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The Bee and the Stockmarket

Research Paper

An overview of pollinator decline and its economic and corporate significance

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Executive summary

For several years there has been a constant flow of research on the topic of pollinator decline and the economic and food security impacts that this could have. This report aims to distil the current research and to determine if this is a material issue for companies with exposure to agricultural produce within their supply chain.

The majority of research into the issue has focused on the demise of the most active pollinator species, *apis mellifera* or the European honey bee (though there are another 25,000 to 30,000 bee species and around 150,000 different pollinator species in total). Research has focused on the European honey bee as it is one of the most common commercial bees; the research has also predominantly been conducted in North America and Europe (where the majority of specialists are located). This research shows that honey bee numbers in these regions are in decline. At the global scale the UN's Food and Agriculture Organisation estimates that around three quarters of all pollinators are in decline and that their numbers have reduced by about one third in the past decade. There are several reasons for this which include habitat decline, pesticide use and the spread of disease vectors.

The importance of pollinators to agricultural crops varies. Some crops can produce seeds through wind or self pollination, others see yields improve (both by quantity and quality) as a result of pollination but are not entirely dependant on it, whilst others may depend almost entirely on animal pollination in order to produce fruits and seeds. In all, around 70% of agricultural crops (by crop species) depend to some degree on pollination, although if looked at by mass then 60% of global agricultural yield is not affected by animal pollination (this refers to crops such as wheat, maize and rice). In total, it is estimated that, should animal pollinators disappear, then this would only decrease global agricultural production by 4-6% by mass. This doesn't, however, measure the nutritional or economic value that could be lost as pollinator-dependant crops are an important source of proteins, vitamins and minerals in our diet and also tend to have a higher economic value than non pollinator-dependant crops.

By determining the yield dependency on animal pollination economists have been able to determine that pollinators contribute around £130 billion to the global economy (a service that is predominantly provided for free) but that should this service be lost then the consequential impacts on food prices would mean a consumer surplus loss of between £160 to £260 billion in addition to the £130 billion of pollination service that would be lost. The degree of economic importance depends on the subject in question: pollinator dependence at a national or farm level is much more significant than within the global economy. Farmers clearly put a value on pollination by employing the services of commercial bee keepers, but there is also strong evidence to suggest that payment for commercial pollination services could be better employed by investing in the conservation and establishment of wild habitat for pollinators near crops with pollinator dependence.

At the corporate level this is clearly an issue that is likely to affect cash flow because of the impacts on raw material prices and is therefore a topic that should be addressed by companies that have exposure to agricultural produce or pollinator habitat. However, our research suggests that there is limited focus on this specific issue by the companies we assessed, though there is a broader, and growing, recognition of the economic value of maintaining biodiversity and ecosystem services within the supply chain.

Introduction

Pollination plays a critical role in sustaining much of the biodiversity on earth and, as a result, plays an essential service in maintaining the integrity and resilience of most terrestrial ecosystems and the services that these ecosystems provide¹. There are around 150,000 flower-visiting pollinators, the majority of which are flies, butterflies, moths, bees, wasps and beetles as well as a small number of animal pollinators such as birds, bats and some non-flying mammals. One of the more common and most prolific pollinator groups is the bees, of which there are between 25,000 to 30,000 different species¹.

There is growing scientific concern about observed declines in bee numbers and the associated impact that this may have on agricultural production, not just from the perspective of tonnage produced but also from the impacts that this may have to the diversity and nutritional quality of the modern diet. In addition, the decline in pollinator numbers may not just be limited to the bee family, but it may actually be a reflection of a general decline in pollinator numbers, most of which are not as well studied as the bees.

Within this paper we will provide an overview of the current rates of decline in pollinator numbers and some of the potential causes for it. We will then review the importance of pollinators to agriculture (bearing in mind that the 3,000 agricultural crops are only a small proportion of the estimated 240,000 flowering plants that depend on pollination services¹) and the economic significance of pollinators, before covering the current level of engagement and discussion on the topic by companies that have direct exposure to pollination services (e.g. soft drink manufacturers, food retailers, food producers, luxury goods and agro-chemical companies).

¹ For an introduction to ecosystem services please see our 2009 report "*Ecosystem Credit Crunch*". www.schroders.com

Pollinator decline

In conducting the background research to this report, it quickly became apparent that despite the large numbers of pollinator species the most important pollinator group is that of the *Apidae* family (the bees). Bees are found on every continent in the world, except Antarctica, and in all habitats that contain insect-pollinated flowering plants. There are between 25,000 and 30,000 different members of the *Apidae* family though the one which is probably most well studied is *apis mellifera*, or the European honey bee, because of its value as a source of honey and, more recently, as a commercial pollinator.

Declines in managed bee hives (*apis mellifera*) have been documented since the 1940s, with a 60% decline in the number of North American managed hives from 1940 to 2009ⁱⁱⁱ. Similar declines in managed colonies have also been documented in Europe where it is estimated that between 15% to 35% of honey bee colonies have been lost between 1985 and 2005ⁱ. Bee disappearance is predominantly reported in Europe and North America where little natural habitat remains. The decline in managed stocks in these regions has been offset by increases in Asia, Latin America and Africa resulting in a 45% increase in managed colonies over the last 50 years^{iv} reflecting the increase in demand for pollination services as agricultural production has increased to keep up with the demands of a growing population.

The observance of declines in managed colonies in the US and Europe has increased in the last decade or so with the spread of Colony Collapse Disorder (CCD). CCD is the rapid loss of a colony of its adult bee population; no dead bees are found inside or in close proximity to the colony. This term was originally coined in the US in 2006/2007 when US bee keepers reported an average loss of 38% of colonies during this period (significantly higher than the background rate of 10% loss). More recently the US Department of Agriculture reported a 31% decline in colonies over the winter of 2012/2013. In 2011, CCD was also observed in China and Japan^v.

It is not just in honey bee populations that declines have been recorded. A study by the University of Illinois into the relative abundance of eight North American bumblebee species found that four of the sampled species showed declines of up to 96% and their geographic ranges had contracted by between 23% to 87% within the past two decades. Whilst in the UK, three of twenty five British species of bumblebee are extinct and 50% are in serious decline (often by up to 70%) since the 1970s^{vi}.

There is limited information available about pollinators other than honeybees, although it is estimated that three quarters of pollinator species have declined by more than a third in the last decade^{vii} (the Food and Agriculture Organisation [FAO] states that in the UK, half of British pollinators have disappeared from over 20% of their range, with a quarter declining by more than 50%ⁱ). It should also be noted that data collection on pollinator numbers is more a reflection of the concentration of specialists to gather the data versus a reflection of the zones of greatest concern (hence the higher number of studies in North America and Europe), and pollinator decline has been reported in at least one region or country on every continent. To date, however, there has been no global assessment of the changes in distribution and levels of pollination services, but the decline in numbers of key species should be cause for concern.

Causes of decline

It is clear that pollinator decline can not be attributed solely to one individual factor, but to a number of stressors. What's more, the exposure to one of these stressors will decrease the resilience of populations to other stressors. These stressors include habitat loss, predators and pesticide use.

Habitat loss

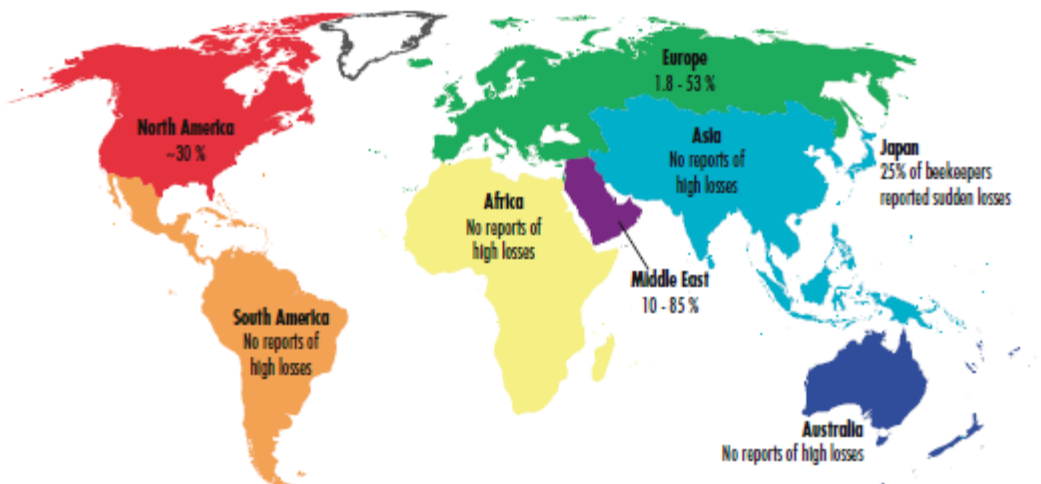
Pollinators require foraging, nesting, reproduction and shelter resources from their environment and the loss of one of these resources will affect pollinator numbers. Evidence shows that the diversity of wild bees has declined greatly over much of Western Europe owing mostly to natural habitat destructionⁱⁱⁱ. An Anglo-Dutch study found that since the 1980s there has been a 70% decline in key wildflowers^{vi}, and there is evidence to suggest that only farms located near natural habitats are able to sustain communities of pollinators sufficient to provide the necessary pollination services.

Several of the companies we spoke to raised the concept of "green deserts". These are areas where intensification of agriculture has resulted in large areas of land being converted to extensive monoculture systems, which will provide a food bonanza for pollinators during the short period of flowering for the entire monoculture, but a desert thereafter, compounding the impacts of natural habitat loss. This can occur as the unintended consequence of national or regional policies such as the EU's renewable fuel policies which has significantly increased the cultivated crop area given over to biofuel crops such as oil seed rape.

Predators

Parasitic mites, fungal parasites and viral diseases are all recognised as having an impact on pollinator numbers. However, it has been the spread of one particular mite, the varroa mite, which has been blamed most for the decline of pollinator numbers, and more specifically for CCD. The varroa mite has spread from Asia to the rest of the world over the last fifty years. Figure 1 shows the global estimates of CCD caused by the varroa mite.

Figure 1: Yearly average managed honey bee colony losses caused by the varroa mite.



Source: UNEP, 2010, UNEP Emerging Issues: "Global honey bee colony disorders and other threats to insect pollinators"

Pesticide use

In April 2013 the European Commission voted to ban the use of a group of pesticides known as neonicotinoids across the whole of Europe because of concerns about their impacts on beneficial, non-target insects such as pollinators. The neonicotinoids (the world's most widely used insecticide) will be banned for two years from use on flowering crops such as corn, oil seed rape and sunflowers. Prior to this decision, neonicotinoids were banned in France, Italy, Germany and Slovenia. In addition to this ruling, a coalition of beekeepers, environmental groups and food campaigners are suing the federal Environmental Protection Agency to get the insecticides banned in the USA.

This follows a series of scientific studies which have linked neonicotinoid use to losses in the number of queen bees (UK research found that the pesticide leads to an 85% decline in queen bee production^{viii}) and to increases in the incidence of “disappeared” bees. Neonicotinoids can affect navigation capacity of bees by interfering with the bee’s ability to learn and remember which subsequently impacts their ability to forage and to communicate to other hive members.

Given the financial significance of this range of pesticides to the agro-chem companies (Syngenta told us the Neonic ban would reduce sales by \$75 million, which is approximately 6.5% of Syngenta’s worldwide sales), and their global dominance as a pesticide, it is unsurprising that both proponents and exponents will contest each others’ findings. Disputes range from the impracticality of comparing lab tests with field tests, lack of focus on wider species range, lack of analysis of the impacts of chemicals in cocktail versus in isolation, and contamination of experimental process.

The findings from our research favour the conclusion that neonicotinoids do have an impact on bee behaviour, although they are not necessarily the sole cause of pollinator decline. Perhaps the words of Professor May Berenbaum (a leading US expert on CCD from the University of Illinois) best sums up the situation:

“there is no question that neonicotinoids are being used recklessly, for want of a better word. Fifty years of experience should have taught us that overuse of a single class of compounds is an inherently unsustainable practice, and that pre-treating seeds when pest problems might not even be present is colossally unwise. But neonicotinoids could be banned everywhere in the world, and honeybees would still have problems with pathogens, parasites, habitat degradation and overuse of just about every other class of chemical pesticide”^{viii}.

In referring to the lessons learnt over the last fifty years, Berenbaum refers back to a book, published in 1962, which was widely regarded as being instrumental in the launch of the environmental movement. Rachel Carson’s *Silent Spring* documented the effects of pesticides (DDT) on the environment and especially on birds, highlighting that chemicals can not be indiscriminately used without regard for their wider, indirect consequences on ecology and human health. As a result of her work DDT was banned from use in the US in 1972 and subsequently banned from agricultural use worldwide under the Stockholm Convention. It is therefore interesting to note that the American Bird Conservancy, perhaps in the spirit of *Silent Spring*, is claiming that neonicotinoids can also harm birds^{ix}.

As well as the direct impact on bees, there are also questions about the wider environmental impacts associated with the use of these pesticides. The chemicals accumulate in the soil and are likely to have a profound affect on soil microbes. Neonicotinoids have also been found in wild plants around treated fields and in streams and ponds, raising concerns about impacts on non-target insects.

In addition to the above stressors, mention should also be made about the impacts of climate change. Climate changes at all levels (global, regional, national and local) will alter the greening, flowering and ageing cycles of plants which will impact on pollinators, multiplying the impacts of habitat loss, predators and pesticide use. Ultimately climate change could alter the natural synchronisation between pollinator and plant life cycles and over the longer term be the most serious threat to pollinator numbers.

Importance of pollinators to agricultural production

Pollination is not essential for agricultural production and the level of dependence on pollination for different crops varies from 100% dependence (e.g. cocoa beans, kiwi fruits and melons) to no dependence (e.g. barley, rice, wheat and citrus fruits)^x. This is because some plants can self-pollinate or depend on wind pollination as opposed to animal pollination.

As a result, if we are talking about crop production in terms of quantity produced, then 60% of global food production comes from crops that do not depend on animal pollination (e.g. wheat, maize and rice) and 35% of crop production shows improvement (either in yield or quality) as a result of pollinationⁱ. However, within this 35% resides a far higher diversity of crops from fruits to vegetables and from oil-crops to spices which mostly have some degree of dependence on pollination. It is this diversity of crops that has a far greater importance to human nutrition as they add the proteins, vitamins and minerals to our diets, which we would not be able to get through eating cereals alone. Therefore, a focus simply on the total mass of production as dependant on pollination is misleading.

FAO states that 70% of the 115 most produced crops, including fruits and oilseeds, are animal pollinated^{iv}, and it is this 70% that account for 35% of agricultural production by mass mentioned in the previous paragraph. However, as we have discussed earlier, the dependence of these crops on animal pollination varies so it is misleading to say that, in the absence of pollinators, 35% of agricultural yields (by mass) would be lost. It is, though, clear that the quality and yield themselves would be affected to some degree.

Impact of pollinators on quality and yield

Pollinators have a significant influence on the quality of fruits and vegetables. For example, the more ovaries that are pollinated the higher the quality of the fruit (e.g. a perfect strawberry needs every single ovary to be pollinated).

One study assessed the impact of pollination on global agricultural production. It selected crops which represented around 99% of global food production (94.5% of production came from 57 leading single crops and 4.5% from five commodities which included fruit and vegetables). The study found that of the 57 single crops, 39 showed improvements as a result of pollination and 48 of the 67 commodity crops also demonstrated increased yields with pollination. The majority of crops would experience production loss owing to pollinator decline^{xi}. Another study found that 70% of 1,330 tropical crops showed increased fruit and seed quality and quantity as a result of animal pollination, as did 85% of 264 crops cultivated in Europeⁱⁱⁱ. There is clearly a relationship between yield improvements and animal pollination but, as demonstrated by the table in Appendix 1, the significance of this link varies depending on the crop in question.

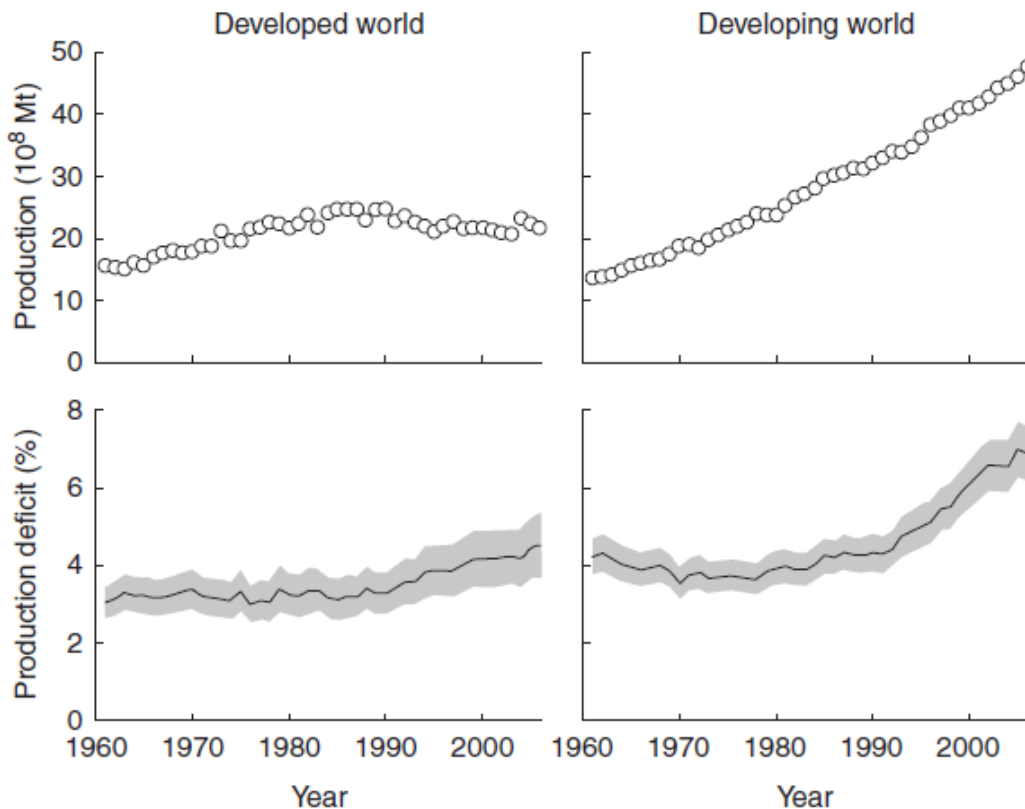
Crop dependency on pollination

As we have already mentioned, animal pollination is only one form of pollination with wind and self-pollination also playing a role. The majority of the world's agricultural production (by mass) is wind or self pollinated (e.g. carbohydrate crops such as wheat, rice and corn), but the majority of agricultural crops by diversity are affected by animal pollination. The level of dependence will affect crop yield, with some crops being 100% reliant on animal pollination, whilst in others the dependence on pollination for yield improvements could be as low as 5% (please refer to Appendix 1 for a list of the dependency ratios of some of the world's main crops). In addition to its yield benefits (e.g. a well pollinated flower will contain more seed which will deliver an enhanced capacity to germinate leading to bigger, better shaped fruits), improved pollination can also reduce the time between flowering and fruit set which in turn helps to reduce a crop's exposure to pests, disease, bad weather, agro-chemicals and water demand^{iv}.

There is still debate about the impact of pollinator decline on global crop yields and, if taken in terms of mass, then studies suggest that at the global level, if pollinators were to disappear, this would only reduce agricultural production by 4% to 6%. This is according to an article published in the *New Scientist*^{xii}, which was supported by the findings of a study published in the *Annals of Biology* stating that the production deficit in the absence of pollinators would be 3% to 5% in the developed world and 8% in the developing worldⁱⁱⁱ; however, the latter article notes that this does not measure the other values, such as nutritional or economic value, that would be impacted. With regards to the economic value argument it is estimated that the production value of one tonne

of pollinator-dependant crop is five times greater than a crop category that isn't dependant on animal pollination^{iv}.

Figure 2: Trends in total agricultural production and mean production deficits in the absence of animal pollination for the developed and developing world 1961–2006



Source: Annals of Biology, 2009, “How much does agriculture depends on pollinators? Lessons from long-term trends in crop production”

Global agricultural production has increased by about 140% between 1961 and 2006 (as demonstrated in figure 2), though production in the developed world has levelled off since the 1980s, whilst production in developing countries has shown a constant rate of increase over the last fifty years. However, the area that is given over to dependant crops has been growing faster than that allocated to non-dependant crops, implying a greater demand on pollinator services^{xiii}, as supported by a recent piece of research which states that in Europe the demand for pollination services from increasing areas of pollinator dependant crops is rising at a rate that is 4.9 times faster than available pollinator stocks^{xvi}. At the same time, research has indicated that yields of pollinator-dependant crops have levelled off (and this has been compensated for by expanding the cultivated area given to these crops) whilst yields from pollinator independent crops have continued to increase.

The developing world accounts for around two thirds of agricultural production and cultivated land, and supports agricultural systems that are 50% more dependant on pollinators than that of the developed world. This means that the cultivated area needed to compensate for pollinator collapse is six times larger in the developing world than in the developed world. At the same time, research has indicated that native crop pollinators seem to be lost faster in tropical agricultural landscapes than in temperate ones. We can also see in figure 2 the increase in production deficit as a result of pollinator decline which has increased by 50% in the developed world (despite production levelling off in the developed world) and has increased by 62% in the developing world (cultivated area has increased by 25% between 1961 and 2006)ⁱⁱⁱ.

So when discussing the impact of pollinator decline on global agricultural systems one has to differentiate between a focus on the mass of global crop yield or a focus on the diversity of plants affected and their nutritional and economic value. Currently, yields in dependant crops have started to decline which may have been compensated for by an increase in cultivated area for dependant crops. Whilst there is currently no clear evidence of negative impacts of pollinator decline on global crop yields, the increasing demands for pollination

services (due to increasing cultivated area and changing diets) at a time when pollinator numbers are in decline imply that this could threaten future crop yields, with broad economic and nutritional implications. The following section will discuss the economic value of pollination services and their decline.

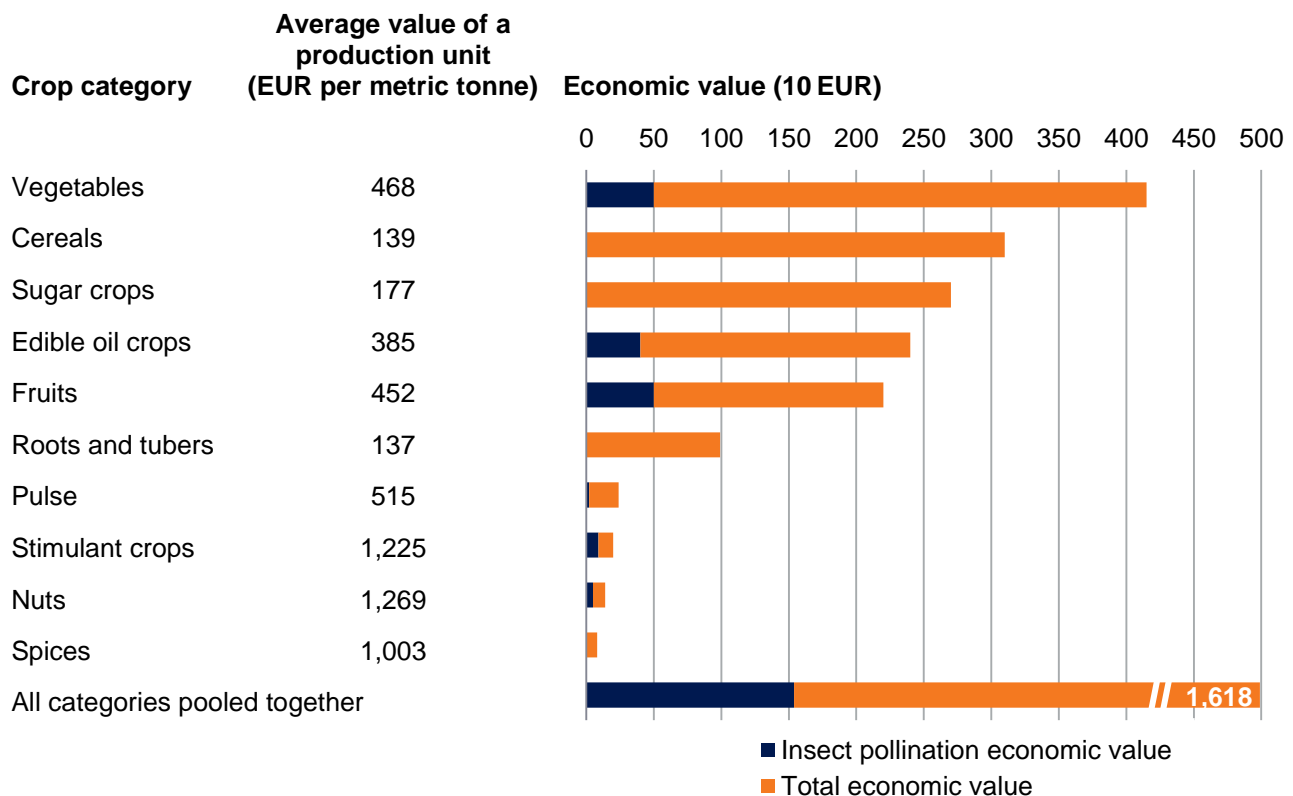
Economic impacts of pollinator decline

There are a number of studies which have attempted to quantify the value of pollination services to agricultural production. Typically these have focused on calculating the losses that could be accrued as a result of pollination service decline, although they could also be calculated by focusing on the costs of mitigation. The loss calculation approach (deficit approach) requires the quantification of the decrease in productivity measures (e.g. yield, quality) in the absence of pollination, whilst the second approach (or compensation method) requires a calculation of the inputs needed to offset pollination declines (e.g. increasing cultivated areas, increasing the use of commercial bees or the labour costs for hand pollination). The dominant methods used in the reports read as background to this paper have used the deficit approach.

Any economic calculation should calculate not only the production yield changes but also the price changes which will impact the consumer surplus, because typically if yields decrease then prices increase and less food will be traded which will cause the consumer surplus to decline.

In terms of the economic impacts of pollinator decline there are a wide range of figures presented in the research, some of which talks about the economic loss from managed bee decline, others simply from pollinator decline. The most common figures are given at a global level though there are some figures which also provide an indication of the economic impact in the UK and the USA. At the global level, predictions range from £26 billion to £141 billion per year, with most estimates clustering around £130 billion per year (approximately 10% of the economic value of agricultural production). In the UK, two media sources quote a figure of around £430 million per year at the national level and in the USA the figure ranges from £3.9 billion to £9.4 billion per year at the national level.

Figure 3: Economic impact of insect pollination in agricultural production used directly for human food worldwide



Source: “Global honey bee colony disorders and other threats to insect pollinators”, UNEP Emerging Issues, 2010

The figure of €153 billion (or £129 billion) is used both by FAO and the United Nations Environment Programme, and figure 3 provides a visual indication of where this value is derived from across different agricultural crops (as well as demonstrating the relevance of pollination dependency to yields).

As mentioned earlier these figures tend to only focus on the deficit calculation, and a more complete economic analysis would also include the consumer surplus figure. Table 1 is adapted from the website for the statistics division of the FAO. It not only demonstrates the different levels of dependency of a selection of crops but also how this affects consumer surplus based on two different elasticities of demand. FAO estimate that the global value of pollination services was €153 billion in 2005 (around £129 billion) and that the associated consumer surplus loss would be €190 billion to €310 billion (£160 billion to £261 billion).

These figures should not be considered precise, but should be taken as an indicator of the magnitude of the value of pollination services which are currently not being recognised by the market as providing a service of economic value. In addition, these figures have tended to focus only on agricultural production of crops for human consumption, they do not take into account the importance of pollination services in the production of seed used for planting (important for vegetable and forage crops) nor of non-food crops, wild flowers and all services that natural flora and fauna provide to agriculture and society as a whole (e.g. the pharmaceutical, perfume and biofuel industries all have exposure to pollination services within their supply chains). Furthermore they do not consider that pollination service decline will, more than likely, impact a multitude of crops at once, further exacerbating the economic and consumer surplus losses as opposed to individual crops.

Table 1: A hypothetical example of the methodology for calculating the economic valuation of the contribution of insect pollination to agriculture and the associated impacts on consumer losses*

*We have used average prices for crop category [see figure 3] and a generic production unit of 10 tonnes. Using the full data set it is possible to calculate the economic value at national and global levels for all crops.

Crop common name ¹	Crop category following FAO ¹	Dependence upon animal pollination ²	Min ²	Max ²	Mean (D) ²	Producer price per metric ton USD/metric ton	Production Metric ton	Total value of crop (TVC) Price * production USD	Economic value of insect pollinators (EVIP) TVC*D USD	Ratio of vulnerability (RV) EVIP/ TVC	Consumer surplus loss (CSL) with elasticity =	
											-0.8 USD	-1.2 USD
Barley	Cereals	No increase	0	0	0	139	10	1,390	0	0%	0	0
Apples	Fruits	Great	0.4	0.9	0.65	452	10	4,520	2,938	65%	5,280	4,280
Rapeseed	Oilcrops	Modest	0.1	0.4	0.25	385	10	3,850	363	25%	1,140	1,076
Beans, dry	Pulse	Little	0	0.1	0.05	515	10	5,150	258	5%	266	263
Potatoes	Roots and tubers	Increase – breeding	-	-	-	137	10	1,370	0	0%	-	-
Vanilla	Spices	Essential	0.9	1	0.95	1,003	10	10,030	3,529	95%	41,151	22,604
Cocoa beans	Stimulant crops	Essential	0.9	1	0.95	1,225	10	12,250	11,638	95%	50,260	27,607
Sugar beet	Sugar crops	No increase	0	0	0	177	10	1,770	0	0%	0	0
Almonds, with shell	Treenuts	Great	0.4	0.9	0.65	1,269	10	12,690	6,249	65%	14,624	12,017
Watermelons	Vegetables	Essential	0.9	1	0.95	468	10	4,680	4,446	95%	19,201	10,547

Note: Adapted from FAOSTAT's "Array for the economic valuation of the contribution of insect pollination to agriculture and impact on welfare; ¹Sources: FAOstat (<http://faostat.org>) and ²Sources: Klein et al. 2007

A question of scale

The majority of studies have aimed to quantify the global impact of pollinator decline and have generally concluded that the impact would be around 10% of the total value of human food production. However, a global analysis disguises the impacts of pollination decline at national and local levels or on specific sectors (e.g. the production of cocoa beans is 95% dependant on pollination, and so chocolate confectionary production has a very real, material exposure to this issue).

At the national level the contribution of agriculture to GDP varies immensely. World Bank figures indicate that, in 2011, it can range from 57% in Sierra Leone to less than 0.1% in Singapore^{xiv}, with developing economies showing a greater dependency on agriculture and hence a greater exposure to the risks of pollinator decline. In Latin America, Africa and Asia an average of 40% of the cultivated land is planted with crops with some dependence on pollinatorsⁱ, although this is considered to be a low estimate by FAO. In addition, some countries may have a material exposure to one crop (e.g. coffee) as a significant contributor to its GDP magnifying the impact that pollinator decline could have.

At the local level, there are a couple of examples in the literature demonstrating the importance of pollination services (and of the supporting natural habitat) to agricultural returns. A study of a Canadian apple orchard found that good pollination increased the number of seeds per apple, which in turn lead to larger and better formed apples. These improved apples were estimated to provide marginal returns of about 5% to 6%, or CAN\$250/hectare, compared with insufficiently pollinated orchards. The paper also noted that farmers were also willing to pay for commercial pollination services when their crops may be getting adequate pollination from wild pollinators, yet farmers didn't pay to secure these services (e.g. through habitat maintenance) though they clearly placed a value on pollination^{xv}.

This reference to the value of natural habitat for wild pollinators was echoed in a study of the commercial importance of pollination services to coffee production in Costa Rica. The study found that yields of coffee plants near to natural forests increased by 20.8% due to wild pollinators, giving an annual surplus of \$62,000 generated by these forest patches (around 7% of the annual income of the plantation)^{xvii}. This indicates that the value of intact forests (according to the author) was far greater than the expected annual earnings from the same land if it were deforested and converted to agricultural useⁱ (not to mention the other ecosystem services provided by the forest such as pest control, carbon sequestration, soil stabilisation and water regulation). This supports calls for natural areas to be managed not just for the goods that they provide, but also the services they provide, and that agricultural intensification maybe having a long-term negative impact on yields through the decline in the provision of wild habitats for pollinators.

Stock level relevance of pollinator decline

So far this paper has illustrated that there is mounting evidence showing that there is a global decline in pollinators around the world as a result of various factors. The impact of this decline depends on what is being assessed; at the global level the impact of pollinator decline is limited though at the micro level the impact can be quite significant. We have also seen that yields and quality do vary as a result of pollinator decline, affecting the productivity of the majority of crop species, which can be supplemented for by increasing cultivated area at the expense of natural habitat and through the use of commercial pollination services. However, there is also evidence supporting the economic benefits of maintaining natural habitats.

We do not believe that this issue is currently having a material impact on the global economy, though its relevance for national economies will vary depending on the significance of agriculture to a nation's economy. However, we do believe that with increasing food demand (the FAO projects that food production will need to increase by 70% by 2050 to meet demand) and decreasing pollinator numbers this is an issue that needs to receive more attention. Furthermore, future academic, non-governmental, governmental and corporate analysis should broaden in geographic scope and species assessed (recognising that declines in bee numbers may simply be a reflection of what may be happening in other pollinator species), as well as assessing the potential impacts on other non-target organisms which are essential for ecosystem function.

At the stock level we have highlighted the following sectors and companies that we believe would have exposure to this issue.

Table 2: Companies assessed for coverage of pollinator decline within publicly available information

Sector	Companies	Rationale
Agrochemicals	<ul style="list-style-type: none"> — Syngenta — Bayer 	Producers of neonicotinoids pesticides which are blamed for being one of the stressors responsible for pollinator decline. These companies also have self-interest in ensuring the long-term survival of pollinators to ensure the economic success of their main client base.
Food Retailers	<ul style="list-style-type: none"> — Tesco — Marks & Spencer — J Sainsbury — Metro Group — Carrefour — WM Morrison — Ahold — Colruyt 	Food retailers have exposure to most if not all agricultural crops, whether through the provision of fresh fruit and vegetables, processed meals, fruit juices or confectionary. This means they should be monitoring and managing any medium- to long-term risks in their supply chain.
Food Producers	<ul style="list-style-type: none"> — Nestle — Unilever — Kraft — Danone — ABF — Hershey 	These companies have differing exposure to pollinators because of different product ranges. Some produce confectionary (cocoa exposure) and dairy products with natural fruit flavourings and others produce fruit juices. In addition some of the oil crops will be used in marinades and sauces made by these companies.
Luxury Goods	<ul style="list-style-type: none"> — LVMH — L'Oreal — Christian Dior — Hermes 	Perfumes use different parts of a plant (amongst other sources) for their aromatic properties. The largest and most common source is from the flowers and blossom of a plant, which evolved aromatic properties in order to attract pollinators. These would be at risk should pollinator numbers decline.
Beverages	<ul style="list-style-type: none"> — Coca-Cola — Dr Pepper — Snapple Group — Britvic — Pepsico 	Most of the companies in this sector have exposure to the issue through some of their products, whether flavoured fizzy drinks or concentrated fruit drinks to fresh fruit juices.

We reviewed the publicly available information (annual reports and accounts, websites and corporate responsibility reports) of these companies, searching for key topics such as bees, pollinators, pesticides, biodiversity and sustainable agriculture in order to develop a snap-shot of the level of discussion on this topic.

Almost a third of the 25 companies made explicit reference to their long-term success being dependant on the functioning of a healthy ecosystem, with 20% also recognising their role in having to preserve and restore ecosystem services and biodiversity. 50% of the companies referred to pesticide usage, though this predominantly focused on the concerns about the impact of pesticide residues on food products to human health and on sustainable pesticide use. However, recognising that discussion on bees may be too specific we also searched for references to sustainable agriculture and biodiversity which was covered by almost a third of the companies assessed.

There is clearly recognition of the importance of healthy, functioning ecosystem services to most of the companies within this research. Nestlé notes that: *“to ensure our long-term success we must ensure that biodiversity and ecosystem services continue to flourish”*. Comments like this demonstrate the increasing recognition of the services that ecosystems play in the successful execution of a business strategy. Interestingly, when it came to the specific topic of pollinator decline, both the agro-chemical companies covered the topic, and it was also explicitly covered by two supermarket chains and one luxury good provider.

Scientific awareness of pollinator decline has been around for some time now, so it is disappointing not to discover a higher level of discussion on the topic. However, we have to recognise that around 25% of the companies researched have very poor levels of disclosure on corporate responsibility in general. So it is therefore encouraging to see the emerging recognition of the role that healthy ecosystem services play in the long-term success of the business, and also to see that there is some recognition of the role of pollinators within this.

The following companies (from table 2) responded to our request for a discussion on this topic: **LVMH, Syngenta, Britvic, Morrisons, Sainsburys and Marks & Spencer**. These meetings served to reinforce the findings of our literature review, though also to provide confidence that more work is being dedicated to this area as well as to broader biodiversity concerns. Broadly speaking no company was able to directly link pollinator decline to an impact on operating costs, though most would agree with M&S which said that there clearly was a cost but its value would only be recognised when the service was completely lost (M&S also said that the costs and quality of hand pollination made this, as an option, prohibitive). Britvic, perhaps with a touch of irony, also recognised that if quality decreases with declining pollinator numbers then this may actually be beneficial to its business as there would be larger quantities of low-value crop available in its supply chain.

In terms of recognising the causes of pollinator decline, all companies engaged with recognised that habitat loss was a major driver and many were taking advice on pesticide use and providing guidance on this in their supply chains. Most of the specific action to tackle pollinator decline was limited to recently updated guidelines for suppliers and the establishment of pilot studies within supply chains to assess the outcomes of adopting different production practices, reflecting the relative newness of this issue.

However, LVMH provided a very clear case study of a longer-term involvement in managing wild bee habitat in recognition of its economic value to the business. LVMH uses the honey from a remote, pesticide and predator free, island population of black bees off the coast of Brittany in one of its brand's cosmetic creams. LVMH recognises the importance of keeping this population pesticide and predator free not just for its product (where the purity of a product applied to the body is a value) but also as a reference population for future scientific study. The value it places on this is so much that it has used its legal team to help protect the pristineness of the environment in which the black bees live, while also supporting various bee conservation organisations.

Perhaps less encouraging was the finding that, because of concerns about competition rules, discussion *between* companies is limited. This means any industry responses will have to be co-ordinated through external bodies. It is clear, though, that this issue has numerous stakeholders in different industrial sectors and it is here that investors, as universal owners, have a role to play through the recognition that a system-wide response is needed to tackle the issue and investors will have an exposure to many of the actors involved in such a response.

Conclusion

The aim of this research was to determine the seriousness of the issue of pollinator decline and the potential ramifications for investable stocks. We have found that this is clearly an issue with economic and nutritional significance, but that we were only able to gather a few current examples of pollinator decline directly affecting yields. However, the research would suggest that should pollinator numbers continue to decline then this is surely an eventuality.

There is also little to suggest that it is visibly impacting operating costs for the companies we analysed. That said, all companies recognise it as an issue, acknowledging that pollinators provide an economic service which is only likely to be recognised should the service be ceased or seriously reduced. Efforts, by corporates, to address the issue are in early stages and predominantly focus on pilot projects with a small group of suppliers.

However, the broad scope of pollinator-dependant products – covering sectors from food retailers to cotton manufacturers – means that this is a systemic issue and one to which investors have a unique exposure as universal owners. It is too early to reflect a consideration of pollinator decline in valuations but it is not too early to engage with companies throughout the investment universe on this issue in order to develop a response to halt and reverse this decline in a valuable part of our economy before its consequences become more significant. This will cover a broad range of companies from water utilities with large land reserves, food retailers with direct exposure in their supply chain, agro-chemical companies with product exposure, cosmetic firms and everything in between.

Appendix 1

Dependence of crops on insect pollination

Crop common name ¹	Crop category following FAO ¹	Dependence upon animal pollination ²	Dependence Ratio		
			Min ²	Max. ²	Mean (D) ²
Barley	Cereals	No increase	0	0	0
Hops	Cereals	No increase	0	0	0
Maize	Cereals	No increase	0	0	0
Oats	Cereals	No increase	0	0	0
Rice, paddy	Cereals	No increase	0	0	0
Rye	Cereals	No increase	0	0	0
Sorghum	Cereals	No increase	0	0	0
Wheat	Cereals	No increase	0	0	0
Apples	Fruits	Great	0.4	0.9	0.65
Apricots	Fruits	Great	0.4	0.9	0.65
Avocados	Fruits	Great	0.4	0.9	0.65
Bananas	Fruits	Increase – breeding	—	—	—
Cashewapple	Fruits	Great	0.4	0.9	0.65
Cherries	Fruits	Great	0.4	0.9	0.65
Cranberries	Fruits	Great	0.4	0.9	0.65
Currents	Fruits	Modest	0.1	0.4	0.25
Grapes	Fruits	No increase	0	0	0
Kiwi fruit	Fruits	Essential	0.9	1.0	0.95
Lemons and limes	Fruits	Little	0	0.1	0.05
Oranges	Fruits	Little	0	0.1	0.05
Peaches and nectarines	Fruits	Great	0.4	0.9	0.65
Pears	Fruits	Great	0.4	0.9	0.65
Pineapple	Fruits	Increase – breeding	—	—	—
Plums and sloes	Fruits	Great	0.4	0.9	0.65
Raspberries	Fruits	Great	0.4	0.9	0.65
Strawberries	Fruits	Modest	0.1	0.4	0.25
Tangerines, mandarine, clem	Fruits	Little	0	0.1	0.05
Coconuts	Oilcrops	Modest	0.1	0.4	0.25
Groundnuts, with shell	Oilcrops	Little	0	0.1	0.05
Linseed	Oilcrops	Little	0	0.1	0.05
Mustard seed	Oilcrops	Modest	0.1	0.4	0.25
Oil palm fruit	Oilcrops	Little	0	0.1	0.05
Olives	Oilcrops	No increase	0	0	0
Rapeseed	Oilcrops	Modest	0.1	0.4	0.25
Seed Cotton	Oilcrops	Modest	0.1	0.4	0.25
Sesame seed	Oilcrops	Modest	0.1	0.4	0.25
Soybeans	Oilcrops	Modest	0.1	0.4	0.25
Sunflower seed	Oilcrops	Modest	0.1	0.4	0.25

Crop common name ¹	Crop category following FAO ¹	Dependence upon animal pollination ²	Dependence Ratio		
			Min ²	Max. ²	Mean (D) ²
Beans, dry	Pulse	Little	0	0.1	0.05
Chick peas	Pulse	No increase	0	0	0
Lentils	Pulse	No increase	0	0	0
Peas, dry	Pulse	No increase	0	0	0
String beans	Pulse	Little	0	0.1	0.05
Cassava	Roots and Tubers	Increase – breeding	—	—	—
Potatoes	Roots and Tubers	Increase – breeding	—	—	—
Sweet potatoes	Roots and Tubers	Increase – breeding	—	—	—
Chillies and peppers, dry	Spices	Little	0	0.1	0.05
Cloves	Spices	Unknown	—	—	—
Ginger	Spices	Unknown	—	—	—
Pepper (Piper spp.)	Spices	No increase	0	0	0
Vanilla	Spices	Essential	0.9	1.1	0.95
Cocoa beans	Stimulant crops	Essential	0.9	1.1	0.95
Coffee, green	Stimulant crops	Modest	0.1	0.4	0.25
Tea	Stimulant crops	No increase	0	0	0
Sugar beet	Sugar crops	No increase	0	0	0
Sugar cane	Sugar crops	No increase	0	0	0
Almonds, with shell	Treenuts	Great	0.4	0.9	0.65
Brazil nuts, with shell	Treenuts	Essential	0.9	1.0	0.95
Cashew nuts, with shell	Treenuts	Great	0.4	0.9	0.65
Pistachios	Treenuts	No increase	0	0	0
Walnuts, with shell	Treenuts	No increase	—	—	—
Artichokes	Vegetables	Increase – seed production	—	—	—
Asparagus	Vegetables	Increase – seed production	—	—	—
Beans, green	Vegetables	Little	0	0.1	0.05
Cabbages and other brassicas	Vegetables	Increase – seed production	—	—	—
Carrots and turnips	Vegetables	Increase – seed production	—	—	—
Cauliflowers and broccoli	Vegetables	Increase – seed production	—	—	—
Chillies and peppers, green	Vegetables	Little	0	0.1	0.05
Cucumbers and gherkins	Vegetables	Great	0.4	0.9	0.65
Eggplants (aubergines)	Vegetables	Modest	0.1	0.4	0.25
Garlic	Vegetables	Increase – breeding	—	—	—
Lettuce and chicory	Vegetables	Increase seed production	—	—	—
Mushrooms and truffles	Vegetables	No increase	0	0	0
Onions (inc. shallots) green	Vegetables	Increase seed production	—	—	—
Other melons (inc. cantaloupes)	Vegetables	Essential	0.9	1.0	0.95
Peas, green	Vegetables	No increase	0	0	0
Pumpkins, squash and gourds	Vegetables	Essential	0.9	1.0	0.95
Spinach	Vegetables	No increase	0	0	0
Tomatoes	Vegetables	Little	0	0.1	0.05
Watermelons	Vegetables	Essential	0.9	1.0	0.95

Note: Adapted from FAOSTAT's "Array for the economic valuation of the contribution of insect pollination to agriculture and impact on welfare"

¹Sources: FAOstat (<http://faostat.org>)

²Sources: Klein et al. 2007

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