Policy brief

Biodiversity mitigates health risks

Biodiversity can mitigate the spread of infectious diseases. Human disruptions alter ecosystems' ability to protect our health

Main findings

- Wildlife host a variety of pathogens. Extensive surveys across Africa and Europe found that many species of rodents and bats are infected with a large variety of zoonotic viruses, some of which can potentially infect and harm humans.
- Land use change and other human disruptions to ecosystems reduce the diversity of small mammals, increasing the relative proportion of species that host zoonotic pathogens.
- The effect of biodiversity on pathogen transmission is highly dependent on local ecological communities, either diluting or amplifying transmission risks.
- Habitat properties, such as forest structural diversity, may also reduce the spread of tick-borne diseases.
- Microbial diversity limits pathogen infection in animals and plants and inhibits the spread of antimicrobial resistance.

Policy recommendations

- Protect and restore natural habitats and conserve biodiversity with the additional goal of protecting human health by reducing pathogen prevalence.
- Strengthen the implementation of the One Health approach to address the interlinks between the health of humans, animals, and the environment.
- Implement pathogen surveillance in wildlife in the environment to identify risks of pathogen transmission to humans.
- Strictly enforce regulations against illegal wildlife trade to conserve biodiversity and to prevent the risk of new pathogens spillover to humans.
- Invest in local examinations of the relationships between a pathogen, its disease vector, and hosts, within local ecological communities to identify and address potential human disease risks.
- Monitor the spread and propagation of antimicrobial resistance in the environment and its link to biodiversity.
- Support microbial diversity to protect the health of humans, animals and plants by restricting antimicrobials and reducing chemical pollution.

Context

Biodiversity provides multiple ecosystem services essential for human health, including the control of infectious diseases[1]*.

Most (75%) of emerging infectious diseases (EIDs) are zoonotic, meaning they originate in animals[2]. These diseases were not previously known in humans and, therefore, can be particularly harmful because they emerge without existing vaccines or treatment, posing significant health risks. Emerging outbreaks such as COVID-19, H1N1 influenza, and Ebola have taken a devastating toll on human lives, health, and the economy[3]. In addition, there has been a global increase in vector-borne diseases, which are transmitted from host vertebrates to humans by vectors like mosquitos or ticks[4].

Biodiversity loss, land-use change, agricultural expansion and intensification, and wildlife trade and consumption are the main drivers of emerging pathogens and pandemics[3]. Chemical pollution, climate change and invasive alien species are additional key drivers associated with the emergence of infectious diseases[5]. Global trade and travel exacerbate these effects.

Many wildlife species are infected with pathogens (viruses, bacteria, fungi and parasites), some of which can potentially infect and harm humans. However, many pathogens do not cause disease in wildlife, and diverse ecological communities help to reduce the prevalence of infectious pathogens. Human-driven destruction of ecosystems disrupts host-species communities and increases contact between humans, domestic animals, and wildlife, increasing the transmission of new pathogens to humans (spillover) (Figure 1)[6].

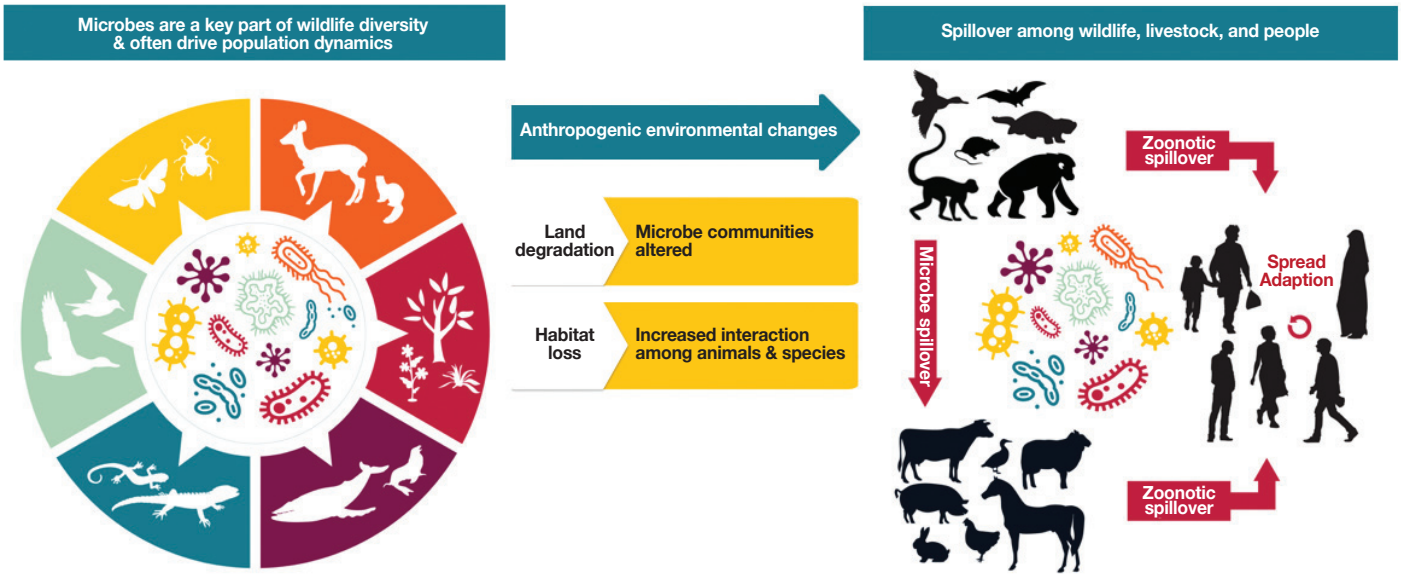


Figure 1: Origins and drivers of emerging zoonotic diseases and pandemics. Pathogens have evolved within wildlife species **(left)**. Human-driven environmental changes alter populations of pathogen reservoir hosts, and bring wildlife, livestock, and people into contact **(centre)**. These interactions can alter transmission dynamics within hosts, increase transmission of pathogens among wild species, and result in transmission to livestock and people (spillover), causing novel diseases to emerge **(right)** (Source: IPBES 2020)

* Full citations are provided in the attached information sheet for this policy brief.

Key results

In 2018, Biodiversa+ launched the BiodivHealth call to support research at the nexus of biodiversity and health. This policy brief highlights findings from six funded research projects: Biodiv-AFREID, BioRodDis, Dr.FOREST, DiMoC, ANTIVERSA, and SuppressSoil.

Biodiversity harbours a large variety of pathogens with zoonotic potential

Extensive surveys across Western and Central Africa found that 20% of sampled bats carried diverse viruses from the Coronavirus family, some of which could infect humans, including viruses related to the SARS-CoV-2 virus that was responsible for the COVID-19 pandemic[7]. Similarly, across Europe, 31% of small mammals and 8% of bats tested positive for Coronaviruses[8].

In the Democratic Republic of Congo, 4% of bats and 18% of rodents had antigens against viruses from the Ebola virus genus, suggesting past infections[9–11]. Interviews with local residents revealed that they frequently go into the forest, where they interact with a large variety of animals, and most villagers consume wild meat. This close contact increases the risk of pathogen spillover to humans. Previous outbreaks of Ebola were linked to the consumption of infected bushmeat[7,9].

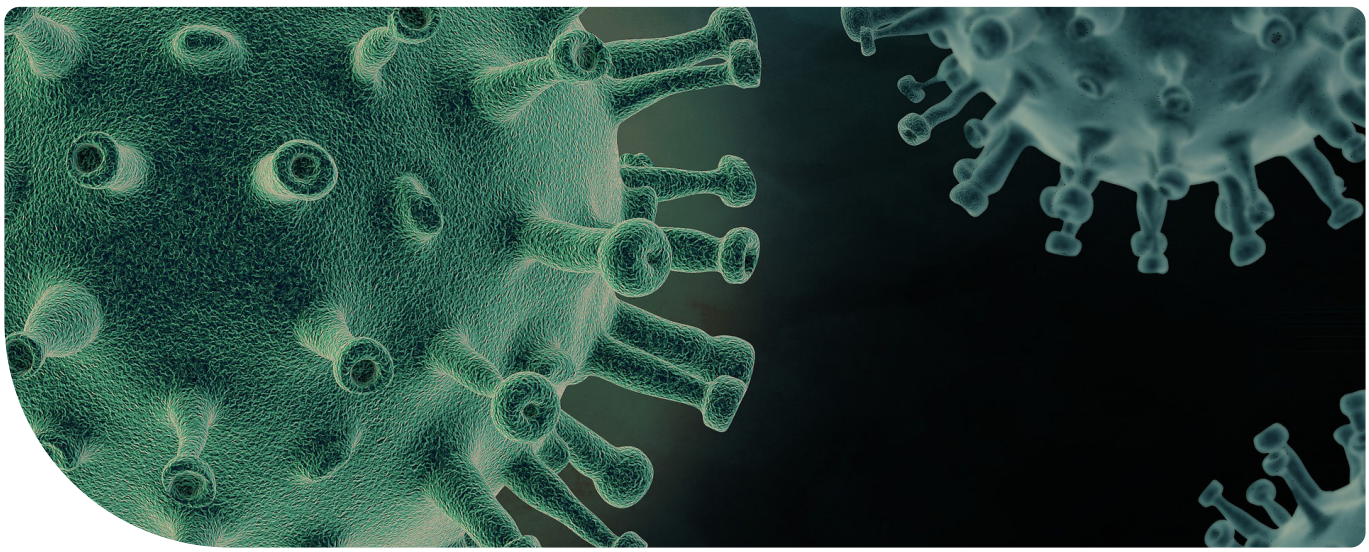
The diversity and health of small mammals affect zoonotic pathogen spread

The BioRodDis project examined how land use changes affect small mammal diversity (rodents and shrews) across Europe. The diversity of rodent species was lower in urban parks compared to natural forests and had different compositions. Urban-adapted rodent species carried more pathogens. Human disturbance to natural ecosystems significantly influences pathogen dynamics by increasing the proportion of species more likely to host zoonotic pathogens[12–14].

Multiple meta-analyses demonstrated that biodiversity of host species reduces pathogen prevalence in various host-pathogen systems, known as the **dilution effect**. However, it is unclear under which conditions higher biodiversity will lead to a higher abundance of pathogens or to a lower one[15,16].

Bouilloud *et al.* examined the relationship between small mammal diversity and the prevalence of multiple pathogens in forests across France. Higher biodiversity decreased some pathogens (dilution effect) but increased others or did not change them. The pathogen-biodiversity relationship was determined by the effect of diversity on the relative abundance of the primary host of the pathogen[12,13]. These results demonstrate that while biodiversity can play a role in mitigating pathogen spread, it depends on the specific interaction between hosts, pathogens, and species diversity within each ecological community.

Importantly, Canet *et al.* found non-specific rodent eradication ineffective, sometimes even increasing pathogen prevalence. Species control can change the community composition of hosts and increase the abundance of unintended species that serve as hosts of other pathogens[12,17].



Biodiversity is tightly linked to the prevalence of mosquito-borne diseases

A global meta-analysis found that different *Culex* mosquito species are primary vectors in various regions[4]. For example, *Culex pipiens* is a major vector in Europe, particularly for the West Nile Virus[4] (Figure 2).

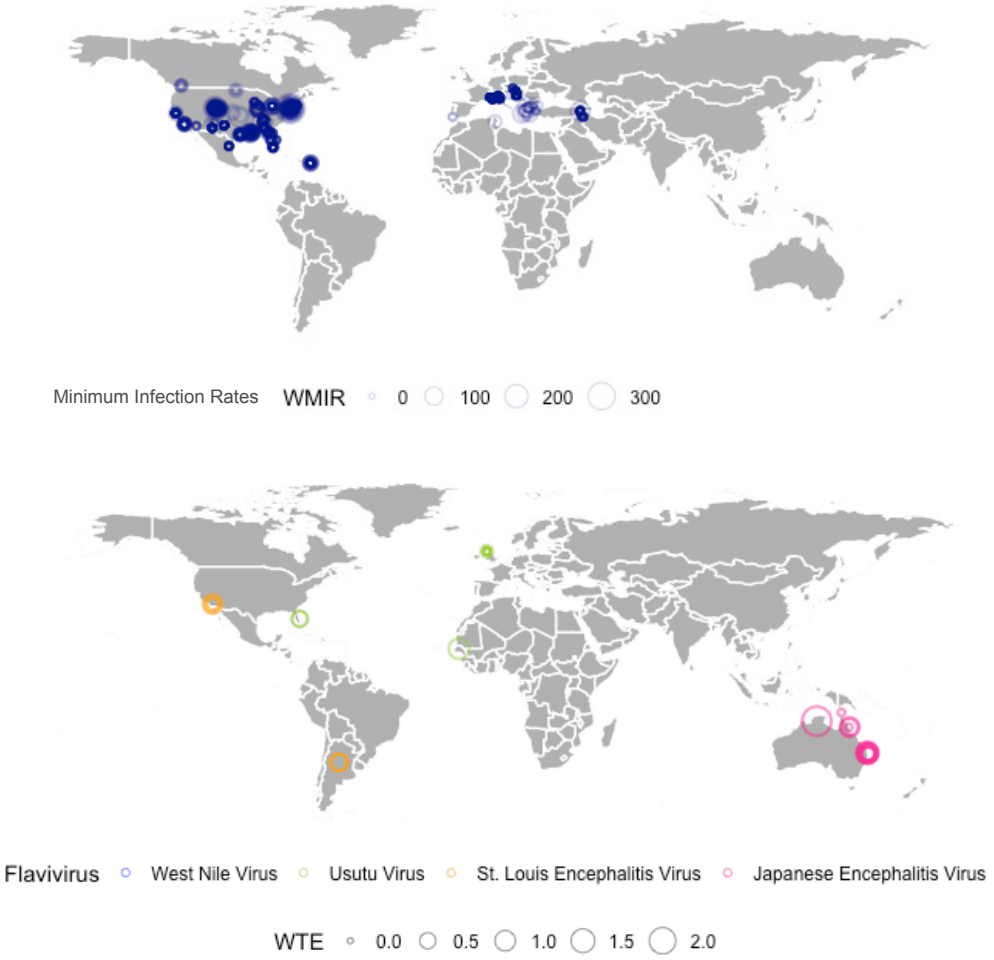


Figure 2: Global infection rates of *Culex* (Cx) mosquito species vectors for viruses belonging to the Japanese encephalitis serocomplex (JES) (Source: adapted from Tolsá-García *et al.* 2023)

Examining global mosquito feeding patterns on hosts found that *Anopheles* and *Aedes* mosquitoes mainly feed on mammals, while *Culex* mosquitoes feed on birds. Importantly, 60% of the mosquito taxa fed on humans, highlighting their potential risk to public health[18]. Identifying the vector mosquito species and the relevant hosts with a high risk of pathogen infection in each region can help more efficiently target surveillance and vector control strategies[4].

Contrary to the prediction of the dilution effect hypothesis, the prevalence of three mosquito-borne pathogens increased with a higher diversity of vertebrates[19,20]. These results suggest that the community composition and interactions among hosts, vectors, and pathogens are more influential in determining local disease risk than species richness alone[20].

Forest diversity reduces tick-borne pathogens

Tick-borne diseases are spreading worldwide, impacting the health of both humans and domestic animals. Bourdin *et al.* revealed that *Ixodes* ticks were more abundant in forest habitats, especially in mixed deciduous-coniferous forests than in open habitats[21]. However, forest structural and species diversity reduced the infection of ticks by *Borrelia* bacteria, a pathogen causing Lyme disease (Figure 3)[22]. These results support the idea that habitat diversity, in addition to species diversity, is essential in managing the prevalence of pathogens and should be integrated into conservation and public health strategies[22].

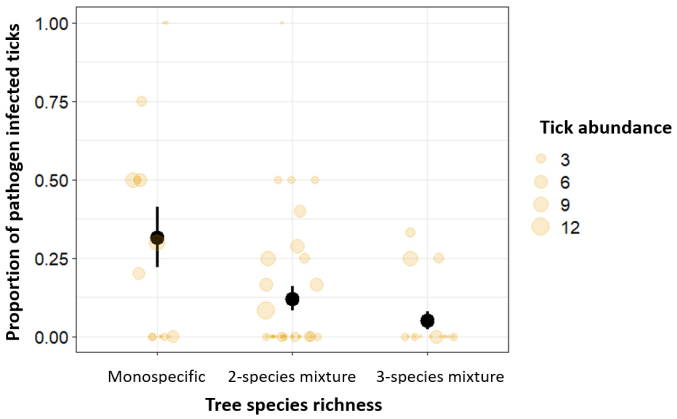


Figure 3: Forest diversity reduces the proportion of ticks (nymph stage) infected with *borrelia* (Source: adapted from Bourdin *et al.* 2022)

Microbial diversity reduces infection by pathogens

Bouilloud *et al.* showed that the gut microbiome of small mammals reduces along a gradient of land use change intensity. Urban small mammals have a less diverse gut microbiome compared to those in pristine forest areas, which may impair their immune responses[23]. Specific gut microbiome families were found to reduce pathogenic infection[24].

In plants, Todorović *et al.* found that diverse soil microbial communities were more likely to contain bacterial functional groups that suppressed harmful pathogens like *Fusarium*, which causes significant crop damage and economic loss[25]. Moreover, the microbiome of soils that protect plants from fungal pathogens can also protect plants from some pest insects, meaning the plant-protecting microbiota may confer a wide range of plant-beneficial properties[26]. This highlights the importance of maintaining microbial diversity for the health of both animals and plants.

Antimicrobial resistance (AMR) is a major global health threat, exacerbated by the inappropriate use of antibiotics in humans and animals, sewage overflow, and treated wastewater contamination[27]. Klümper *et al.* found that soils from natural environments with higher microbial diversity and richness have a significantly lower abundance of antibiotic resistance genes (ARGs)[27]. In river microbial communities (biofilms), greater microbial diversity also reduced the invasion of new antimicrobial resistant bacteria into the microbiome[28,29].

Policy recommendations

The results from the BiodivHealth research call demonstrate that biodiversity is tightly linked to infectious diseases, including zoonotic and vector-borne diseases. Although no specific studies on the effectiveness of the suggested policies were conducted by the research groups or during the production of this brief, the knowledge presented highlights measures that could simultaneously support biodiversity conservation and mitigate human health risks.

- **Strengthen the implementation of the One Health approach** that recognizes the link between the health of people, animals, and the environment by implementing the UN One Health Joint Plan of Action. Results presented in this brief indicate the need for cross-disciplinary collaborations, specifically between ecologists, veterinarians, and public health professionals, to address the interconnected risks to human health and biodiversity.

- **Protect and restore biodiversity to benefit human health** and reduce pathogen prevalence. The Convention on Biological Diversity (CBD) Kunming-Montreal Global Biodiversity Framework and the EU Biodiversity Strategy for 2030 acknowledge the interlinkages between biodiversity and human health. Findings on the effects of human disturbance on ecosystems and zoonotic spread emphasize the urgency of implementing these conservation plans to reduce spillover risks linked to ecosystem degradation.

- **Investigate the specific interaction between pathogens of zoonotic risk, host species, and biodiversity within local ecosystems**. Locally tailored studies are needed to guide effective conservation practices and reduce zoonotic risks.

- **Limit wild meat trade and strictly enforce bans on illegal wildlife trade**, such as Regulation (EC) 338/97 on trade in wild species and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Illegal wildlife trade drives biodiversity loss and increases the risk of pathogen transmission to humans[30].

- **Identify and restore habitat properties** that reduce the prevalence of pathogens near human populations. Human health risks could be considered within the newly adopted EU Nature Restoration Law. For example, conserve urban ecosystems (Article 8) to support small mammal diversity and to reduce relative abundance of pathogen hosts, and restore forest structural and species diversity (Article 12) to reduce tick-borne pathogens.

- **Implement surveillance of pathogens in wildlife and the environment** (soil, water) to identify emerging risks to humans. Support global reporting of zoonotic outbreaks in humans and wildlife as part of a pandemic preparedness plan under Regulation (EU) 2022/2371 on serious cross-border threats to health.

- **Apply animal control with caution** Non-specific eradication programmes can disrupt ecological balance and increase pathogen spread; targeted control is recommended. Amending Article 31 of Regulation (EU) 2016/429 ('Animal Health Law') to ensure high specificity to target species, might promote this goal. Similarly, target mosquito and tick control to relevant vector species to protect globally declining insect populations.

- **Monitor the spread and propagation of antimicrobial resistance (AMR) in the environment**, focusing on the role of local biodiversity in attenuating AMR propagation.

- **Support microbial diversity in a sustainable way** to promote resistance to pathogenic infections. Restore ecosystem health and diversity and reduce the use of chemicals and broad-spectrum antimicrobials. Enforce Regulation (EU) 2019/6 to prohibit routine antibiotic use in farming (Article 107). Soil microbial diversity can be protected with the newly adopted EU Soil Strategy for 2030. Monitoring microbial diversity could also serve as an indicator of ecosystem health.

Link to sources

ANTIVERSA
Biodiv-AFREID
BioRodDis
DiMoC
Dr.FOREST
SuppressSoil

The scientific publications used in this policy brief can be found in the Information Sheet of this briefing, downloadable from:
www.biodiversa.eu/policy-briefs/

Photos: Pixabay

Contact

contact@biodiversa.eu
www.biodiversa.eu

@BiodiversaPlus

@Biodiversa+

About this Policy Brief

This Policy Brief is part of a series aiming to inform policymakers on the key results of the biodiversity research projects funded by Biodiversa+ and provide recommendations to policymakers based on research results.

The series of Biodiversa+ Policy Briefs can be found at https://www.biodiversa.eu/policy-briefs/.

This publication was commissioned and supervised by Biodiversa+, and produced by Dr. Miri Tsalyuk.

The key research results presented here were co-drafted and validated by researchers from the research projects: ANTIVERSA, Biodiv-AFREID, BioRodDis, DiMoC, Dr.FOREST, and SuppressSoil funded by the Biodiversa+ BiodivHealth research call on biodiversity and health.

The policy recommendations made do not necessarily reflect the views of all Biodiversa+ partners.

Co-funded by the European Union under Grant Agreement No 101052342 and No 642420

MIX Paper from responsible sources FSC® C019064

Produced in October 2024.