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Insect Decline

European stag beetle (*Lucanus cervus*)

SÉNAT

Summary

- *The decline of insects is a complex phenomenon that is difficult to evaluate, but on which there is nevertheless a scientific consensus. Currently, 41% of species are thought to be concerned and 31% threatened with extinction around the world, with a loss in the order of 1% of species per year.*
- *The causes of this decline are linked to habitat loss, the worsening quality of the environment (pollution), global warming and invasion by alien species. Agriculture seems to be one of the main drivers behind the insect decline, in particular due to excessive pesticide use.*
- *Insect decline is leading to a major weakening of biodiversity. Insects provide fundamental services to the ecosystem, such as pollination, recycling of organic matter, biological control of pests, and food for many vertebrates. Protecting them must be a political priority; otherwise, we risk dramatic consequences for ecosystems and humanity itself.*

Annick Jacquemet, Senator

Insects, symbols of biodiversity

Insects appeared more than 400 million years ago and were among the first animals to colonise land ecosystems.[1] Although their global population is still not well known,[2] **they represent 80% of the eukaryote[3] species currently present on Earth, and their biomass exceeds that of humans.** They can be recognised by their three-part bodies (head, thorax and abdomen), their chitinous exoskeleton, their compound eyes, two antennae and three pairs of legs.[4] Among the 28 current orders of insects, five represent 80% of insect species: Coleoptera (beetles, ladybirds, weevils), Lepidoptera (butterflies), Diptera (flies and mosquitos), Hymenoptera (bees, wasps, ants) and Hemiptera (so-called 'true bugs', aphids).[5]

Insect decline: a scientifically well-established mass phenomenon despite certain methodological difficulties

There is only a small portion of data available on the changes in insect populations and diversity. This data focuses on a small number of species, mainly in Europe and North America.

Insect decline has long been underestimated, unlike the decline in more iconic vertebrates,[6] in particular due to the methodological difficulties[7] encountered in measuring them. Putting forward precise and global figures on the extent of this decline remains difficult.

Insect decline can be measured in terms of abundance (number of individuals), richness (number of species) and biomass (weight).

The evidence that has accumulated through a multitude of scientific studies has led to the following observations.

The loss of major taxa[8] began in the early 20th century, accelerated in the 1950s-1960s, and has taken on alarming proportions in the past two decades.[9]

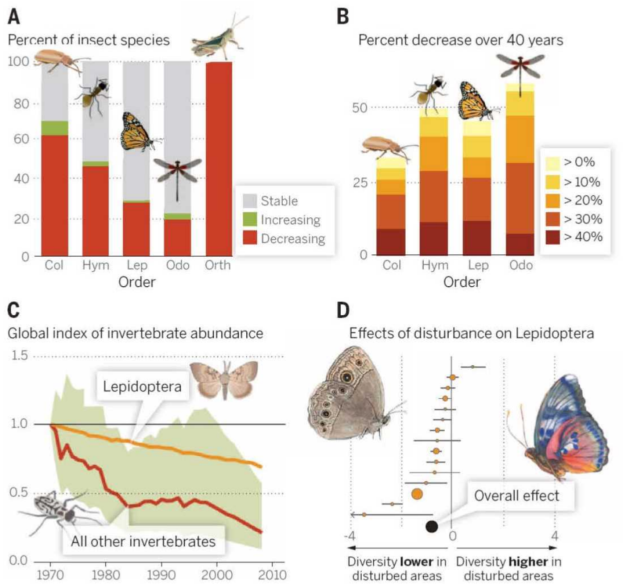
In France, there is no overall study of the knowledge about the condition and trends of insect communities.[10] However, as part of the European Habitats Directive,[11] in 2019 France undertook the evaluation of the conservation status[12] of 44 insect species of Community importance.[13] 35% of the evaluations concluded that the conservation status was favourable, 56% of them unfavourable and 11% unknown.[14] **The situation for insects associated with aquatic and humid ecosystems is particularly critical, with two-thirds of them found to be in an unfavourable conservation status.** The Alpine biogeographical region,[15] which only has 9% of bad statuses, is where the share of favourable evaluations is the highest (52%). The Atlantic region is where insects are in the most delicate situation, with two-thirds of evaluations being unfavourable (including a quarter of bad statuses), followed closely by the Continental region (61% of unfavourable evaluations, including a third in bad status).

Almost no positive trends were observed in the insects evaluated during the 2013-2018 period.[16] The insects associated with grasslands, moors and thickets, mainly butterflies, showed the strongest trend of decline (27% of evaluations related to this type of ecosystem).

These results are consistent with those of other international works.

For example, a study conducted on a million arthropods (around 2,700 species) collected between 2008 and 2017 in 150 grasslands and 140 forests located in three different regions of Germany showed a **decline in arthropods in the grasslands and forests of respectively 78% and 17%[17] in the number of**

individuals, 34% and 36% for species richness and 67% and 41% in terms of biomass.[18]



Source: Rodolfo Dirzo et al (2014). Defaunation in the Anthropocene. Science. Vol 345

Another study[19] looked at five orders of insects[20] appearing on the red list of the International Union for Conservation of Nature (IUCN).[21] **33% are in decline, with substantial variations between orders (20% of odonatopterans, 100% of orthopterans[22] and 60% of coleopterans are in decline)** (figure A above). In these five orders, there are many more species in decline than species that are growing. In the United Kingdom, for four orders of insects, the decline in the number of individuals over the last 40 years varies between 30% and 60% (figure B above). In general, **based on a long-term monitoring of a sample of 432 species, we can see a decline of 45% over the last 45 years for 2/3 of taxa**, although the decline is less severe for lepidopterans than for other orders (figure C above). Consequently, if we base ourselves on lepidopterans to describe insect decline (because this is the order for which we have the most specific data), we tend to underestimate it.

In total, the proportion of insect species in decline (41%) is thought to be twice as big as that of vertebrates, and the extinction rate of local species[23] (10%) eight times greater. **Currently, around a third (31%) of insect species around the world are threatened with extinction under IUCN criteria.** Furthermore, each year 1% of insect species are added to this list, which is thought to lead to an annual loss of 2.5% of biomass at the global level.[24]

Insect decline remains a complex phenomenon. We are far from seeing all species in decline, and some are even growing.[25] Multivoltine species (several generations per year)[26] and mobile species are globally less affected. However, species that are specialised,[27] reliant on rarefying habitats or potential nesting or hibernation sites, species that depend on specific host plants[28] as well as univoltine or sedentary species are the most exposed.

A consensus is emerging within the scientific community to say that insect decline concerns above all groups of specialist insects, whereas generalist species hold up better.[29]

A multicausal phenomenon largely linked to the expansion of intensive farming

Anthropic pressure through deforestation,[30] the expansion of intensive farming[31] and urbanisation[32] is drastically changing how land is used. **The resulting loss, weakening[33] and fragmentation[34] of natural[35] and semi-natural habitats[36] are probably the most significant threats to biodiversity in general[37] and insects in particular.** Insects have fewer or modified supplies of resources and possibilities for reproduction. For example, in areas of widespread soya and sunflower farming, domestic bees suffer from food shortages in the spring and from the end of summer due to the lack of varied sources of pollen throughout the year.[38] Furthermore, species variety is harmed at the expense of specialist insects that cannot change habitat or adapt to these changes.[39]

Air, water and ground pollution contribute heavily to insect decline, and **pesticides (insecticides, herbicides, fungicides) have a particularly significant responsibility.**

Whatever the type of insecticide,[40] its inherent toxicity has unintended effects on insects, especially pollinators.

Three characteristics make neonicotinoids (which were allowed to be sold in Europe in the 1990s) particularly harmful:

- their range of action is very broad, they are toxic at a very low dose,[41] their systemic effect makes them present in all the plant's organs (including pollen and nectar), and they can be ingested by many insect species,
- they are used, often needlessly, as a prophylactic at the start of farming (for example, by coating the seeds) regardless of a proven risk of proliferation of the targeted insects,[42]
- their residues persist in the environment for a very long time, especially in the soil,[43] where they continue to poison wildlife long after they are no longer used.[44]

Besides insecticides, **herbicides,[45] fungicides[46] and fertilisers[47] contribute heavily to insect decline, in particular by modifying the usable plant life.**

Pesticides constitute an especially significant threat to insects due to their intensive use[48] over the past decades[49] and regulations that are unsuitable[50] for evaluating the risks that they entail.[51]

The evaluation of risks linked to pesticides before they are placed on the market: insufficient regulations at the European and national levels

The European regulations require that ecotoxicological data on domestic bees be presented before pesticides are placed on the market. **However, this evaluation is incomplete with respect to the effects demonstrated in the scientific literature such as the chronic effects on adult bees[52] and larvae[53], the effects on behaviour,[54] the effects on reproduction,[55] the effects on other species of domestic bees,[56] multi-stress effects,[57] and multi-substance effects.[58]** This is why the European Food Safety Authority (EFSA) issued an **opinion in 2012 that concluded that the procedures to evaluate the risks to bees were insufficient** and drafted a new guidance document on the methods to evaluate the risks to bees and other pollinating insects (EFSA GD 2013). **Eight years after this guidance document was published, it has still not been adopted by the Member States.[59]**

At the national level, Anses was twice requested[60] to issue an opinion as part of the revision of the order of 28 November 2003 relative to the conditions for using insecticides and acaricides for agricultural use with a view to protecting bees and other pollinating insects. In both opinions, it insisted on **restricting the application of products with an exemption from treatment prohibition to after sundown and the three following hours.** As part of the new request, it recommended **expanding the regulatory provisions to all sprayed plant protection products[61]** during periods of flowering and/or exudation. The revised order was published last 20 November. It only partially incorporates Anses's recommendations.[62]

Finally, in a 2019 self-referral,[63] Anses recommended a change to the methods of assessing the toxicity of plant protection products based on the 2013 EFSA guidance document.

Industrial pollution such as air, chemical and heavy metal pollution also leads to a decline in insect population with sublethal effects, just as pesticides do. Water pollution impacts freshwater insects dramatically.[64]

Sound[65] and light pollution[66] (made worse by the spread of LED lights)[67] are also becoming omnipresent.

Climate change has contrasting effects on insects[68]—thermophile species, generalists and certain pests benefit from it—**but, overall, it constitutes a threat to species diversity.** First, it leads to a **change in the potential distribution area** that certain insects cannot keep up with due to dispersion barriers.[69] Secondly, it comes with **extreme weather phenomena** such as heatwaves, droughts, strong rains, and rapid changes in temperature that can have a strong impact on populations at the local level.[70] Finally, it causes variations in plants' lifecycles and leads to **phenological discrepancies[71]** (for example, pollinators' foraging periods and flowers' blooming periods are no longer synchronised, leading to a shortage of food for the insects, premature death, and ultimately less pollination of flowers).

Biological invasions (plants, insects, pathogens and alien predators) have a real impact on insect biodiversity.[72] These are fostered by global trade and climate change.[73]

Insect decline is therefore a complex, multicausal phenomenon, whose stress factors can cumulate or, sometimes, counterbalance each other, depending on the species. **Nevertheless, the spread and intensification of agriculture[74] appear to be the main drivers behind insect decline** with habitat loss, the reduction in functional connectivity, over-intensive management of land, the increase in nitrogen levels[75] and the use of other fertilisers, as well as the too-frequent and unreasonable application of pesticides.[76] [77]

Dramatic ecological consequences for ecosystems and humanity

Biodiversity has inherent value beyond the eco-systemic services it provides.[78] It makes up the natural heritage that humanity leaves to future generations. Given that insects make up 80% of land species, **their decline constitutes a major weakening of biodiversity for our planet.**

In the collective imagination, insects are often reduced to potential vectors of illness such as dengue, yellow fever or malaria, or pests to crops. However, insects that are vectors for human pathogens only represent 1% of mosquito species, and only 1% of insects are considered to be pests to crops.[79] **The extent of these afflictions is often made worse by the direct and indirect effects of human activities.[80]**

In fact, **insects provide many eco-systemic services on which humanity greatly depends.**

First, they offer basic services that stabilise and allow ecosystems to function:

- **they play an essential role in plant reproduction through pollination** and help to maintain their genetic diversity: 80% of wildflowers depend on entomophilous pollination in some form,[81] and 50% of them are completely dependent on it,[82]
- **they are an essential link in the food chain** by providing food for a great number of vertebrates.[83] In France, depending on the species, up to 30% of bird numbers have been lost over the past 30 years, and 2% of individuals die out every year.[84] Insect decline is one of the scientific explanations for the decline in insectivorous birds,[85]
- **they recycle organic matter** (macro-decomposition of leaves and wood, elimination of excrement[86] and carrion) and contribute to the cycle of nutriments, soil formation and water purification,[87]
- **their diversity contributes to keeping ecosystems in good working order[88] and resistant to the changes and stress factors to which they are subject.[89]**

Insects also provide regulation services through biological control of pests (micro-wasps that lay eggs in aphids, aphids attacked by syrphus fly larvae and ladybirds), **weeds and vectors of disease.**

Additionally, through pollination, insects provide ever more important provisioning services[90] by guaranteeing our food safety not just in volume,[91] but above all in quality.[92] Out of the 107 main types of crops worldwide, 91 (fruits, grains and nuts) depend on animal pollination to varying degrees. It has been calculated that **a total extinction of pollinators would lead to a drop in production of over 90% for the 12% of the world's main crops**[93] and an increase in the number of people with a deficiency in vitamin A, iron and folate.

The impact of the decline of pollinators on agriculture is already being felt, since the yield per hectare of the crops that depend on pollinators is increasing less and varying more from one year to the next than the yield per hectare of the crops that do not depend on them.[94]

Finally, insects provide marketable products, such as silk and honey, and make up a source of protein, vitamins and minerals in many parts of the world.[95]

Insects occupy key positions in many ecological networks. While ecosystems may have shown surprising ecological resilience until now, **the scientific community is unanimous in believing that there is a threshold beyond which insect decline will have irreversible cascading effects and threaten the eco-systemic services that humanity depends on.**

The need for political will to effectively fight insect decline

The main causes in the fall in insect diversity and numbers is well known and scientifically demonstrated.[96] The measures to be taken are as well, which, beyond the "*urgent and global actions to slow down the general erosion of* *biodiversity*",[97] seek in particular to change the methods of agricultural production to make them more compatible with wildlife.[98]

However, scientific knowledge has rarely led to political effects[99] and is sometimes used by certain players as a stalling tactic to distract attention, **sow confusion and delay action from public authorities.[100]**

Many measures have been taken in the past few decades[101] at both the European and national levels to improve knowledge on insects and their decline, protect endangered species,[102] control how plant protection products are placed on the market and encourage farming that is more respectful of insects. However, these measures have proved relatively ineffective in fighting insect decline.[103]

Today, there are two priorities to change agricultural production methods:

- **use the right levers of action to support the agro-ecological transition**. At the European level, the common agricultural policy (CAP) represents €50 billion per year.[104] It is a considerable lever for action that, despite its reform in 2021,[105] could be used further, in particular to respect the **objectives to reduce the use of chemical pesticides set in the European Commission's "Fork to Table" strategy.[106] Ultimately, only the most environmentally respectful practices should receive economic aid**.[107] At the national level, the national strategic plan,[108] France's PNDAR national agricultural and rural development plan,[109] the national plan for pollinators, the ecophyto plan, and the objectives and performance contracts between the government and the Permanent Assembly of Chambers of Agriculture as well as technical institutes must serve as major tools to accelerate the agroecological transition,[110]
- **support farmers without blaming them**: farmers are subject to many contradictory demands[111] that they are supposed to figure out by themselves, although they are largely dependent on a system in which all the players have adapted their strategy to specialised production systems that use chemical inputs intensively (a "sociotechnically" locked situation).[112] [113] Farmers should be trained and supported over the long term[114] by incorporating the territorial aspect, mobilising all players that come after farming[115] and making sure that the levers of action used are coherent, be they political, regulatory, economic or scientific.[116]

The Office's websites:

http://www.assemblee-nationale.fr/commissions/opecst-index.asp
http://www.senat.fr/opecst

Références

[1] Jactel et al (2020). Insect decline: immediate action is needed. Reports. Biology, Volume 343. Académie des sciences.

[2] More than a million species of insects have been identified throughout the world, including 40,000 in metropolitan France, but their real diversity is estimated to be five times greater than this at the global level.

[3] Non-bacterial organisms

[4] *Académie suisse des sciences naturelles* (2021). *Diversité des insectes en Suisse. Importance, tendances, actions possibles.* Volume 16, Issue 9.

[5] Stork (2018). How Many Species of Insects and Other Terrestrial Arthropods Are There on Earth? Annual Review of Entomology. 63: coleopterans represent 38.5% of species, lepidopterans 15.7%, dipterans 15.5%, hymenopterans 11.8% and hemipterans 10.3%.

[6] Ceballos, Ehrlich, (2002). Mammal population losses and the extinction crisis. Science, Vol 296.

[7] The difficulties appear at the moments of sampling and recognition. Sampling suffers from several biases. First, geographical, in the sense that the data is rare for regions outside Europe and North America. Long-term demographical data is particularly lacking for tropical regions, even though they are home to more than half the world's insects. There are also temporal biases linked to the significant annual variations in insect frequency, either due to poor weather conditions in a given year or their characteristics (certain species have underground or benthal larval cycles for periods that can last up to several years). Only long-term studies can prevent yearly fluctuations from being mistaken for long-term trends. Methodological biases also come from the difficulty in establishing standard protocols for making comparisons and identifying trends. The types and number of traps and weather conditions are all factors that influence the results, which must be obtained in the same conditions in order to be comparable. Participative science can play a growing role in collecting data in industrialised countries, especially when it comes to common species. Generally, observation requires gathering and sorting samples. Traditional methods of morphological identification using documents are time-consuming and require taxonomical skills that are increasingly hard to find. To help tackle the challenges in recognition, high-speed taxonomical identification is becoming more widespread thanks to barcoding: captured specimens are identified using a short sequence (called a bar code) of the DNA characteristic of their species. This is then compared to the data recorded in a centralised database that is being expanded, such as the International Barcode of Life Project, which recorded 500,000 species between 2010 and 2015. This technique is also used for environmental samples (water, soil, faeces). We call this metabarcoding. Without identifying the species, we can use the various sequences obtained to identify operational units (MOTUS: *Molecular Operational Taxonomic Units*), from which we can quantify the samples' biodiversity. For a metabarcoding approach to effectively identify a group of species whose DNA is mixed in an environmental sample, we need a reference barcode library in order to be able to compare the samples of unknown DNA to the species registered in that library. Artificial intelligence should also help people without taxonomical skills to use computer tools and contribute to species identification using photos, sounds or food searching methods.

[8] A taxon is an entity that covers all the living organisms that share certain well-defined characteristics. The species is the basic taxon of systematic classification.

[9] Sánchez-Bayo, Wyckhuys (2019). Worldwide decline of the entomofauna: a review of its drivers. Biological Conservation, Vol 232

[10] There is more specific information on pollinating insects. See Schatz et al (October 2021). Convergent evidence for promoting pollinator conservation in the context of global change: a view from France and Belgium. Acta Oecologica, Special issue: Pollination in the Anthropocene.

[11] Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora.

[12] To evaluate species' conservation status, four parameters are taken into account: the distribution area (surface area, trends, favourable reference area), the population (size, trends, favourable reference population), the habitat (surface area, quality, trends), and future prospects (pressure, threats).

[13] 23 butterflies, 10 coleopterans, 10 dragonflies and one grasshopper. Species of Community interest are species that are either in danger of extinction or are vulnerable, rare (if they have small population sizes) or endemic (characteristic of a certain restricted geographic area and strictly located in this area).

[14] *Commissariat général au développement durable* (March 2020). Rare or endangered biodiversity: few improvements since 2007.

[15] The directive defines six biogeographical regions within the European Union: Atlantic, Boreal, Macaronesian, Continental, Alpine and Mediterranean.

[16] The trends were stable in 42% of evaluations. However, the proportion of unknown trends is particularly high (35% on average and up to 46% for coleopterans).

[17] This last figure is not considered statistically significant, however.

[18] Seibold et al (2019). Arthropod decline in grasslands and forests is associated with landscape-level drivers. Nature. Vol 574.

[19] Dirzo et al (2014). Defaunation in the Anthopocene. Science, Vol 345.

[20] Coleopterans, hymenopterans, lepidopterans, odonatopterans and orthopterans.

[21] The IUCN's red list is the most complete inventory of the global conservation status of plant and animal species. It is based on a set of specific criteria to find the threat level that weighs on biodiversity. With the IUCN's red list system, each species

or sub-species can be categorised into one of the following nine categories: Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CR) when the rate of decline is greater than 75%, Endangered (EN) when the rate of decline is greater than 50%, Vulnerable (VU) when the rate of decline is greater than 30%, Near Threatened (NT), Least Concern (LC), Data Deficient (DD), and Not Evaluated (NE).

[22] Other studies put forward different figures. According to the European Red List of Grasshoppers, Crickets and Bush-Crickets, 30.2% of Europe's orthopteran species are in decline. See Hochkirch et al (2016). European Red List of Grasshoppers, Crickets and Bush-Crickets. Luxembourg. Publications of the European Union.

[23] Percentage of species that have not been seen in over 50 years.

[24] Sánchez-Bayo, Wyckhuys (2019). Article previously cited.

[25] In particular, this refers to generalist species that are capable of adapting to their environment, which leads to the homogenisation of species.

[26] Jactel et al (2020). Article previously cited.

[27] For example, among bumblebee species, those most concerned by decline are the bumblebees that forage in planted fields and grassland, particularly long-tongued bumblebees that forage among clover and other vegetables traditionally planted in rotation as a source of nitrogen and which are now replaced by fertilisers.

[28] Académie suisse des sciences naturelles (2021). Report previously cited.

[29] IPBES (*Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*) (2017). The assessment report on pollinators, pollination and food production.

[30] Vancutsem et al (2021). Long-term (1990-2019) monitoring of forest cover changes in the humid tropics. Science advances: since 1990, 220 million hectares, or 17% of wet tropical forests have been lost to farming and other land uses.

[31] Cultivated areas represent 12% of the planet's surface. Given that oceans represent 71%, farming has a significant impact on insect species.

[32] Science for Environment Policy (European Commission). May 2020. Future Brief Pollinators: Importance for nature and human well-being, drivers of decline and the need of monitoring: urban areas represent 22.5% of the European Union's surface area. Urbanisation leads to habitat loss but to a lesser extent than agriculture.

[33] Hedges, small uncultivated areas, and protein crops, beneficial for supplying pollen and nectar to pollinating insects, are disappearing in favour of monoculture, which homogenises landscapes. Thus, between 1960 and the end of the 1980s, 600,000 km of linears were destroyed in metropolitan France. However, cereals and oleaginous and protein crops covered more than 50% of the utilised agricultural land in 2010. Currently, seven categories of crops occupy more than 90% of metropolitan France's fields (fields cultivated by farming equals the total utilised agricultural land minus the land in temporary or permanent grassland for more than five years, in perennial, pluriannual cultivation, and in fixed set-aside): soft wheat, durum wheat, barley and maize represent 60%, rape and sunflower 11%, and temporary grassland 19%, while all other crops only represent 11%. See *Les abeilles, des ouvrières agricoles à protéger* (overseen by Axel Decourtye). 2018.

[34] Landscape fragmentation has two pernicious effects: it reduces the connectivity between insects' habitats and the places where they find resources. It also leads to a decline or even local extinction of certain sedentary species, since their genetic composition means they are not adapted to surviving in small, isolated groups (they suffer from consanguinity).

[35] Jactel, Grandcolas (2021). *L'avenir des insectes est entre nos mains*. *La Recherche*. No. 567: around the world, around 90% of wet areas, favourable to insects and aquatic larvae such as dragonflies, have been drained. 10% of the world's forests have been destroyed since 2001.

[36] Since the 1930's, the United Kingdom has lost 97% of its permanent grasslands. Worldwide, 70% of grassland has been lost. In France, perennial semi-natural spaces, including permanent grassland, lost 6.6 million hectares between 1960 and 2006, equal to 25% of the metropolitan utilised agricultural land. This trend continues today.

[37] Foley et al (2005). Global consequences of land use. Science, Vol 309.

[38] Pollinators now depend on the flowering of a few short-term crops such as rape in April and sunflowers in July. Outside these periods limited to around fifty days per year, semi-natural spaces are no longer enough to provide regular and constant food resources. Nectar, the leading source of carbohydrates, stimulates workers' metabolisms. Pollen, the leading source of lipids and proteins, is required to raise the brood. The colony's needs change during the season according to its development phase. Needs are greatest during the months of May and June when the population reaches its maximum. However, at the same time, the food resources in the environment are at their lowest. Bees suffer a second food shortage at the end of summer and in the autumn, just when they need to build up reserves for the winter. If the colonies do not have the resources provided by blooming cover crops or the ivy present in woods and hedges, their chances for surviving the winter are reduced.

[39] Such as the monophagous lepidopterans who live in peat bogs or Maculinea lepidopterans, typical of grassland, whose biological cycle is linked to two specific hosts: a plant in which the eggs are laid and which will provide food for the caterpillars until their third moulting, and an ant (of the genus Myrmica) which will take care of the caterpillar until its nymphosis. Figure D of the above-cited article from Rodolfo Dirzo compares the evolution of insects in areas disturbed by human activities and areas that are not disturbed: the richness of lepidopteran species is on average 7.6 times greater in undisturbed areas, and abundance is 1.6 times greater.

[40] Insecticides include a wide range of chemical products that work in different ways, but the main chemical categories are as follows: organophosphorous insecticides, carbamates, organochlorine insecticides, pyrethroid and neonicotinoids. Introduced in the 1990s, the latter make up 40% of the world's agricultural insecticide market. Each time these pesticides

have been put on the market, bee colonies have been poisoned. See *Les abeilles, des ouvrières agricoles à protéger*. Book previously cited.

[41] Henry et al (2012). A Common Pesticide Decreases Foraging Success and Survival in Honey Bees. Science, Vol 336: the administration of a low dose of a neonicotinoid (thiamethoxam) with no direct effect on survival reduces the number of foragers that return to the hive by a factor of 2 or 3 by altering the bees' central nervous system and their cognitive capabilities (in the present case, the visual information that allows them to find their return path). We should note that foragers' disorientation has been demonstrated with other types of pesticides such as deltamethrin from the pyrethroid family.

[42] Lechenet et al (2017). Reducing pesticide use while preserving crop productivity and profitability on arable farms. Nature plants: with the support of a network of 946 farms, this study showed that a reduction in the use of pesticides of 42% (reduction of 37% of herbicides, 47% of fungicides and 60% of insecticides) had no negative impact on productivity or profitability for 60% of the farms evaluated.

[43] During his hearing, Mickael Henry mentioned that 80 to 98% of the neonicotinoids used in agriculture go into the soil.

[44] Wintermantel et al (2020). Neonicotinoid-induced mortality risk for bees foraging on oilseed rape nectar persists despite EU moratorium. Science of Total Environment, Vol 704: in 2013, neonicotinoids' involvement in bee decline led the European Union to impose a moratorium on the use of three neonicotinoids (imidacloprid, thiamethoxam and clothianidin) for crops that are attractive to bees. However, it was demonstrated that, during the five years the moratorium was imposed (2014-2018), rape fields continued to be contaminated by these neonicotinoids, especially imidacloprid. Neonicotinoids seem to spread very widely into the environment, beyond the wildflowers that border treated fields. They seem to impact fields geographically far away or planted several years after they have been spread onto the field. They are thought to spread through contaminated particles, wind erosion of the soil, as well as by water through contaminated leachate, run-off water and irrigation water.

[45] They reduce the abundance and diversity of the flowering plants that provide pollen and nectar.

[46] There is an increasing number of studies that demonstrate fungicides' toxicity, either by making bee colonies more susceptible to infections by viruses and pathogens (see above), by reducing the survival rate of developing worker and queen larvae, or by preventing the development of micro-organisms essential to pollen's fermentation into bee bread. See *Les abeilles, des ouvrières agricoles à protéger*. Book previously cited.

[47] Using fertiliser impoverishes the plant life present in the fields and reduces the richness of pollinating insects in these areas. They also encourage the domination of nitrophilous plants, which bees rarely visit. They introduce heavy metals into the agricultural ecosystems such as copper, iron, zinc, manganese, cobalt, selenium, and cadmium, which can be harmful to bees' health (see He, Yang and Stoffella, (2005). Trace elements in agrosystems and impacts on the environment. Journal of Trace Element in Medicine and Biology). Finally, by contributing to eutrophication, they are particularly toxic to certain aquatic species (see Kalkman et al (2010). European Red List of Dragonflies. Publication Office of the European Union).

[48] In France between 2009 and 2018, the sale of active substances other than for use in organic farming and biocontrol products increased by 13.1%. After falling 43% between 2018 and 2019, it rose once again by 23% between 2019 and 2020. We should remember that the first eco-phytosanitary plan expected a reduction of 50% in the use of pesticides between 2008 and 2018. Worldwide, around €48 billion were spent on phytosanitary products in 2018. This represents an increase of nearly 69% over ten years (€28.4 billion in 2008).

[49] Many pesticides now prohibited in France (DDT, Chlordecone) are persistent organic pollutants that pose a lasting threat to the environment even though they are no longer used.

[50] Appendix 2 of the opinion of 5 July 2019 from the French Agency for Food, Environmental and Occupational Health & Safety (ANSES) on the changes to the methods for evaluating the risks to domestic bees and wild pollinating insects within the scope of applications for a permit to market plant protection products notes the European and national regulatory context: approval for active substances and permits for placing plant protection products on the market are governed by Regulation (EC) no. 1107/2009 of 21 October 2009 of the European Parliament and of the Council concerning the placing of plant protection products on the market.

Active substances are approved at the European level through an assessment of the dangers and risks related to the active substances that enter into the composition of plant protection products.

The risks and benefits of the products that contain these approved substances are evaluated by the Member States before they are placed on the market.

In France, for the risk assessment for bees and other pollinating insects, the European regulatory foundation has been reinforced by three orders:

- the order of 28 November 2003 relative to the conditions for using insecticides and acaricides for agricultural use with a view to protecting bees and other pollinating insects,
- the order of 13 January 2009 relative to the conditions of coating and using treated seeds,
- the order of 7 April 2010 relative to the use of extemporaneous preparations of plant protection products.

[51] Brühl, Zaller, (2019). Biodiversity decline as a consequence of an inappropriate environmental risk assessment of pesticides. Frontiers in Environmental Science.

[52] The contamination of food resources (nectar and pollen) brought to the hive and stored can lead to repeated exposure throughout a bee's life, from the larval to the adult stage, and over a period ranging from several weeks to several months, especially during the wintering period. Therefore, it is essential to test the chronic toxicity of plant protection products with doses less than the DL50 (average lethal dose that kills 50% of individuals exposed to the tested substance). A test that

assesses the chronic toxicity by mouth of adults after 10 days of exposure is part of the OECD's guidelines. This should be required for all risk assessment procedures, even though recent studies show that it can still be perfected (see below footnote on page 53).

[53] A test that measures the lethal effects at 22 days following larvae's repeated exposure is part of the OECD's guidelines. It should be required for all risk assessment procedures.

[54] Numerous scientific studies have observed the effects of insecticides on bees' behaviour at sublethal doses, affecting learning and memory performance. Nevertheless, there is currently no test whose protocols have been approved at the OECD level.

[55] Chmiel et al (2020). Understanding the Effects of Sublethal Pesticide Exposure on Honey Bees: A Role for Probiotics as Mediators of Environmental Stress. Frontiers in Ecology and Evolution: the study discusses the effects of neonicotinoids on the reproduction capacities of queens and drones.

[56] The statutory tests are only interested in the risks to the domestic bee, which is considered to be the representative species of all bee species, of which there are nearly 20,000 worldwide. However, several studies have shown toxic effects that can vary from one group of bees to another. Moreover, the structure of honeybee colonies (a colony comprises between 40,000 and 80,000 bees) acts as a buffer between the loss of foragers and workers. On the other hand, drones have a lower buffer ability, and solitary bees have none since a single individual must forage, search for and build a nest, and reproduce. It is therefore essential to include standardised tests that measure toxicity for drones and solitary bees in the risk assessment procedures for phytosanitary products.

[57] In case of exposure to several stress factors, it is important to be able to understand the interactions between them. Numerous scientific studies have demonstrated a link between the presence of illness (nosema) in bees and insecticides. This raises the question of whether it is the fungus that boosts the insecticide's effects, or if it is the insecticide that facilitates the fungal infection. It seems that bees' immune defences are weakened by chronic exposure to low doses of neonicotinoids (see Pettis et al (2012). Pesticide exposure in honey bees results in increased levels of the gut pathogen Nosema. Naturwissenschaften). Other studies have observed a stress-factor potentiation phenomenon. See Aufauvre et al (2012). Parasite-insecticide interactions: a case study of Nosema ceranae and fipronil synergy on honeybee. Scientific reports: this study observed the mortality rate of bees that were either exposed to fipronil, infected by Nosema ceranae, or exposed concomitantly to both of these stress factors. The mortality rate of the control group 20 days after the bees emerged was 24%. It was 39% in case of Nosema ceranae infection and 31% in case of fipronil exposure, but could reach up to 84% if the young bees were exposed to both these stress factors. And yet the toxicity assessments of plant protection products do not take into account the impact of other stress factors.

[58] The toxicity of active substances is evaluated substance by substance. In natural conditions, insects are subject to numerous chemical substances. Thus, in Germany in 2016, six different pesticides were applied on wheat, seven on rape, 14 on potatoes, 22 on grape vines and 32 on apple trees. And yet the bees' toxicological status influences pesticides' toxicity. See Almasri et al (2021). Toxicological status changes the susceptibility of the honey bee Apis mellifera to a single fungicidal spray application. Environmental Science and Pollution Research: when bees are first exposed to glyphosate, the toxicity of the fungicide (difenoconazole) is made worse. This study also shows the complexity of the impact of combinations, which is not proportional to either the number of preparations or doses applied. Thus, the toxicity of the preparation "acute exposure to the fungicide and chronic exposure to glyphosate" is the highest when the dose of glyphosate is very low (0.01 mg/L). Similarly, when bees are exposed to a preparation of imidacloprid and glyphosate before acute exposure to the fungicide, its toxicity is lower than if they are exposed to the fungicide alone.

[59] Since the regulation (EU) no. 284/2013 came into force, the adult chronic toxicity test (OECD 245) is systematically requested by the European Union for its product registration applications. The chronic toxicity test on larvae is not mandatory, however. Furthermore, the EU's uniform risk assessment plan is still based mainly on the Hazard Quotient value (HQ = dose of application/DL50, regulation EU 546/2011) applied for short-term adult toxicity tests (48 to 96 hours). There is no uniform threshold value to assess the risk from the results of adult and larval chronic tests. Finally, the duration of tests that assess a product's chronic toxicity (currently 10 days) appears to be too short. Thus, a recent study as part of a circular test involving seven European and North American laboratories and using the OECD 245 test extended to 31 days on average showed that the insecticide tested (flupyradifurone) can affect bees' survival at lower doses of daily exposure (environmental doses). See Tosi et al (2021). Long-term field-realistic exposure to a next-generation pesticide, flupyradifurone, impairs honey bee behaviour and survival. Communications Biology 4, 805.

[60] On 19 December 2013 then on 23 November 2018.

[61] Either insecticides, herbicides or fungicides.

[62] As recommended by Anses, the order of 20 November 2021 relative to the protection of bees and other pollenating insects and the preservation of pollinating services when using plant protection products extends to all plant protection products the requirement to make an assessment for crops that attract pollinators before using them during the flowering period. Additionally, the order limits the spraying period but does not follow Anses's opinion since the spraying must be done in the two hours before sundown and the three hours after sundown. The order provides for two exceptions: when bio-aggressor activity is exclusively diurnal or when the effectiveness of a fungicidal treatment is conditional to it being carried out within a specific period of time given the development of the disease. Furthermore, it allows for a three-year experiment into the use of plant protection products beyond the time range mentioned in the order. Finally, the order provides for an eight-month period (which corresponds to the next production campaign) where it will be possible to treat at any time of day as long as the temperature is low enough to avoid any bee presence. However, these thresholds are not specified.

[63] Opinion of 5 July 2019 previously cited.

[64] Darwall et al (2012). Freshwater invertebrate life. In Spineless: Status and Trends of the World's invertebrate. Zoological Society of London: freshwater insects are proportionally more affected by pollution: More than 41% of species are threatened by different types of pollution, particularly nitrates and phosphates from agricultural sources, from domestic waste water and various pollutants from industrial sources (including mining exploitations).

[65] Sound pollution changes the acoustic landscape and interferes with insects' acoustic communication and the auditory surveillance of their environment.

[66] Nocturnal insects are particularly vulnerable to changes in the day/night cycle. Thus, light pollution destabilises insects that use the natural light from stars and the moon for orientation and navigation as well as insects that communicate using bioluminescent signals, such as fireflies. Light pollution desynchronises the activities triggered by natural light cycles, such as feeding and laying eggs. An English study showed that public lighting reduced the number of moths at ground level by 50% and species diversity by 25% (see Macgregor et al (2017). The dark side of street lighting : impacts on moths and evidence for the disruption of nocturnal pollen transport. Global Change Biology). Another study into the impact of artificial lighting observed that the number of pollinators visiting plants in the light is 62% lower than when the plants are not in the light, and species diversity is 29% lower (see Knop et al (2017). Artificial light at night as a new threat to pollination. Nature).

[67] The emission spectrum of LEDs is thought to be more harmful than traditional lamps. Furthermore, the overall quantity of light emitted after the massive conversion to white LEDs is thought to be greater than before.

[68] Global warming is causing a decline in species that are adapted to the cold. However, the increase in winter temperatures removes climate barriers that limits the distribution area of certain native or alien species, allowing them to expand into areas that were previously unfavourable to their survival during the winter (See Roques, Auger-Rozenberg (2018). Article previously cited.

[69] Devictor et al (2012). Differences in the climatic debts of birds and butterflies at a continental scale. Nature Climate Change. This study observes that climate change in Europe (analysed using temperature increases) corresponds to a displacement of butterflies' distribution area of 249 km to the north between 1990 and 2008. And yet, during this period, butterflies only moved 114 kilometres to the north.

[70] Ward et al (2020). Impact of 2019-2020 mega-fires on Australian fauna habitat. Nature Ecology & Evolution: the wildfires that hit Australia in 2019-2020 are thought to have burned 97,000 km^2 of vegetation. Several hundred billion insects are thought to have died.

[71] Duchenne et al (2020). Phenological shifts alter the seasonal structure of pollinator assemblages in Europe. Nature Ecology & Evolution

[72] The impacts are direct through predation (for example, the Asian wasp which represents a direct threat to European bee populations that are already under stress), competition for resources (such as the Asian ladybird that threatens the seven-spot ladybird) and pathogen transfer (the European strains of the fungal pathogen *Nosema bombi* are generally considered to be behind the overall collapse of North American bumblebees). The impacts are also indirect through the planting of invasive plants that can compete with native species, reduce food diversity and impoverish the diets of insects that cannot make use of them.

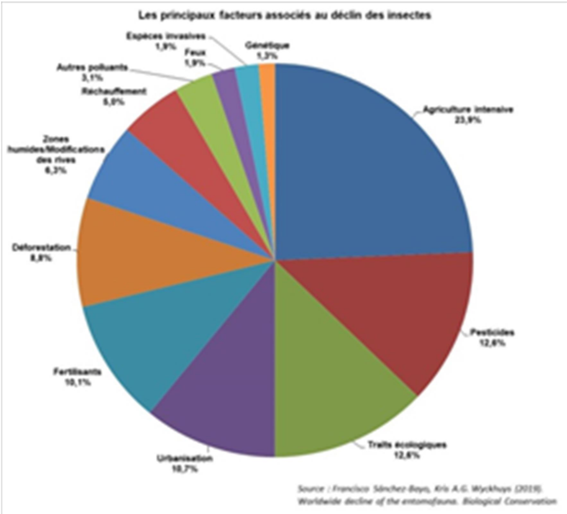
[73] See Roques, Auger-Rozenberg (2018). Article previously cited: the acceleration in the settlement of invasive species is, in the vast majority—more than 90%—of cases, due to accidental introductions related to human activities, mainly the boom in the global decorative plant trade, which facilitates the transport of the species associated with the plants. Climate change, by removing or displacing temperature barriers, allows certain species to expand into areas that were previously unfavourable to their settlement. Many species quickly respond to rising temperatures by moving their distribution area to higher areas or to the north.

[74] Intensification results in the conversion of diversified agricultural systems into conventional intensive agriculture (vast, homogeneous fields, the massive use of agro-chemical products and intensive forms of ploughing, grazing or mowing: ploughing destroys the superficial part of the nests of agricultural species, directly destroying the larval cells or preventing adults from emerging the following spring. It also cuts into the seed bank of wildflowers present in the soil. Mowing grassland and roadsides considerably reduces the floral resources that could be available in the landscape (see *Les abeilles, des ouvrières agricoles à protéger*. Book previously cited).

[75] Gunthern et al (2020). *Übermässige Stickstoff-und Phosphoreinträge schädigen Biodiversität, Wald und Gewässer*. Swiss Academies Factsheet 15 (8): in Switzerland, the nitrogen cycle is primarily stimulated by imports of fodder and fertiliser. Ammonia emissions come from livestock and nitrogen oxide emissions from the combustion process. Thus, around 70% of nitrogen-rich atmospheric pollutants come from agriculture, 18% from transport, 9% from industry and crafts, and 3% from households.

[76] Habel, Samways, Schmitt (2019). Mitigating the precipitous decline of terrestrial European Insects: Requirement for a new strategy. Biodiversity and Conservation.

[77] Sánchez-Bayo and Wyckhuys (2019). Article previously cited.



[78] See Senapathi et al (2015). Pollinator conservation – the difference between managing for pollination services and preserving pollinator diversity. Current opinion in Insect Science.

[79] Hervé Jactel et al (2020). Article previously cited.

[80] *Académie suisse des sciences naturelles* (2021). Report previously cited (page 24): "*The globalisation of trade and climate change are respectively responsible for the introduction and the expansion in Europe of species such as the box tree moth and the Asian tiger mosquito and, therefore, the consequences that their presence brings. The industrialisation of agriculture, the expansion of monocultures and the resulting homogenisation of landscapes have facilitated the expansion of many pests, whose populations can boom in the absence or scarcity of antagonistic organisms.*"

[81] IPBES (2017). Report previously cited.

[82] Potts et al (2016). Safeguarding pollinators and their values to human well-being. Nature.

[83] Shrews, moles, hedgehogs, lizards, amphibians, most bats, many birds and fish feed off insects or depend on them to raise their offspring.

[84] See *Suivi des oiseaux communs en France* (2019 results of the common birds participative monitoring programme). The most significant declines concern specialist birds in agricultural environments (-29.5%) as well as specialist birds in urban environments (-27.6%).

[85] All insectivores are impacted by insect decline, whether they are bats, amphibians, micromammals, etc.

[86] Gilles (11 March 201). Insect disappearance: causes and consequences. *Passion entomologique* (website). Europeans' colonisation of the Australian continent was accompanied by the development of cattle breeding. Since the native coprophagous coleopterans were not adapted to break down and eliminate these animals' excrement, billions of flies multiplied in the hundreds of millions of cow pats that were left each day. In the 1960s and 70s, African and European coprophagous species were introduced to compensate for this ecological deficiency that was resulting in the annual loss of a million hectares of pasture whose grasslands were covered in dung. The introduction of these insects worked to dry out and bury the dung, which greatly reduced the resources available for the flies and helped to recycle the organic matter. The balance in the Australian grasslands was quickly re-established.

[87] Wagner et al (2021). Insect decline in the Anthropocene: death by a thousand cuts. PNAS (*Proceedings of the National Academy of Sciences of the United States of America*).

[88] Species' diversity helps to develop interdependencies that are essential to keeping a given ecosystem functioning optimally. For example, the species that pollinate crops need wild plants for nests and food resources. And these wild plants often depend on other species for pollination.

[89] Senapathi et al (2015). Article previously cited: a greater diversity of species allows for functional redundancies to be established, i.e. the ability of several species to carry out the same function, such as pollination. The presence of several species of pollinators improves resilience to change to the extent that species react differently to stress factors.

[90] Aizen, Harder (2009). The Global Stock of Domestical Honey Bees is Growing Slower Than Agricultural Demand for Pollination. Current Biology: agriculture's dependence on pollinators has increased by 300% in the last fifty years.

[91] See IPBES (2017). Report previously cited. In terms of global production volumes, 35% of agricultural production comes from crops that depend, at least in part, on animal pollination. Animal pollination is directly responsible for 5 to 8% of the world's current agricultural production in volume. These figures may seem small. This is explained in particular by the fact that cereals—30% of the cultivated land in the European Union—are pollinated by wind. Furthermore, these figures only take into account the direct role that pollinators play in the production of fruits and seeds that are consumed directly. They do not take into account the indirect role that pollinators play in producing the seeds used to grow many vegetables or for producing crops used as fibre or fuel.

[92] The crops that depend on pollinators are generally the richer in micronutrients such as vitamin A, iron, and folate than other crops and are essential to human health.

[93] Klein et al (2007). Importance of pollinators in changing landscapes for world crops. Proceedings of the Royal Society B 274.

[94] See IPBES (2017). Report previously cited. He adds that "*while the factors that cause these changes are not clear, studies conducted locally on several crops show that production falls at the same time that pollinators are on the decline*".

[95] In Europe, insect consumption is still in its infancy. However, in the "Farm to Fork" strategy presented by the European Commission, insects are recognised as a substitute source of substitute proteins that "*can support the European Union's transition to a more sustainable food system*". In May 2021, the European Union's Member States approved a proposal from the European Commission allowing for the use of dried yellow mealworms as a "*novel food*".

[96] *Académie suisse des sciences naturelles* (2021). Report previously cited.

[97] See Jactel et al (2020). Article previously cited. Fighting climate change, stopping urbanisation and deforestation, and controlling trade and biological invasions are cited.

[98] Concretely, the *Académie des Sciences* insists on a reduction in the use of synthetic insecticides in farming and an improvement in the specificity of their targets as well as the research and spread of alternative methods (in particular through an integrated approach against pests). It also calls for the preservation and improvement of refuge habitats for insects through the protection of forests, natural grasslands and freshwater environments as well as the development of quality habitats for insects in agricultural and urban areas. Finally, it supports strengthening the heterogeneity of landscapes and connectivity between the different types of habitats in order to promote exchanges of individuals and genes between insect populations. Similar proposals have been made in a number of scientific studies (Habel et al (2019). Article previously cited; Sánchez-Bayo, Wyckhuys (2019). Article previously cited; IPBES (2016). Report previously cited).

[99] Several scientists who gave testimony mentioned that the pesticide toxicity risk assessment procedure has essentially remained the same for thirty years despite the accumulation of scientific knowledge. Similarly, the 2021-2026 national plan for pollinating insects and pollination that the government published last 20 November provides no substantial action to speed up the agro-ecological transition (it sets no quantified objectives for the reduction in the use of pesticides and does not encourage the implementation of alternative solutions) even though all the scientific studies insist that intensive agriculture and wide-scale pesticide use contribute to the decline of pollinators.

[100] A recent trend in the history of science considers that ignorance can be a lack of knowledge that is deliberate. This theory of the social construction of ignorance applied to science dissects the process that seeks to "*mobilise science to attack science*" (see Mathias Girel (2017). *Science et territoire de l'ignorance*). Among these is the search for a "decoy", which can be partially funded by lobbies and seeks to divert research to less relevant subjects. The scientific results can also be systematically called into question to undermine their credibility, destabilise political decision-making and tends to delay it under the pretext that additional research is needed. This strategy often proves effective. Thus, neonicotinoids were placed on the market in Europe in the early 1990s. Very quickly, beekeepers saw excess mortality in the bees located near crops treated with neonicotinoids. Nevertheless, the use of plant protection products containing neonicotinoids were not banned in France until September 2018. The law of 14 December 2020 relative to the conditions for placing on the market certain plant protection products in case of sanitary danger to sugar beets reauthorised their use until 2023 for sugar beet crops threatened by viral jaundice. At the European level, only three neonicotinoids have been banned since 2018. In a decision on 6 May 2021, the Court of Justice of the European Union definitively validated this prohibition, which Bayer had disputed in court.

[101] The above-cited European Habitats Directive dates from 1992.

[102] 64 species of insects are protected in metropolitan France and 8 in overseas departments and territories.

[103] Thus, in ruling no. S2019-2659 on the results of the ecophyto plans, the Court of Auditors concluded that, despite a decade of initiatives using significant public funds, the effects of the ecophyto plans remain well below target. Through Natura 2000, the European Union has established a network of sites essential to the rest and reproduction of rare and endangered species. These protected areas cover 18% of Europe's surface. Nevertheless, one study has shown that establishing these protected areas does not counter the decline of certain insects. See Rada et al (2019). Protected areas do not mitigate biodiversity declines: a case study on butterflies. Diversity and Distribution: in 11 years, these areas have seen an overall decline in butterflies of 10%.

[104] €10.21 billion per year for France over the 2021-2027 period, to compare with the €47 million per year for the ecophyto plan.

[105] In 2020, the European Court of Auditors reported on the funds allocated to the CAP between 2014 and 2020. It observed that most of the CAP's funds had a limited positive impact on biodiversity. Indeed, most direct payments do not contribute to the preservation or improvement of biodiversity in agricultural lands. The system of sanctions linked to conditionality had no obvious impact on the biodiversity of agricultural lands. The potential that greening offers to improve biodiversity is not exploited enough. (see Special report. *Biodiversité des terres agricoles : la contribution de la PAC n'a pas permis d'enrayer le déclin*). Thus, the CAP was reformed in 2021 with a view to optimising its contribution to sustainable development, in particular. With this is mind, the percentage allocated to eco-schemes (which replace the green direct payments) is set at 25% of the first pillar's budget. 35% of the second pillar's budget is set aside for climate and the environment.

[106] As part of its "European Green Deal", the European Commission proposed two strategies, the "Biodiversity strategy for 2030" and "Farm to Fork" on 20 May 2020. The latter sets several objectives, in particular concerning the use of inputs and the expansion of organic farming in Europe: 25% of agricultural land for organic farming by 2030 and a 50% reduction in the use of chemical pesticides, particularly the most dangerous pesticides, by 2030.

[107] We must shift from thinking in terms of subsidies to thinking about paying farmers to preserve ecosystems.

[108] This plan is intended to define the interventions and methods for implementing the common agricultural policy at the national level. At the time of writing, it has yet to be published, and drafting it has provoked strong tensions between the government, environmental associations and farming unions.

[109] The reduction in funds for France's special allocation account for rural and agricultural development CASDAR runs counter to the agro-ecological transition policy pursued by public authorities.

[110] Several experiments to reduce and then stop the use of pesticides have demonstrated that they result in a return of pollinators and crop auxiliaries that help increase agricultural production and farmers' income.

[111] Farmers must obtain high yields at low prices while respecting the environment and ensuring a fair income for themselves.

[112] Laurence Guichard et al (2017). *Le plan Écophyto de réduction d'usage des pesticides en France : décryptage d'un échec et raisons d'espérer. Cahiers Agricultures*. The underlying sociotechnical locking mechanism is that the more widely a technology is adopted, the more it becomes attractive and effective. Pesticide reduction clashes with an extremely robust and coherent collective organisation of agriculture, its industries and its research and development.

[113] Meynard (2012). Innovating in cropping and farming systems (chapter 5) in Coudel et al. Renewing innovation systems in agriculture and food: how to go towards more sustainability? The lock has impacts on many aspects:

- the economic aspect: the amortisation of industrial installations drives production towards regional specialisation and the rejection of technical solutions that could lead to a drop in production, such as low-input technical itineraries,
- the social aspect: no organisation has the legitimacy needed to organise the collective management at the regional level that is required by certain alternatives to pesticides (landscape developments to amplify certain ecological regulation functions performed by auxiliaries, varying crop rotations to limit the proliferation of parasites, etc.) Furthermore, it is risky for an agricultural consultant's credibility to be wrong in saying that treatments should not be used when they are, in fact, necessary, or by encouraging treatment when it is actually not needed.
- the cognitive aspect: the familiarity of simple solutions (an input for each problem) does not encourage farmers and consultants to take ownership of preventive farming methods, which are seen as risky. This in fact leads to a loss of skills concerning traditional solutions (rotations, deferred sowing, etc.),
- the cultural aspect: the prestige of high yields as well as the collective representation among farmers of a "beautiful field" (very green and homogeneous) and "beautiful fruit" (without any exterior defects) among consumers, reinforce dependence on pesticides,
- the regulatory aspect: sales authorisations, mainly granted to pure varieties, mean that farmers cannot find combinations of plant seeds, and the standardisation of fruit quality prioritises a lack of epidermic defects that is impossible to attain without pesticides.

[114] The reduction in inputs must be high (30 to 50%) in order to be effective, and its effects on diversity take time: up to 10 years to restore the biodiversity of degraded soil.

[115] Transformers, distributors, consumers

[116] At the political level, public policy must be consistent, and the plans drawn up in the various ministries (nitrates plan, plan for pollinators, the national strategic plan, etc.) must all make the fight against biodiversity decline a priority. At the regulatory level, it is all the more essential to reinforce the regulations on the risk assessments of plant protection products, which is particularly difficult to roll back, as the example of neonicotinoids has shown. Furthermore, farmers need to find an economic benefit in the agro-ecological transition. This requires a dissemination of best practices that have scientifically shown that a reduction of inputs does not result in a drop in yields and income. But this also requires simultaneously mobilising and coordinating all the actors that follow agriculture (transformers, distributors, consumers), especially so that the varieties produced by farmers can find a market. This also requires a revision to the specifications of the industry agreements to allow farmers more room to manoeuvre in terms of quality, yields, etc. This also requires anticipating and countering the competitive distortions that could have a negative impact on the industries that are the most vulnerable given the regulatory differences between countries. Moreover, this entails the development of mechanisms that can help soften the risks and losses and compensate for the insurance effect of nicotinoids. At the scientific level, any regulatory changes must be preceded by commissioned research projects to avoid leaving farmers without an alternative when a product is introduced. More generally, the fight against insect decline entails an increase in the funding granted to research to both better understand and monitor insect decline (establish the red list of bees and syrphus flies, maintain taxonomical skills, develop reliable evaluation methods) and to adopt an operating method that is more respectful of the environment (develop alternatives to intensive agriculture for a larger set of crops, diversify cultivation systems, develop varieties that resist pests and diseases, promote the integrated fight against pests, improve the yields of organic farming).

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