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The emergence of the Biodiversity/Health nexus: making biodiversity a health issue

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Abstract

Before the COVID-19 pandemic, a French epistemic community has forged and promoted a Biodiversity/Health nexus, which legitimizes biodiversity as a health issue. The relationship between biodiversity and health is now part of French local government agendas, after being included in new international programs. Based on observation of this nexus's epistemic community and 35 semi-structured interviews conducted in France between 2017 and 2020, this article aims to show which actors and groups have been forging and promoting this nexus, and to understand how such an emergent environmental nexus challenges the governance of the present biomedical- and technical expertise-based health system. This article discusses environmental nexus from the perspective of building a new cause by reconstituting chains of causality to “demonstrate” the new problem (Barthe, *Politix*, 23(91), 77–102, 2010), and the growing importance of integration of concepts as a new ideal of policy-making (Cairns & Krzywoszynska, *Environmental Science and Policy*, 64, 164–170, 2016). As well as a justification (Boltanski & Thevenot, 1991) of their effectiveness in legitimizing the cause of defending biodiversity, environmental nexuses contain a challenge to recognize knowledge, calling for a change in governance methods in a One Health approach.

Keywords Environmental nexus · Health governance · Infectious diseases · Biodiversity · Ecology · One Health

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Introduction

COVID-19 is an opportunity to hear from a variety of infectious disease experts for whom the cause of the increase in animal-related infectious disease outbreak events is to be found in the loss of biodiversity. The view that the biodiversity crisis favors the emergence of infectious diseases is connected to a critique of the so-called modern world,¹ and the nature of the specific social, ecological, biological, and microbial interactions which take place within it. Although it is widely visible in the French media² and in public policy with the Health-Environment National Plan, what we will call here the French Biodiversity/Health nexus has been developing for several years (Guernier et al., 2004; Morand, 2016). In April 2019, the French Foundation for Research on Biodiversity (FRB), the French Agency for Biodiversity (AFB), in partnership with the French Agency for Food, Environmental and Occupational Health and Safety (ANSES), and the French Ministries of Ecology, Agriculture and Health, organized, in the premises of the Ministry of Health, a symposium entitled: “Biodiversity: an ally in the prevention of certain infectious diseases?” This conference marked the culmination not only of an initial phase of expertise but also of meetings within a health/biodiversity working group which began in 2015 as part of the monitoring of Health-Environment National Plan (PNSE3 — Plan National Santé Environnement) actions. The issue of the links between biodiversity and health was included in this interministerial plan, and in French local government agendas. It seems that the issue of health has taken the defense of biodiversity out of the realm of nature conservation, which was confined to a minority group. Indeed, if biodiversity has been an issue for more than 40 years,³ the cause of biodiversity has been struggling to take hold (Takacs, 1996). During the 2000s, several European countries, including France (2004), adopted a national biodiversity strategy. The objective of reducing biodiversity erosion by 2010 was set, but since it was not achieved, it was postponed until 2020. Biodiversity diplomacy work has been deepened with the emergence and progressive stabilization of an international institution dedicated to biodiversity, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (Charvolin & Ollivier, 2017).

How is the Biodiversity/Health nexus’s conceptual framework being coordinated with lobbying in favor of public action in the fields of health and biodiversity? The French case presents the specificity of a cause carried by actors

¹ Natacha Devanda, « La crise de la biodiversité favorise les maladies infectieuses émergentes », <https://charliehebdo.fr/2020/02/societe/la-crise-de-la-biodiversite-favorise-les-maladies-infectieuses-emergentes/>

² Few examples here: Maria Helena Semedo (FAO), « Promouvoir des actions collectives pour permettre à la biodiversité de jouer le rôle de régulateur des pathogènes », *Le Monde*, 16 juillet 2020 https://www.lemonde.fr/idees/article/2020/07/16/maria-helena-semedo-promouvoir-des-actions-collectives-pour-permettre-a-la-biodiversite-de-jouer-le-role-de-regulateur-des-pathogenes_6046369_3232.html « Le Coronavirus: un boomerang qui nous revient dans la figure » <https://www.mediapart.fr/journal/international/220320/le-coronavirus-un-boomerang-qui-nous-revient-dans-la-figure>; Sonia Shah, « D’où viennent les Coronavirus. Contre les pandémies, l’écologie », <https://www.mondediplomatique.fr/2020/03/SHAH/61547>; « Coronavirus: La disparition du monde sauvage facilite les épidémies », <https://www.marianne.net/societe/coronavirus-la-disparition-du-monde-sauvage-facilite-les-epidemies> March 17th 2020).

³ The Convention on Biological Diversity (CBD) was created in 1992.

originating from the senior civil service who forge special links with scientists specializing in epidemics and zoonoses, animal health professionals (human health to a lesser extent), militant organizations of the ecological cause, and political professionals. Based on the French case over the survey period 2018 to 2020, this article presents the way in which the aims of this nexus are being built in France: the structuring of a network of a few stakeholders, the construction of expertise for public action, and compelling narratives. Our contribution, rooted in a social and political science approach, does not aim to demonstrate how much biodiversity protects, or not, health, nor why we should protect biodiversity, but to understand how this new approach to biodiversity as a public health issue has taken shape and what this transformation implies for new governance practices. Based on 3 years of research, it analyzes this issue of the (unfinished) appropriation of biodiversity as an ally of public health.

Subsidized by the French Agency for Biodiversity (AFB) in 2018 and 2019 to create a mapping of the stakeholders and challenges of the Biodiversity/Health interface, our research gradually took as the focus of investigation the subject for which we were assumed to be the experts. As stakeholders within the ministerial working groups, in particular the one called Working Group “Health/Biodiversity,” we were in a unique position to observe how stakeholders were mobilizing, and were trying to make the links between health defined from the outset as the health of humans in relation to that of animals and ecosystems, and biodiversity. In order to understand the construction and narrative of the Biodiversity/Health nexus, we analyzed the archives of this interministerial Working Group and interviewed not only the key actors but also the ones who participated occasionally or just mentioned in the archives (35 semi-structured interviews). In order to find the historical background of the founding principles of this link between biodiversity and health, which will become a much more widespread narrative after the second phase of the COVID-19 pandemic, we conducted both a systematic review of the international literature and an analysis of the setting of health-related biodiversity agenda in France.

In the wake of Claude Gilbert’s work on the conditions and mechanisms for defining issues in terms of risks and public problems (Gilbert, 2002; Gilbert & Henry, 2012), and Barthe’s work on causal politics (Barthe, 2010), we have sought to characterize and analyze how biodiversity is being defined as a health issue. In this perspective, the “nexus” concept is heuristic from a sociological and political point of view, even if the French stakeholders who are involved in the Biodiversity/Health nexus do not use this term but systematically attempt to model the relationships and impacts between biodiversity (especially its losses) and health (especially infectious diseases). A nexus implies a desire to adopt a systemic vision: “The notion of nexus has the advantage of favouring processes from the outset, by making their complexity not an obstacle, but a resource for their understanding” (Chauveau, 2017). This approach allows the sociologist to question the linking of two concepts (which are both social concepts and natural phenomena), and the consequences of this linkage in terms of governance and policy-making. It makes possible the re-examination of the pattern of policy-making, especially a so-called new ideal of integration into public policies (Cairns & Krzywozynska, 2016), and its challenges in terms of governance. Indeed, a nexus usually means the preconceived and often

simplistic ideas of the links which highlight the complexity and multiplicity of causal relationships between studied phenomena.

We will thus grasp the structural contradictions and even the denied intentions of this announced policy of “biodiverse health,” by taking the option, in this article, of grasping the mechanisms of the trajectory of the Biodiversity/Health nexus onto the agenda in French political and administrative life (“[The Biodiversity/Health nexus in France: few stakeholders and compelling narratives](#)” section), the methods and means used to do so (“[A French epistemic community challenging biomedical framing](#)” section), and its governance implications linked to the One Health agenda (“[Implementation challenges](#)” section).

The Biodiversity/Health nexus in France: few stakeholders and compelling narratives

The epistemological construction of the Biodiversity/Health nexus in France is inseparable from a network of a few stakeholders, identifiable thanks to a list of publications and symposia over the last 10 years in France, and which associates animal health professionals, ecology researchers, whose constitution as a discipline was accompanied throughout the twentieth century by a lasting feeling of “inferiority” vis-à-vis researchers from other, better-recognized and better-funded disciplines, notably physicists (Granjou, 2015), working scientists, and scientists in institutional positions.

Of course the geopolitics of biodiversity was preceded by work carried out in the international academic community dealing with the interfaces between conservation biology, animal health, and human health (which will be structured around the emerging discipline of disease ecology). Originally from the USA, scientific articles and books relating to the relationship between biodiversity and health have multiplied since the mid-1990s (Reid, 1995), with the development of a literature that reveals the effects of environmental degradation on human health and well-being (Carson, 1962; Chivian, 1993; Grifo & Rosenthal, 1997; Stephenson, 1997). In this respect, the French Biodiversity/Health nexus is in line with the notion of “ecosystem service” which emerged in the late 1980s (Pearce & Moran, 1995; Perrings, 1998; Randall, 1988; Westman, 1977), and which became politicized in 2005, after the publication of the international report on the assessment of ecosystems by the Millennium Economic Assessment (Hrabanski, 2013; Pesche, 2013). But health regulation was seen to be insufficiently associated with ecological functions within the Millennium Ecosystem Assessment conceptual framework initiated in 2001 which assessed the consequences of ecosystem change for human well-being.⁴

In the 2000s, a convergence can be observed between scientific output and international actions, with Eric Chivian and Peter Daszak as the main actors (Bernstein & Chivian, 2008). Eric Chivian helped set up the first International Conference on Health and Biodiversity in Ireland in 2005. Peter Daszak, a

⁴ From 2001 to 2005, the MA involved the work of more than 1360 experts worldwide.

specialist in emerging infectious diseases in wildlife (Daszak et al., 2000), heads the Ecohealth Alliance (formed by the merger of The Wildlife Trust and the Consortium for Conservation Medicine in 2010), a US-based non-governmental organization. The Daszak team also authored with K. Jones the much quoted article (Jones et al., 2008), published in *Nature*, on the emergence of infectious diseases in developed countries. Since then, this article has featured prominently in all the references and speeches related to biodiversity in a One Health approach.

The French Biodiversity/Health nexus is also part of a political and administrative lobbying effort aimed at changing methods of governance. Indeed the French people behind this agenda is composed of a handful of human health specialists and senior civil servants with scientific and technical training who form an “epistemic community.” Some of these stakeholders produce the research that serves as a resource for the epistemic community’s proposals. The reason for the investment of these heterogeneous members in these activities is the result of a shared criticism of a health governance model which is thought to be failing to take account of the complexity of living species. Actors working to put the Biodiversity/Health nexus on the agenda are gradually coming together around a narrative of making biodiversity an ally of public health, combining research done in the natural sciences with examples of crisis management that disregards biodiversity and ultimately compromises health defined more broadly.

From 2010, this network dedicated to the Biodiversity/Health nexus in France intended to re-prioritize the problems on the public policy agendas. To paraphrase Michel Callon (1986), some stakeholders have made themselves indispensable on this issue by pursuing advocacy work. The French association *Humanité et Biodiversité* is central in the promotion carried out in favor of the Biodiversity/Health nexus. As a French nature conservation association, created in 1976, it is approved for nature conservation by the Ministry of the Environment, affiliated to the French Nature Environnement Federation (FNE), the French committee of the International Union for Conservation of Nature (IUCN), a member of the National Council for Sustainable Development, and the Grenelle Environment Forum. Its actions, initially engaged in nature conservation and particularly against certain hunting activities — until 2001, its name was “ROC” for Rally of Opponents of Hunting, then in 2012, it changed its name to “Association for preservation of wildlife and the defense of non-hunters,” are currently part of the general framework of biodiversity conservation. Between 2000 and 2015, Christophe Aubeil was head of *Humanité et Biodiversité* then head of the French Agency for Biodiversity (AFB)⁵ till 2019. Former teacher, he comes from the world of nature protection associations. In 2015, his successor was Bernard Chevassus-au-Louis, a biologist and an ecologist, also an Inspector General of Agriculture, a member of the French General Council for Food, Agriculture and Rural Areas (CGAAER) since 2007, previously Director General of INRA, before chairing the Board of Directors of the National Centre for Veterinary and Food Studies (CNEVA, in French). Between 2002 and

⁵ The Agency has become « Office français de la biodiversité » by integrating the French national hunting and wildlife office (ONCFS) in 2019.

2006, he was head of the French Museum of Natural History (MNHN). Gilles Pipien, a senior civil servant and an engineer, Jacques Weber, an anthropologist and an economist, who headed the previous French Institute of Biodiversity, now called the Foundation of Research for Biodiversity (FRB), Serge Morand, an evolutionary biologist in CIRAD, who is today an international pillar of the One Health concept, and Justine Roulot, a former advisor in charge of biodiversity, water, and the sea in Nicolas Hulot's office, are all scientists who belong to the association.

In 2009, Jacques Weber, noting that “the population is increasingly sensitive to health,” suggested that Gilles Pipien look at the links between health and biodiversity. He also advised him to bring together competent people on the subject including Serge Morand. In the 2010s, Jacques Weber, Robert Barbault (from the MNHN), Gilles Pipien, and Serge Morand publish a number of popular books and collaborate with each other (Weber & Barbault, 2010; Barbault & Pipien, 2013; Morand et al., 2014). Gilles Pipien played a central role in publicizing the links between biodiversity and health, based on his network as a former “Ingénieur des Ponts” [the French Ecole des Ponts et Chaussées trains Road, Canal and Port Engineers] and not as an environmental activist. Lobbying activity has therefore mainly taken place in the arcane of ministries and general councils, with senior officials and members of Parliament. Faced with the lack of interest in the environmental cause in France (Chansigaud, 2017), this lobbying activity within the administrations has focused the Biodiversity/Health nexus on public health, first in terms of risk prevention and infectious diseases, as Gilles Pipien, then Chief of Staff to the French Minister of Ecology, pointed out:

I became Roselyne Bachelot's chief of staff [RB was the former French Minister of Health between 2007 and 2012]. I told her: this ministry must become the ministry of humans (and not of little flowers). There are three main topics: renovations, risk prevention, and a law on biodiversity. When I left Bachelot, I couldn't get the biodiversity law out. I was lucky enough to run into Hubert Reeves (renowned astrophysicist and honorary president of Humanité et Biodiversité), he phoned me to thank me. We continued together.

The civil servant will rely on his multi-positioning, between the French high administration and militant organizations. The members of *Humanité et Biodiversité* lobby both externally and internally, through official reports, scientific meetings, and meetings with decision-makers, while they mobilize people who are veterinarians, conservationists (from French national parks), but also from the human health system (the biggest challenge). From 2010, a handful of scientific actors and senior officials has been building this cause in order to mobilize both managers and citizens. To do so, they made an inventory of the services provided by biodiversity to human health starting by thinking of drugs which come from nature with an approach which was still focused on the cure. The cause was built step-by-step, with the idea of looking for scientific causalities.

To be able to say that it was organized between an association for the protection of nature and an association bringing together doctors, is obviously interesting to establish the credibility of the subject, and in

*addition with scientists behind it. We had a triptych that allows us to say: wait, we're not telling you cracks, there's a real subject behind it. (A leading member of *Humanité et Biodiversité*)*

In 2013, with a mandate from the French Ministry of Ecology, a national project for the French General Council for the Environment and Sustainable Development (CGEDD in French), to which Gilles Pipien (*Humanité et Biodiversité*) belongs, was carried out on the links between health and biodiversity. The report clearly entitled “The links between health and biodiversity” was edited by Patrick Lavarde, general *Ingénieur des Ponts*, Eric Fouquet, general inspector of veterinary public health, and Philippe Maler, general inspector of the sustainable development administration (Lavarde et al., 2013). What catches our attention is the list of people heard included in the report as it reveals the process of selection and aggregation of similar points of view to frame the new problem. The range of legitimate interlocutors to be heard on the problem of relations between health and biodiversity, their institutional affiliation, corresponds to the selection of interlocutors who will be heard in the future on these issues, i.e., a high proportion of professionals from or close to health ecology.

More broadly, the actors of human health are absent and must be convinced of the relevance of the nexus. The CGEDD report was a first step in the National Health and Environment Plan (PNSE) 3 (2015–2019). This was a plan co-piloted by the ministries of health and ecology. The authors mention the biodiversity/health link explicitly. The term “biodiversity” was first used in relation to health in the Grenelle 1 and Grenelle 2 laws (environmental programming laws), then in the National Strategy for Biodiversity (2011–2020). The National Health and Environment Plan (PNSE) 3 explains the biodiversity/health link through concrete examples such as infectious diseases and biodiversity (i.e., plant biodiversity and human health) by using pollen as an example, to show the services provided by ecosystems and their beneficial effects on health, and the effects on ecosystems of pollution linked to healthcare practices. Just before this report, Olivier Mastain, a veterinary public health inspector, wrote a note for the Minister of Ecology in order to make the Biodiversity/Health nexus a public policy issue:

Internally, we said, “It’s a good idea, I feel it’s good, but we have to write something consistent because we’re going to have to convince colleagues in the DGPR [Direction Générale de la prévention des risques] who are in charge of the PNSE. We’ll have to convince them that it’s a subject.” (Olivier Mastain, Member of the Office of the Minister of Ecology)

Mastain’s note relies on the fact that ecosystems may have significant consequences on human health: ragweed, for example, through its invasive development causes allergy crises for people who are sensitive to it [ragweed is an invasive plant that causes major health problems such as severe allergies. It uses and aggravates the loss of biodiversity by colonizing more and more surfaces]. For these senior people, who are involved in the environmental cause, biodiversity indicators could serve as sentinels for early warning systems in epidemiosurveillance and toxicovigilance. As a result, ragweed has been an emblematic example of a

conjunction of interest between biodiversity and health stakeholders, until the COVID-19 crisis, which will renew the discourse on the relationship between health and biodiversity after 2020.

In parallel, a “health and biodiversity, in a context of climate change” working group (WG), co-chaired by Thierry Galibert (CGEDD) and Justine Roulot (*Humanité et Biodiversité*), was set up in 2014, at *Humanité et Biodiversité*'s initiative. This WG, initiated in 2014 at the instigation of the lobby, was in charge of monitoring certain actions of the PNSE3, particularly those related to biodiversity, as well as the follow-up of the Ecological Transition Roadmap created by Ségolène Royal, Minister for the Environment between 2014 and 2017. It was finally an institutional arena to promote the Biodiversity-Health nexus in France.

When it was created, the WG had 53 members. Four years later, it had over 80, including a variety of stakeholders from different ministries (Ministries of Ecological and Solidarity Transition, Agriculture and Food, Health), members of public institutions (ANSES, ONCFS, AFB, Regional Natural Parks-PNR), scientists, members of associations (Biodiversity Research Foundation, *Humanité et Biodiversité*, France Nature Environnement, etc.), members from the public sector (ANSES, ONCFS, AFB, Regional Natural Parks-PNR, etc.), private stakeholders (Glass Institute, MEDEF, etc.), trade unions (National Federation of Farmers' Unions, National Union of Private Veterinarians, etc.), and scientific bodies (Tour du Valat, which is a research institute for wetland conservation, Institute of Research for Development, VetAgro Sup, etc.). After analysis of what was said in the meeting minutes and some observations, the highly mobilized participants who speak during the meetings are members of the Ministry of Ecology, ANSES, AFB, and FRB and therefore well anchored in the French institutions.

In 2018, the group reached a general consensus on the opportunity to address the links between biodiversity and health. The ambition of the co-chairs was that health and biodiversity issues should be included as essential elements of environmental and health policies, and to position the WG as a reference interlocutor for the regional governments. Their hypothesis is that biodiversity can be a key agent of human health, with a valuation of biodiversity as a positive factor of health. To this end, various efforts are being made to conceptualize the Biodiversity/Health nexus, along the lines of the modeling of ecosystem services, but aiming to go further in the chain of causality. This Biodiversity/Health nexus community intends to enhance the value of ecology through public health. In this case, public health refers to a broad range of values on political and social agendas. The nexus is the product of a heuristic and epistemological construction (Gautier et al., 2020).

A French epistemic community challenging biomedical framing

The implementation of the nexus in France shows the success of a cause promoted by stakeholders who are firmly rooted in technocratic frameworks and the tension between expertise and militancy through the difficulty of challenging the present medical paradigm by a community united in a strong belief in science to which we will return. As a result of the mobilization of the cause entrepreneurs mentioned

in the first part and the opportunities for professional groups corresponding to technical state bodies (especially the veterinary inspectors) in search of legitimacy, the cause has become visible through the multiplication of both research and events, at local, national, and international levels. It becomes an issue by imposing itself as a public priority in the political and technocratic spaces (Henry, 2021) of public health and veterinary public health as well as those of ecology and by soliciting forms of expertise and knowledge production.

Infectious diseases (including zoonotic and vector-borne diseases) have been by far the main theme addressed to frame the Biodiversity/Health nexus, internationally and in France. The members of the Health-Biodiversity working group decided to objectify the links between infectious diseases and biodiversity loss. The WG commissioned a literature review from the French Foundation of Research for Biodiversity (FRB), whose director is H el ene Soubelet (veterinarian and veterinary public health inspector), with the objective of demonstrating that biodiversity is a bulwark against infectious diseases. This literature review, conducted by a post-doctoral fellow in ecology at the FRB, began in March 2018 with the question: "How can the impact of vectorborne and zoonotic infectious diseases be reduced through ecosystem management?" (Lugassy et al., 2019). To understand the wording of this review, including the redefinition in terms of the services provided to public health by biodiversity, it is necessary to understand how, acting as "moral entrepreneurs" (Becker, 1985), the French epistemic community promotes the need to find tangible arguments for the preservation of biodiversity in the role it plays in favor of human health, and tries to enlist other actors, colleagues, researchers, and managers, including from the human health sector. Through the FRB's literature review (Lugassy et al., 2019), the epistemic community is attempting to respond to the nexus's opponents for whom biodiversity issues are not related to human health issues. A physician asked to participate in the WG, as well as other medical professionals interviewed, questioned the legitimacy of the subject, stressing the absence of victims and deaths. A member of the WG who is a veterinary public health inspector and who work in the Ministry of Ecology reports the contempt of these human health professionals for the issues raised by the group:

Let's do some important things and then go have fun with little flowers and then you'll come back and see us when you show that there will be more deaths from this than from diabetes or from various and varied cancers. [Imitating the physician participating in the working group]. It is a confrontation of universes, between someone who defended purely medical management positions and us, trying to explain to him that it is not because biodiversity loss does not cause the most deaths that we should not deal with it.

Because there are no deaths, and no randomized evidence, the medical sector does not pay much attention to the Biodiversity/Health nexus. The work carried out by *Humanit e et Biodiversit e* stumbles over the difficulty of bringing together the players in the world of health. The interface failed to involve the human health actors, and the Ministry of Health (like INSERM, the National Institute of Health and Medical Research) shows a strong reticence about the biodiversity issue as a human health issue, like this pharmacist, Head of the National Aerobiological

Monitoring Network, who perceives the working group as a militant group for the ecological cause that scorns scientific thinking. This pharmacist defends the priority of population health, particularly in cities where people are increasingly suffering from allergies:

It is certain that this working group is more led by tough activists! We must accept diversity in the group. Biodiversity must stop where the health of the inhabitants may be at stake. For me to expose is to produce allergic people. I ask for scientific proof. I think it's easier to prove that pollens cause symptoms than to prove scientifically that biodiversity in cities will bring well-being. Their objective is to consider that biodiversity does not harm health at all, but on the contrary it improves health. There is a desire to conceal everything that can be negative to biodiversity.

For their part, the defenders of the Biodiversity/Health nexus also defend a scientific approach, which mostly results in a census of meta-analyses, a synthesis of syntheses in other words. According to them, the lack of exposure to plant diversity (lack of biodiversity, invasive plants...) is the cause of allergies. To get out of this impasse relating to nature in the city, the epistemic community directed its work towards infectious diseases (Lugassy et al., 2019), mobilizing the controversial dilution effect. If historically, infectious diseases have been a favorite subject of physicians and veterinarians, little by little, through namely the controversial dilution effect, ecologists have taken up these issues. These bring scientific credence to the nexus through the dilution effect that shows that biodiversity losses negatively impact human health. Indeed, two opposing effects of biodiversity on disease transmission can be considered: amplification and dilution. The “amplification effect” refers to the principle that the more species that can transmit pathogens, the higher the risk of human contamination. By this argument, wildlife represents a risk of re-emergence of contagious diseases almost eradicated from domestic animal populations. The other effect is the “dilution effect”: which takes the opposing standpoint, by this argument wildlife could represent a brake on the transmission of diseases to humans (Roche, 2013; Roche & Teyssède, 2011). Thus, biodiversity represents a barrier effect in the transmission of pathogens and, conversely, an erosion of biodiversity would be likely to increase the probability of human infection. The most obvious demonstration of this phenomenon concerns Lyme disease (Léger et al., 2013). The US states with the highest diversity of small mammals and the prevalence of Lyme disease is the lowest (Roche & Teyssède, 2011).

In the WG, legitimacy is sought by the establishment of a certain scientific evidence, with the idea not of showing (the clinical approach) but of demonstrating (the statistical approach). While it can be argued that 3 out of 4 infectious diseases are zoonoses (Jones et al., 2008), more than 60% of the pathogens responsible for human diseases are of animal origin, and a majority of these pathogens come from wildlife. This Fig. (60%) is widely used to legitimize the nexus. In April 2019, the symposium entitled “Biodiversity can be an ally against certain infectious diseases?” organized by the French Agency for Biodiversity (AFB) and the FRB at the Ministry of Health, was a strong signal of the strategy to legitimize the Biodiversity/Health nexus and its stakeholders. Nevertheless, it did not fully demonstrate causal relations

between biodiversity erosion and human health issues. Indeed, the Symposium was organized around the review undertaken by the FRB that eventually reports the absence of strong scientific evidence on the 14 selected diseases (Lugassy et al., 2021). One reason to explain this situation is that few studies worldwide address the links between infectious diseases and ecosystem functionality. However, some diseases tend to be more studied than others as Lyme or West Nile Virus. And these studies (on Lyme and West Nile virus) are generally limited to making the link with the “Land-use” and its evolution and fail to consider the role of animal biodiversity in the predation of host or vector species or the dilution or amplification effects. The central issue is therefore the application of a methodology for identifying meta-analyses to this new object of knowledge.

Despite these limitations, all the stakeholders agreed to continue the effort to link the protection of biodiversity and the defense of public health through the reduction of infectious diseases. At the same time, if the epistemic community wants to make ecology a partner in the medical sciences, the objectives of nature conservation perspectives in academic research clash with an ideal of pure science. The dilution effect is controversial and opposed to the complexity of biodiversity and ecosystems, including by some active members of the initial French network of actors. Jean-François Guégan is a parasitologist and ecologist, both a former member of the Haut Conseil de la santé publique (HCSP) and a member of the committee of experts that advised Health Minister Roselyne Bachelot during the influenza A (H1N1) epidemic in 2009. “*The problem is that we ask people to take a stand when conceptually, this story can work, but we don’t have any definite proof. Each time, we have tinkered with things to show there is a dilution effect, there is no dilution effect. It’s positive negative, it depends.*” he explained.

Another scientist, Benjamin Roche, a Research Director at the Reasearch Institute for Development (IRD) based in Mexico City, currently tries to gether the fields of evolutionary ecology and public health with few colleagues (Guégan et al., 2022). He is currently leading the Prezode⁶ French Initiative (Peyre et al., 2021) and one of the specialists of the dilution effect. According to him, « *The latest meta-analyses in 2018 point towards a dilution effect. But we get confused: are we looking at the presence of a pathogen or the risk of having an epidemic?* ».

The members and experts of this epistemic community, which more or less corresponds to the WG, are mainly trained in ecology and veterinary sciences. Very few professionals from the medical world are present. These members come together based on an agreement on the complexity, the multifactorial, and interdependent character of living things, which they oppose to what they call “the pasteurian approach” (Latour, 1993) as told by this member of the WG, also leading member of *Humanité et Biodiversité*: “*We must understand the complexity of living things. Otherwise it’s coming back to bite us in the ass. You have to understand Ebola, with the deforestation, the installation of villages and roads, the funeral rites, and the failing health systems of these countries.*”

The nexus results from a positive reconsideration of the role of biodiversity for public health in a health landscape shaped by hygiene logic and practice.

⁶ Prezode stands for preventing zoonotic disease emergence.

Hygienism, the invention and massive use of antibiotics, the eradication of certain microbes, the sanitization of healthcare, food production, and livestock breeding facilities, and a host of practices that have hitherto guided agricultural, food, and public health policies have been reassessed in the light of the degradation of human health they cause. This member of both WG and *Humanité et Biodiversité* takes up this story that contrasts the complexity of ecology with the simplicity of the Pasteurian approach to the foundation of health risk governance practices: “*Ecology is really a science of complexity. Powerful mathematical tools are needed to solve them and it is not the pasteurian approach that, a virus, a bacterium, a disease...no. It’s much more complicated than that.*”

Building the cause for the Biodiversity/Health nexus goes through the association between a type of governance, in this case as an alternative to the current health governance, to particular scientific knowledge as opposed to legitimate knowledge. At the same time, the cause is carried by individuals with a scientific background and a bureaucratic trajectory. The WG managed to keep itself united on the condition that it respected professional logic and the imperatives of the scientific fields themselves. In most environmental health controversies, advocacy focuses on establishing causal links between facts and harm. The mobilization around biodiversity and its health impacts (Rabeharisoa, 2006) initially focused on providing systematic evidence on biodiversity as a rampart against infectious diseases. Although the group began a laborious process of questioning causal attribution, the reality of playing on the health field with the tools of evidence-based medicine ultimately contributed to discrediting their cause. This method does not allow the new cause to be put forward, especially since it is apparently victimless. The politics of causes (the procedures used) blurs the very definition of the political cause and the identity of the group defending it. Thus, the WG was eliminated from the PNSE 4, the new version of the national “health and environment” plan following the unanimous failure of the previous one according to the assessment report done by the General Inspectorate of Social Affairs (Buguet-Degletagne, 2018) and the one done by the General Council for the Environment and Sustainable Development (Pipien & Vindimian, 2018).

With the help of these attempts at conceptualization and systematic modeling, the members of this epistemic community sometimes informally invoke their personal experiences, which in their view attest to the fact that biodiversity is favorable to human health, for instance the benefits of forest walks against allergies, also considering mental health with a therapeutic garden experience for a family member. During meetings, in symposia and in publications, the international watchword “One Health” has been used to give credit to the nexus. The focus is then on the interactions and mutual benefits between the protection of humans, animals, and ecosystems, from the perspective of the paradigm shift within the professions and the need to take ecological aspects into consideration. Those different stakeholders have gained strong political opinions and ultimately pose the eminently political question about the world in which we want to live, spontaneously and systematically like this biologist: “*If I had a message, let’s realize again that we’re alive and that we’re part of biodiversity. Let’s rethink our links to biodiversity, to nature, to others and to ourselves. Then we will be able to rethink health problems.*”

Thus, this new evolutionary and ecological approach to health problems attempts to elucidate the mechanisms involved not only in the transmission and emergence of new pathogens but also in the ever-increasing resistance to antibiotics. Here again, we can observe that if antimicrobial resistance phenomena have been mainly the responsibility of physicians and veterinarians, ecologists are gradually taking over the subject, and some physicians like Antoine Andreumont, an antimicrobial resistance specialist, are part of this epistemic community embedding medical practice and medical science in a One Health approach. This approach also makes it possible to measure the effect of environmental factors on health. Robert Barbault refers to “ecomedicine,” which consists in “moving away from the simplistic paradigm of the pathogen that triggers a disease to a reflection based on ecological epidemiology” (Pipien & Morand, 2013). The Biodiversity/Health nexus testifies to this redefinition of dangers to human health. Many interviewees finish the interview using the famous formula according to which “you don’t eradicate a pathogen, but you learn to live with it” (Haraway, 2008).

The “politics of cause” initially failed taking account of the local experiences dealing with biodiversity and health. The framing, without enough “scientific” data, makes the nexus untranslatable and inconsistent with other justification regimes. Using the biomedical tools and cognitive schemes, the Biodiversity/Health nexus has remained a problem relatively confined to a small epistemic community in France. Indeed, in the framework of post-normal sciences (Funtowicz & Ravetz, 1993) and in a context of great uncertainty, this redefinition of organisms and their components is accompanied by a reconsideration of the states of health and etiologies of many pathologies, now considered from the point of view of ecological balance or disturbance, without the mechanisms at work being elucidated (Blaser, 2014).

Since 2018, the Biodiversity/Health nexus became a less confined public issue when One Health gradually emerged as the political and institutional, while the concept was first interpreted as a response to an institutional crisis between WHO, OIE, and FAO (Chien, 2013) and become then well rooted in national spaces. This is still an attempt by environmental advocates to re-evaluate the ecological cause in health management and for the veterinary public health inspectors’ corps to make veterinarians central actors in public health. But what happens when, beyond the production of new knowledge (Michalon, 2020), the nexus that calls for a change in governance becomes a problem? How do we move from the conceptual framework of health/biodiversity to public action?

Implementation challenges

The conviction of the nexus members is that these reconsiderations of interactions between living beings should, in the middle term, lead to new ecological health policies, and reshape the health system in the framework of a post-pasteurian approach. In concrete terms, the human and veterinary medicines integrate at varying levels this knowledge into their practice of care, and health management of populations. Using the example of the management of infectious diseases involving wildlife, our case study shows not only how the French epistemic community finds a

way to implement its cause but also the need to consider the systemic challenges in local implementation systems, structures, and capacities. This case thus highlights how the management of infectious diseases involving wildlife refer to issues with expertise and action which are embedded within the logic and structure of dominant policy and governance regimes.

While France had not seen a case of ruminant brucellosis in livestock for more than 10 years, following the abortion of a cow in a dairy herd producing raw milk Reblochon fermier, a famous French cheese which belongs to an important economic sector in Haute-Savoie (French Alps), a bovine case of *Brucella melitensis* biovar was detected on 4 April 2012. Five other cows were found to be seropositive and the entire herd was culled as a precaution. A few months earlier, a case of human brucellosis in a child, whose origin remained unknown, had been detected in the region, followed by a second case in the same family in a young man. The French National Agency for Food, Environmental and Occupational Health Safety (Anses) highlighted the similarity of the bacterial strains in the patients and the aborted cow.

Haute-Savoie has been officially free of brucellosis since 2005 — for a country to be considered “officially free” in the EU sense, farmers must no longer vaccinate their herds — and the last case dates back to 1999. The EU’s “officially brucellosis-free” status allows French farmers to have a lower level of constraints in terms of testing and screening their herds and dairy products, and facilitates trade in animals and products with EU member countries. Keeping the status is therefore very important for the department.

Chamois, roe deer, and ibex were tested, but only two chamois tested positive for the bacteria. Conversely, several ibexes have been diagnosed as infected with brucellosis. In addition to the infection of cattle, investigations carried out in the wild fauna made it possible to identify the presence of brucellosis in a population of ibexes that occupying the Bargy massif (Haute-Savoie). But the ibex is a species protected by the law of 10 July 1976 (Bern Convention, ministerial decree of 2007), which has been reintroduced. The species had completely disappeared from the French Alps, notably because of hunting pressure since the nineteenth century. It is therefore banned from hunting and is subject to extensive surveillance in the national parks. However, the ibexes of the Bargy massif are not part of a national park, so the health and population monitoring of these ibexes is less.

From the destruction of all ibexes supported by the agricultural actors to its defense in the name of biodiversity, positions were quickly settled. Indeed, the law suggests that it would be possible to apply prophylactic methods (culling) used on domestic animals to wildlife. This is the same idea defended by the supporters of culling during the crisis, who brought together farmer union activists, representatives of farmhouse Reblochon producers, the Prefect of Haute-Savoie, the Mayor of Annecy-le-Vieux, and Member of Paliament (Haute-Savoie), Bernard Accoyer. Relying on the defense of the Reblochon sector, the Prefect of Haute-Savoie, Georges-François Leclerc, put forward the proposal of a total culling of the ibexes with a reintroduction of healthy animals, after a sanitary vacuum, in line with the National Hunting and Wildlife agency (ONCFS), while promising the reintroduction.

Bernard Accoyer supported this proposal, pointing out the risks for public health and the risks for the Reblochon industry, which is responsible for 40% of the GDP of Haute-Savoie according to him. The idea of addressing the same responses for wild fauna as for domestic fauna was taken up. For their part, given their status as a protected species, the associations for the protection of nature are opposed to the total eradication of ibexes. Furthermore, they argue that there are many healthy animals among this population. Meanwhile, a new approach to health was emerging, based first and foremost on an ecosystem approach and its dynamics, highlighting the complexity and specificities of wildlife.

The question was whether it was better to take the risk of leaving seropositive ibex in one massif, hoping that they would not move to other massifs, or to cull the entire population, at the risk of seeing the ibex flee to other massifs. This was a major issue for biodiversity.

Note written by a member of the Ministry of Ecology, 17 June 2013.

Experts from Anses have been called in by the Ministry of Agriculture and the Ministry of Environment, and provided epidemiological studies showing that the risk of transmission of brucellosis from ibexes to herds was very low. In spite of this, the political decision was to cull the animals. The day after the signing of the decree authorizing the culling of ibexes in October 2013, a lightning operation was carried out: 197 ibexes were culled in 3 days. The captures were difficult for the National Hunting and Wildlife agency (ONCFS) officers who were also subject to external pressure. The farmers were satisfied, while the environmental and animal protection associations denounced the operation. The culling of the ibexes proved to be complicated. The most contaminated young ibexes were dispersed in the massif. The solution was partly counterproductive in managing the zoonosis.

The French Biodiversity/Health nexus epistemic community promotes an ecological understanding of the ibex crisis and a defense of biodiversity. The total, then partial, culling of the ibexes as a crisis management measure was and still is castigated. The detractors make it an emblematic case of the failure of veterinary management. This solution has had mixed results during, just after, and well after the crisis, i.e., at the time of writing this article. The Barge crisis was the catalyst and witness to the hybridization, and even the destructuring, of veterinary knowledge and the management of animal health crises, in particular in contact with other disciplines, notably ecology. Although the Barge crisis received little media attention, it does point to a crisis of territories and professional knowledge. Criticism of the management of this crisis raises the question of the legitimacy of new stakeholders in health management and, more generally, of the way in which crises involving wildlife are subject to negotiated management. The conservationists put forward other arguments against the overriding argument of public health. For them, it is not relevant or acceptable to apply the same prophylactic methods used on domestic animals to wildlife. The case of wildlife thus appears to reveal a reconfiguration of the boundaries between the environment and agriculture. On the one hand, environmental stakeholders are taking up health issues (mobilizing international expert knowledge and local experiential knowledge). Secondly, we can see, through the case of the ibex “crisis,” what the One Health categories

(a single human animal health, ecosystems) produce in terms of professional territories and possibly public action categories. Finally, if public action pursues an ideal of integration and coordination (Biodiversity-health nexus, One Health, interministeriality, etc.), the case study highlights a classic phenomenon of competition between the knowledge, the professionals, and the institutions involved.

The Bargy “crisis” (the Bargy crisis has in fact had many twists and turns) is evidence of the conflicts surrounding wildlife management (associations, farmers, public agents) and of the lively controversies between segments of the State on the solution to be adopted to resolve the crisis. There is here a great deal of uncertainty and a need for expertise, considering little knowledge available on brucellosis in ibex and also the lack of wildlife health surveillance. This “crisis” demonstrated a compartmentalization between the Ministries in charge of Agriculture, Ecology and Health (remaining globally absent on this issue), which led to a certain mutual ignorance, conflicts, and disparity of initiatives. Several recent health crises involve non-manageable species: protected species (Ibex), small mammals (rodents or chiropterans), and migratory birds that cannot be hunted. If, for a long time, wildlife species have been considered as victims of diseases spread by domestic animals, the opposite seems much more likely today.

This case study illustrates the issue of the framing of the Biodiversity/Health nexus and its partial failure to integrate environmental data into health management. The framing of the nexus shows the willingness of ecology professionals and biodiversity institutions to extend the scope of their actions. Secondly, these actors have managed to form broader alliances based on a critique of health system governance based on methods perceived as outdated.

Finally yet importantly, the criticism of the pasteurian approach by the actors involved is connected to a critique of the State, and of local, national, and international health system governance. Moving away from the “science-centric” approach and “de-technicising” debates with the help of an approach rooted in concrete experiences of governance would be ways of taking a step back from health system governance. Proponents of the ecological approach to health promote a preventive model that is complementary to the curative model and that includes local populations and contexts. The protection of biodiversity has indeed a strong local dimension (unlike climate change) and the problem is not to oppose two approaches: the health problem as an ecosystem problem *versus* a problem of the host and its pathogen. “*In my opinion, [these two approaches] do not have to be opposed but they are completely complementary. If we can use biodiversity to limit the number of I don’t know which zoonoses, it will be done upstream, it’s really to prevent it from happening to humans. That doesn’t prevent more conventional medical research from playing its part*” (Scientist, A member of *Humanité et Biodiversité*).

Today in France, human health problems involving wild fauna and flora (Lyme disease, allergies, Influenza, etc.) lead to struggles of expertise and assessment methods between ecological, human health, and animal health professionals. As a result, territories and professional legitimacies are at play in the light of the Biodiversity-Health nexus, and beyond the One Health concept in the politicized nature of decision-making and priority setting (Gardon et al. 2022). The case as far developed also underlines a number of strategies that might help reconfigure

current pathways and accepted norms of practice, namely the challenging scientific expertise, the strengthening national multi-sectoral coordination but also democracy and the reframing of policy narratives (Bardosh et al., 2017).

Conclusion

The sociological analysis of the Biodiversity/Health nexus shows the aims of an epistemic community, the difficulties in coordinating nature conservation (developed around the notion of biodiversity), and public health interventions connected to the notions of infectious diseases, bacteria, and vaccine. Both the means of intervention and the cognitive concept of public health (the so-called pasteurian approach) are targeted, while the elements of biodiversity (nature, species, microbes) are redefined as defenses for public health. While scientific papers (e.g., biology, epidemiology) have mainly considered biodiversity as threats to health (vectorial transmission with West Nile fever, Rift Valley fever, tick-borne encephalitis, and interspecies simple contact with rabies, etc.), an emerging epistemic community has been circulating concepts, texts, and proposals which link biodiversity and health issues, based on the idea that biodiversity provides a wide range of services for human health and well-being.

One of the reasons for the failure of the Biodiversity/Health nexus, until the COVID-19 crisis, at the institutional French level, is the tension between the complexity of causal patterns and relationships on the one hand, and activist commitment to a cause on the other hand. The way the cause has been forged is both technocratic and science oriented. Using the language and the tools of public health, through literature reviews, prevents the inclusion of the practices of the actors in a “bottom-up” approach (in contrast to current participatory approaches in ecology). Beyond the issue of translating science into a technocratic framework, ecologists have been widening their scope and in so doing are attempting to be more legitimate, in this case by becoming coowners of public health issues (Neveu, 1999), raising tensions in terms of institutional prerogatives, allocation of responsibilities, and ways of working.

The Biodiversity-Health nexus shows interconnections between networks of experts and the structuring of a network of ecological activists among researchers in biology and/or ecology. If the Biodiversity/Health nexus does not correspond to a specific public policy, we have shown how this nexus challenges the governance of health since 2015.

Reduction of infectious diseases related to wildlife is a historical objective of health policies. Today the new political cause shows how the health field is being shaken up by the entry of new professionals (such as ecologists) and the irruption of new knowledge and new ways of thinking (interactions are privileged between the different elements that make up ecosystems). Human health problems involving wild fauna and flora (Lyme disease, allergies, etc.) are provoking conflicts of expertise and evaluation methods between ecology professionals, human health professionals, and animal health professionals. The ways of thinking and framing health issues

are contested, thus professional territories and professional legitimacy are being re-examined.

If the too recent time-scale of the process does not allow any anticipation of the logic undergoing social and political construction, the COVID-19 pandemic really gave a boost to the processes described for taking into account the environmental issue in health management. The structural obstacles inherent in this undertaking seem still prevalent (see the evaluation of PNSE3; Buguet-Degletagne, 2018) but the COVID-19 pandemic has given the nexus a different meaning: it is now a matter of public health. This has justified the inclusion of a veterinarian on the COVID-19 scientific committee. It has also justified new partnerships between the training of physicians, veterinarians, and ecologists. We should not underestimate the dynamics underway, initiatives and projects are emerging and producing cognitive and practical effects, but without yet succeeding in shaping a real integrated policy of “bio-diverse health.” Looking at the intellectual foundations of this process of constructing a public problem sheds light on the dynamics at work and more visible in the light of the pandemic.

Abbreviations AFB: The French Agency for Biodiversity; ANSES: The French Agency for Food, Environmental and Occupational Health and Safety; CDB: The Convention on Biological Diversity; CGAAER: The French General Council for Food, Agriculture and Rural Areas; CGEDD: The French General Council for the Environment and Sustainable Development; CNEVA: The French Centre for Veterinary and Food Studies; FNE: The French Nature Environnement Federation; FRB: The French Foundation for Research on Biodiversity; IPBES: The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services; INSERM: The French Institute of Health and Medical Research; IUCN: The International Union for Conservation of Nature; MA: Millenium Ecosystem Assessment; MNHN: The French Museum of Natural History; ONCFS: The French Office for Hunting and Wildlife; PNR: Regional Natural Parks; PNSE: Health-Environment National Plan; ROC: Rally of Opponents of Hunting

Author contribution AG, SG, and CD collected and analyzed the qualitative data, and wrote the article.

Data availability Qualitative data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval The research meets ethical requirements and protects the welfare of study participants.

Consent to participate Not applicable.

Consent for publication The authors have permission to publish research findings.

Conflict of interest The authors declare no competing interests.

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