economic case for nature report (Johnson et al., 2021) that considers 90% loss of pollinators, or see also Bauer & Wing, (2016) that present a total loss of pollination services.

have a high share in total macroeconomic output. For instance, the relative effect of PSL on the GDP level in France or Germany is less compared to pre-PSL shock levels because agriculture and agriculture-related sectors may play a smaller role compared to other countries or the decrease in agricultural production might be compensated by the increase in industrial activities.

Figure 5: PSL effect on Gross Domestic Product (GDP) of countries experiencing hypothetical PSL shocks, 20% and 100% PSL scenarios, % change and absolute change in USD mn



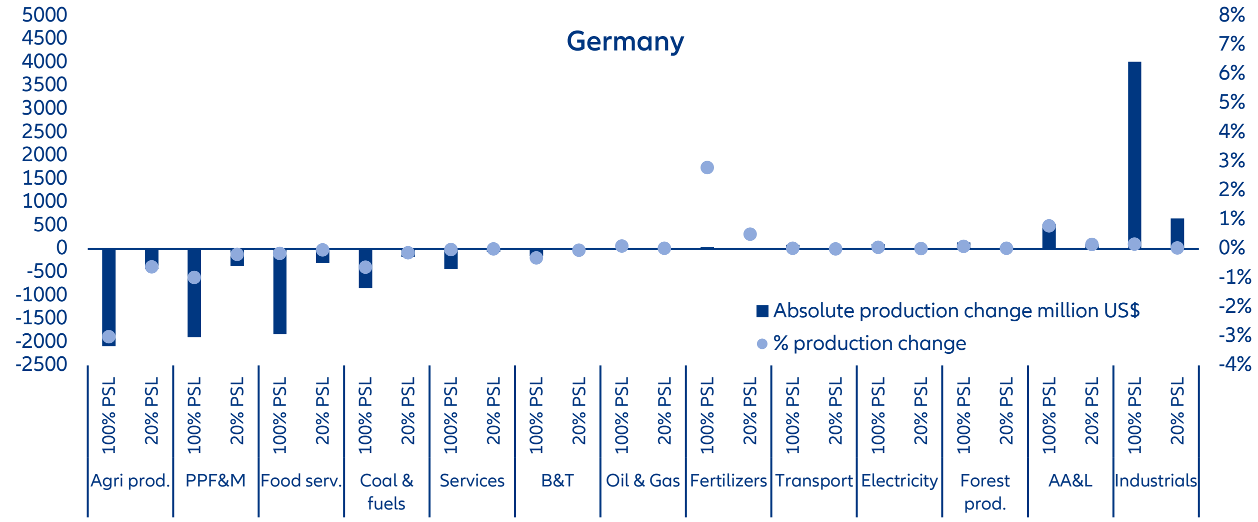
Source: Allianz Research

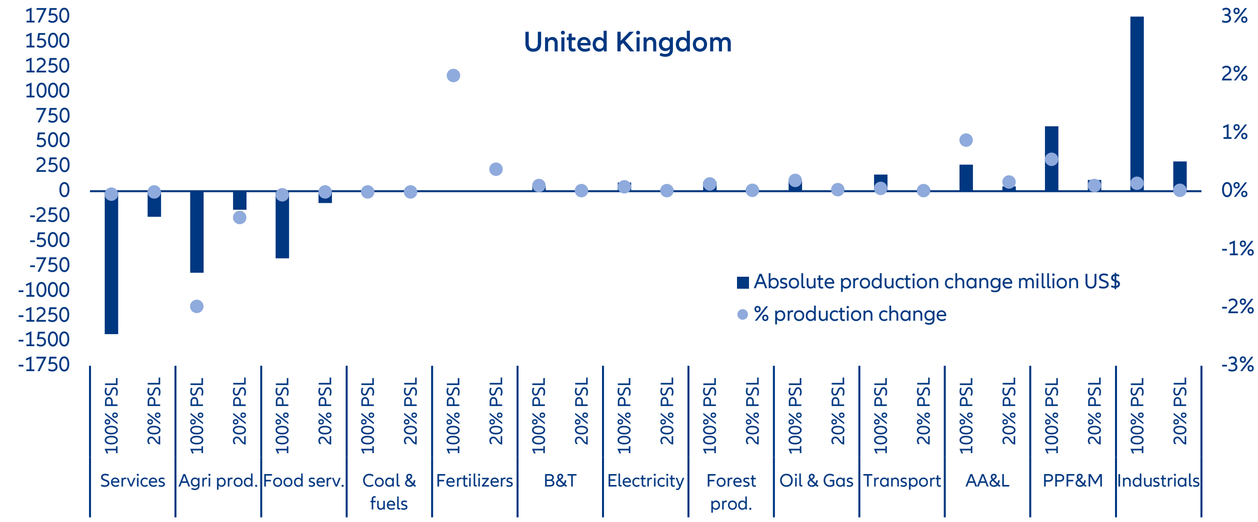
PSL may adversely affect non-agriculture sectors such as processed packaged food and meats, food services, coal and consumable fuels (e.g. biofuels), beverages and tobacco, which depend more on agricultural inputs than other sectors (Figure 6). For instance, the production loss of the processed packaged food and meats industry in Italy is estimated to be about USD4bn per year, and the same sector's losses in Germany are estimated to be about USD2bn, close to the level of the agriculture sector's losses. Similarly, the food services sector, directly dependent on agricultural products, would contract in all countries after PSL. This is mainly because the prices of agriculture products, i.e. inputs for these sectors, increase and, at the same time, the countries hit by a PSL shock import more crops dependent on pollination services.

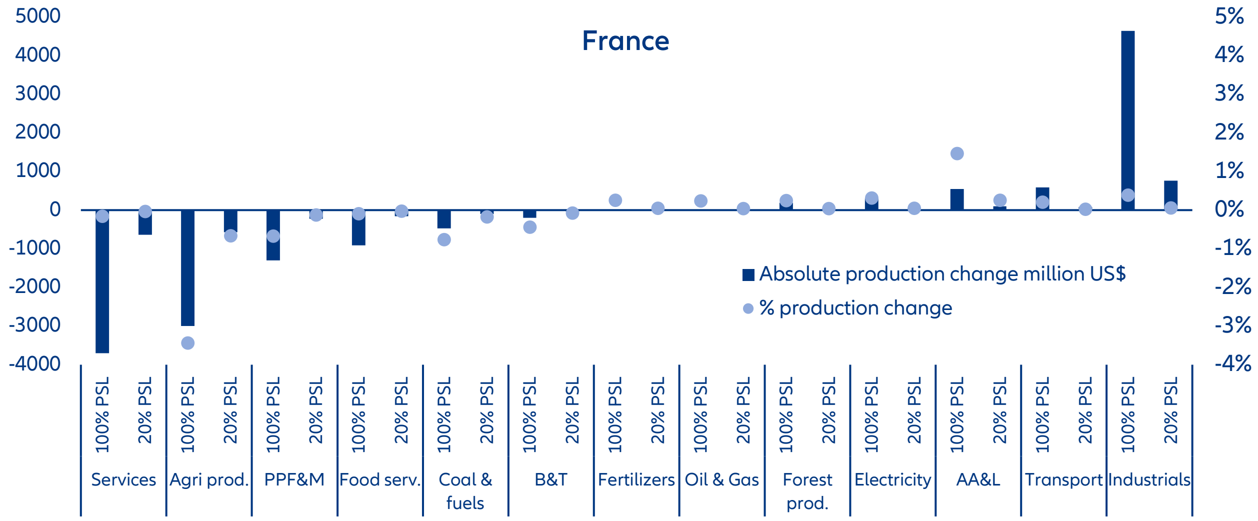
But the story does not end with the negative effects. PSL can increase the production of sectors that benefit from the land, capital and labor released by the contracting agricultural sector. The model predicts that production in almost all countries in the industrials and services sectors will increase after PSL. In the estimations, our model reallocates agricultural labor, land and capital from agriculture to other sectors less dependent on agriculture and with a relatively higher rate of return than agriculture due to reduced returns from crop production after PSL. The wide variety of sub-sectors under industrials and services, such as biochemicals, pharmaceuticals, manufacturing and construction and public and private services are less dependent on agricultural inputs. The positive effect of reallocating resources from agriculture to the industrial and services sector compensates for the negative effect of increased agricultural input prices in those sectors, thus offsetting the GDP losses for example in Germany and France. The model estimates also show that the food processing and meat industry will have a higher production volume after PSL, particularly in the UK and the Netherlands. In these countries, the positive effect of substituting arable land from crop production for livestock production is higher than the negative effect of increased animal feed prices due to PSL (Figure 6).[11]

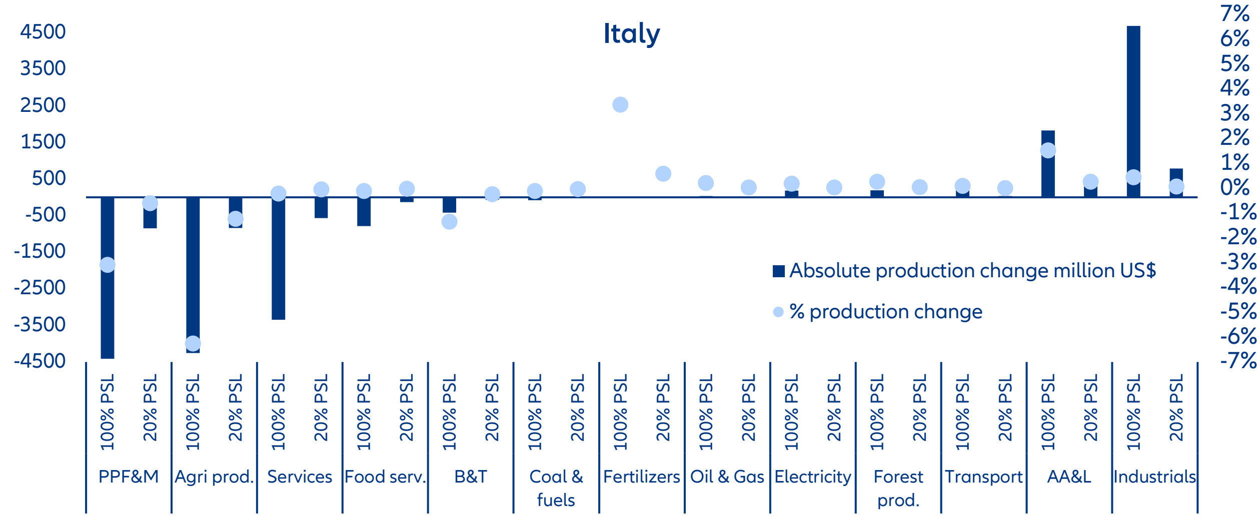
[11]This might be one of the explanations of why processing and meat industry will have a higher production volume after PSL in UK and NL

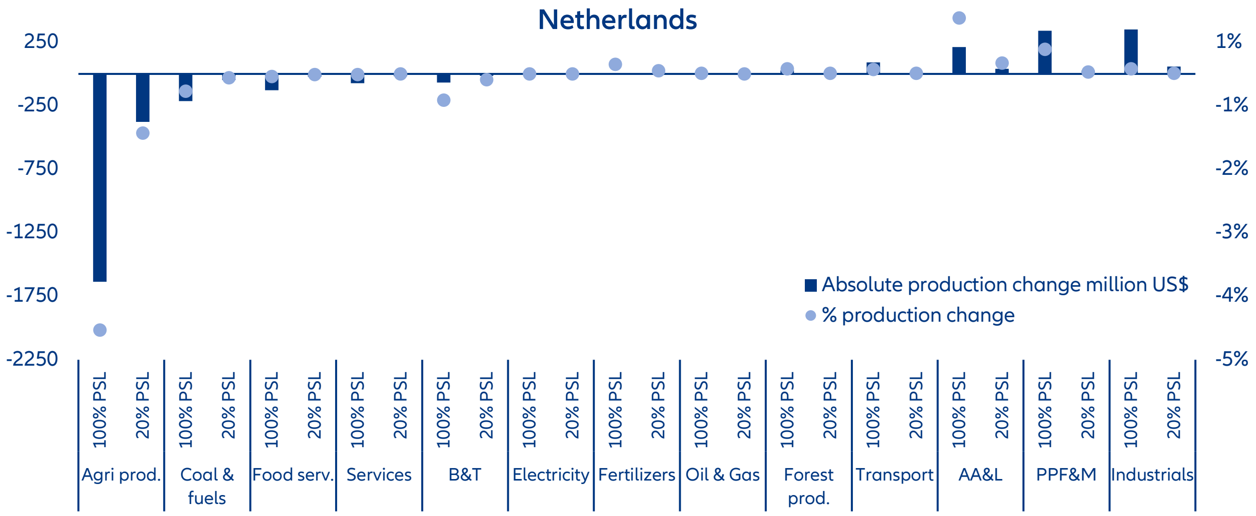
Figure 6: Sectoral effects of PSL in selected countries, USD mn, 100% and 20% PSL scenarios

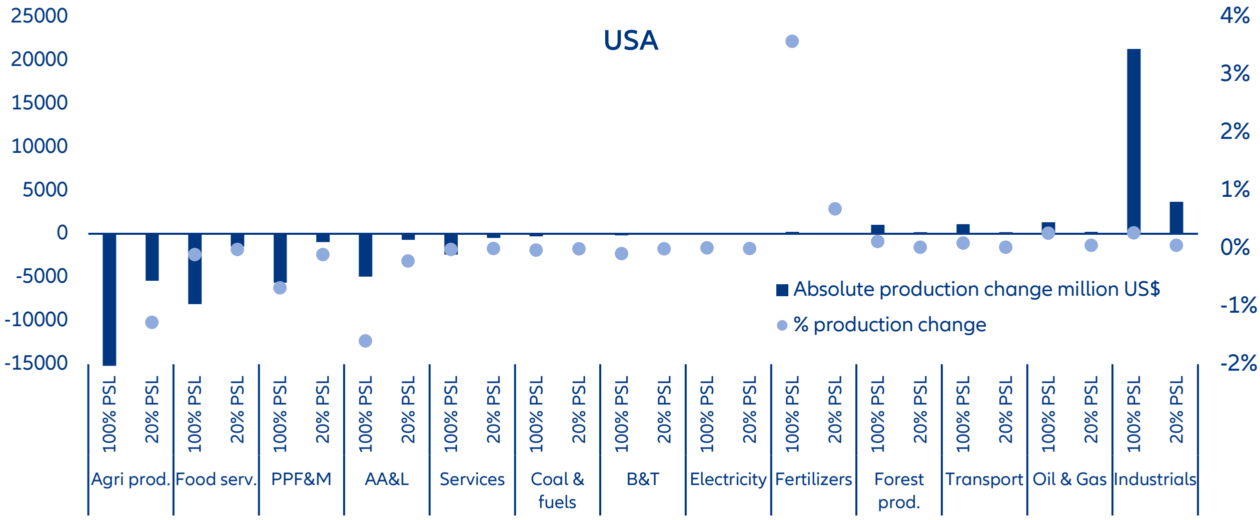












Source: Allianz Research

Notes: The Figures show results for agricultural production (agri prod.), food services (food serv.), packaged and processed food and meat (PPF &M), apparel, accessories and luxury goods (AA&L) services, beverages and tobacco (B&T), electricity, fertilizers, forest products (forest prod.), transport, oil and gas and industrials.

ANNEX I: MSA, LBII or PDF? How to measure biodiversity loss

There are several approaches for biodiversity measurement available but there is no consensus on the when and how of those methods and indicators. The most used indicators to calculate the pressure on biodiversity is the Potential Disappearing Fraction of Species (PDF), the Local Biodiversity Intactness Index (LBII) and the Mean Species Abundance (MSA) (Marques et al., 2021). PDF measures the number of species lost in a given land area or water volume over a given period following land transformation and occupation, toxic emissions, climate change etc. (Crenna et al., 2019). LBII is defined as "the average abundance of a large and diverse range of organisms in a given geographic area, relative to their reference populations," where the reference condition is approximated by current conditions at minimally degraded sites, given the lack of sufficiently accurate historical baseline data (De Palma et al., 2021). Several biodiversity methods provide data and models to link biodiversity pressures to potential impacts on biodiversity. The most common ones are LCA-based methods (e.g. ReCiPe, LC-IMPACT, Impactworld+) applicable at different scales (from global to product) (Chouchane et al., 2022).[12] There is no international consensus in business over which methods and indicators should be used to measure and evaluate biodiversity. However, more and more researchers and enterprises use MSA as their central measure.

ENCORE (Exploring Natural Capital Opportunities, Risks, and Exposure) is an assessment and visualization tool to help users in understanding how businesses across all sectors of the economy potentially depend on and impact nature, and how these potential dependencies and impacts might present a business risk. The tool was jointly developed by the Natural Capital Finance Alliance in partnership with UNEP-WCMC and was financed by the Swiss State Secretariat for Economic Affairs (SECO) and the MAYA Foundation. It uses the Mean Species Abundance indicator.[13] When combined with data from Integrated Biodiversity Assessment Tool (IABT) that provides geographic information on existing biodiversity, it is possible to develop reports showing the proximity of invested companies' assets to areas vulnerable to biodiversity loss and assess the potential effects of existing invested company assets on biodiversity.

[12]This paragraph is work by a research group within WEcR, the publication under review is the following: Chouchane et al. (2022)
[13]Please see ENCORE Guide to Biodiversity Module for detailed information.

ANNEX II: Biodiversity loss estimate methodologies

To estimate the effect of different PSL shock scenarios on agricultural production at the country level, we use pollination dependence ratios (PDR). Like the economic losses calculation methods of Bauer and Wing (2016) and La Notte et al. (2020), it is assumed that PSL decreases crop yields by their PDRs. Using those ratios for various crops from the ecology literature[14] and FAOSTAT data on historic agricultural production[15], we estimate the decrease in crop production in Western Europe and North America for different rates of hypothetical PSL.[16] For instance, a 100% PSL is equivalent to a crop-production loss by the size of the crop's PDR and a 20% PSL is equal to a production decrease of the crop's PDR multiplied by 0.2. As some countries produce more pollinator-dependent crops than others, these steps result in variation in the PSL shocks amongst countries.

Using the MAGNET[17] general equilibrium model, the effect of pollination-loss scenarios on economic activity at the sector-country level is estimated. The crop production losses estimated for different scenarios are used as input in the MAGNET model to generate production effects for various economic sectors in different countries and regions trading each other. The estimation results of this study cover eight countries and 10 regions when relevant: Belgium, France, Germany, Italy, Netherlands, Portugal, Spain, the UK, the rest of EU, the rest of Europe (non-EU), Africa, Northern America, Latin America, Central America, Asia, the rest of the world. In addition to primary agriculture, the model estimates the indirect effect of PSL on sectors such as consumer staples, processed & packaged foods and meats, food services and indirectly affected sectors such as industrial products and the fertilizer sector. Due to agricultural-production shocks, production factors (e.g., land, labor, capital etc.) will be reallocated from agriculture-related sectors that are affected from PSL to non-agriculture-related industries that are less affected. Due to this reallocation of resources, MAGNET can estimate that those non-agriculture-related sectors might increase their production, and those non-affected sectors might increase their output after PSL.

Estimating economic loss due to PSL by this method has some limitations. First, the magnitude of global or local PSL, like Roxburgh et al. (2020) and Johnson et al. (2021,) are not estimated. This study rather simulates or assumes a 20% and 100% PSL and demonstrates what the consequences might be. Using actual estimations of future PSL might provide a more realistic economic impact prediction. Second, related to the first limitation lies the assumption that a 100% PSL causes a decrease in agricultural output of the size of the dependence ratio of the crop and that a 20% PSL is a linear 20% part of that decrease. It should be clear that the pressure on wild pollinators and its effects on crop production are not a linear relationship but a complex system highly dependent on many contextual aspects of a specific area. Third, for estimating the crop-pollinator-dependence ratios, we use estimations of dependence rations provided by Klein et al. (2007) and Aizen et al. (2019). These are estimated very roughly for some crops. For some crops, the dependence ratios were estimated between 40% and 90%.

[14] Crop PDRs are derived from studies by Aizen et al. (2019) and Klein et al. (2007).
[15] Agricultural production of the year 2020 is used.
[16] When necessary, FAOSTAT production volumes per crop type are aggregated according to commodity types in MAGNET model. This implies that for every relevant MAGNET commodity (fruit, vegetables, nuts, etc.), a weighted average production loss for the considered country is calculated.
[17] MAGNET (Modular Applied GeNeral Equilibrium Tool) is a multi-regional, multi-sectoral applied computable general equilibrium (CGE) model, which builds on GTAP datasets (Woltjer et al., 2014). In MAGNET, perfect competition is assumed, and actors choose the cheapest combination of production factors labor, land, capital and natural resources. Contrary to partial agrifood models, MAGNET includes income feedback loops between primary and industrial sectors in order to cover the full (bio)economy

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