Protecting People and Wildlife:
Guidelines for Prevention, Detection, Response, and Recovery from Disease Risks in Protected and Conserved Areas

Draft – 13 March 2022

1) Disease risk in protected areas: challenges and opportunities

Protected and conserved areas (PCAs) are core to global and national conservation efforts. Even if not fully recognized, their role in pandemic and epidemic prevention, detection, response, and recovery is also potentially significant. While protected and conserved areas could be a source of known and novel pathogens, they are also crucial for ecological services that keep human and wild animal populations safe from a range of infectious and non-infectious disease threats. This complexity requires dedicated attention to address disease risk in ways not presently included in conservation planning and management efforts.

PCAs typically have high species diversity. Greater species diversity can be associated with greater microbial diversity, though the vast majority of microbes have beneficial effects and do not cause disease in humans. PCAs vary widely in their biotic characteristics and anthropogenic practices, with some increasing or decreasing risk of zoonotic disease and their capacity to prevent, detect, respond, and recover from disease events. Some practices used in pursuit of other objectives (e.g., ecotourism revenue, habitat preservation) may unintentionally increase risk or serve as a protective factor.

It is important to note that PCAs, and biodiversity itself, do not present inherent risk for pathogen spill over. Human changes to ecosystems (direct and indirect) and human behaviors are responsible for creating the conditions associated with zoonotic disease risk. These conditions can also imperil the health of wild animals.

At present, strategies used to reduce disease risk in and around PCAs are limited, and mainly emphasized by sites with great ape tourism efforts. Health risks and impacts are typically considered in separate processes from conservation planning, and measures aimed at health protection often result from specific disease events. In line with a "One Health" approach, taking a more systematic and proactive approach to assess and manage disease risks can promote safer practices and greater multi-sectoral value derived from protected and conserved areas.

This guidance is targeted to PCAs (and proposed PCA) managers and agents (PAAs). While voluntary, they are intended to support the IUCN's Green List standard, identifying specific actions PCAs managers and agents can take to address disease risks to better prevent, detect, respond, and recover from zoonotic and wildlife disease events. Actions are provided that can be taken at site management level via policy decisions, as well as operational strategies by rangers, researchers, and other front-line workers, including through partnerships. In addition, the guidance can help orient other sectors (e.g., public and animal health, disaster management) on ways to engage the conservation community in disease risk reduction and preparedness. Case studies are provided throughout, building on the PANORAMA - Solutions for a Healthy Planet partnership Species portal.

Biodiversity, ecosystems, and health links

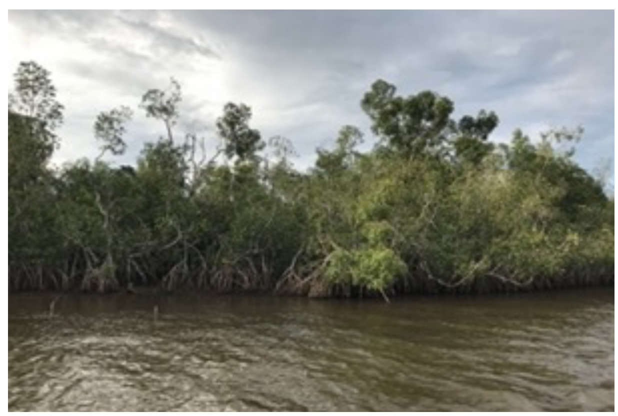
Biodiversity and ecosystems provide significant value for health and wellbeing, and in fact underpin all life on Earth.[1] Thus, PCAs are beneficial for the health of humans and other species. Ecosystem or site designation often occurs on the basis of a need to protect ecological integrity and function of systems, which is often coupled with the generation of ecosystem services such as clean water, pollination, coastal flood protection, or carbon sinks. Many PCAs, such as national or subnational parks, also support physical and mental health benefits via recreation. As part of functional ecosystems, habitat and species protection help to maintain predator-prey relationships, thereby supporting functions including disease regulation. Maintaining species richness and relative abundance (community composition) is part of keeping ecosystems in balance.

Key terms

- *One Health:* an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems. It recognizes the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and inter-dependent. The approach mobilizes multiple sectors, disciplines and communities at varying levels of society to work together to foster well-being and tackle threats to health and ecosystems, while addressing the collective need for clean water, energy and air, safe and nutritious food, taking action on climate change, and contributing to sustainable development.[2]
- *Zoonotic diseases:* infectious disease caused by pathogens that can be transmitted between humans and other animal species.

Many PCAs help to reduce disease risk in significant ways. At the same time, disease risk reduction is not normally a goal of conservation, and thus ways to optimize existing conservation resources for pandemic and epidemic prevention are poorly emphasized. Key opportunities include contributing to:

- Protection of habitats and landscapes to reduce the ecological and anthropogenic changes commonly associated with disease risks;
- Investigation and management of disease risks and impacts;
- Detection and early warning of disease events of threat to human or animal populations;
- Surveillance to inform microbial diversity;
- Uptake of safe practices and policies by staff, visitors, scientists, and communities to reduce pathogen exposure risk



Mangrove forest, Margibi, Liberia. C. Machalaba 2019.

[1] https://www.cbd.int/health/SOK-biodiversity-en.pdf

[2] One Health High-Level Expert Panel, 2021.

Many of these objectives can be pursued through ongoing initiatives or new partnerships, thus reducing their potential cost, or leveraging capacity and resources in other sectors. Protected area sites vary in their existing infrastructure and resourcing, and capacity and infrastructure development or strengthening may be needed for sufficient awareness, training, coordination, and implementation.

Disease examples of relevance and rationale for management action in PCAs

Zoonotic diseases refer to disease caused by pathogens that can be transmitted between humans and other animal species. As a result, zoonotic diseases are of high concern for public health, and may also present a threat to conservation. Examples include Ebolaviruses, rabies, plague, and tuberculosis, which can cause disease in both humans and animals. In fact, nearly two-thirds of pathogens infectious to humans have a zoonotic origin, and a portion of mammalian viruses yet to be discovered in nature have the potential to result in emerging infections in humans. It is critical to note this is not one-directional; humans can and do transmit infections to wildlife, in some cases with high consequence to wild animal populations.

In addition to zoonotic diseases, some pathogens of concern for conservation are transmitted between domestic and wild animals (such as distemper virus in domestic and wild carnivores, and toxoplasmosis in endangered monk seals and sea otters linked to feral and outdoor domestic cats that shed the parasite).[3,4,5] Disease may also be transmitted between wild animal species and previously unexposed populations of the same species or taxonomically close species. For example, the intercontinental spread of the chytrid fungus *Batrachochytrium dendrobatidis* has been documented in frogs, and the potential spread of *Batrachochytrium salamandrivorans* is recognized as a major threat to salamander populations. The decline of species from infectious diseases can have significant impacts on ecosystems and the provision of ecosystem services, thereby also impacting human health and wellbeing.

Globally, canine (domestic dog) rabies is the source of 95-99% of human cases and the major source of infection in animals. However, other sources of introduction and spread can impact individual wild animals or populations, as seen with the introduction of rabies into African wild dog (*Lycaon pictus*) populations suspected by jackals (*Canis mesomelas*) (which themselves were likely infected at one point via domestic dogs). In parts of the Americas, bats maintain a sylvatic rabies cycle, with implications for human and livestock health. Rabies presents a threat to all mammals, and has been detected in at least 190 species to date.[6] The multiple transmission cycles for rabies virus demonstrate the need for tailored approaches, based on the species present, types of interactions, and the extent of canine or livestock vaccination coverage. Where there is uncertainty about a source of transmission (which may lead to human-wildlife conflict or concern over possible disease risk), genetic strain analysis of the virus can help to determine the likely source of introduction and maintenance. This is an example of a way virological science may be part of the toolkit for biodiversity management.

---

[3] https://onlinelibrary.wiley.com/doi/10.1111/tbed.14323
[4] https://www.fisheries.noaa.gov/feature-story/toll-toxoplasmosis-protozoal-disease-has-now-claimed-lives-12-monk-seals-and-left
[5] https://pubmed.ncbi.nlm.nih.gov/22493114/
[6] https://pubmed.ncbi.nlm.nih.gov/30747143/

A disease may be of zoonotic origin and stem from an initial inter-species spillover event that then is sustained in humans, potentially via a series of adaptive genetic mutations, or may have recurring animal-human (zoonotic) transmission. COVID-19 and SARS are examples of diseases resulting from a coronavirus pathogen that at some point spilled over into humans, becoming human diseases. COVID-19 has also spilled over from humans into a number of wildlife species in captive and wild settings. Multiple spillover events from animals to and from humans have been documented for many other zoonotic pathogens, such as those responsible for Ebola virus disease, HIV/AIDS, monkeypox, zoonotic influenzas, and more, including endemic diseases like brucellosis and rabies.

Some zoonotic pathogens have multiple animal hosts, or may become transmissible to humans via an intermediate host or through microbial evolution. As a result, the precise risk of transmission of a given bacteria, fungus, parasite or virus to humans is not always known. However, there are some patterns that can guide general understanding for zoonotic disease. Mammals and birds are generally considered highest risk for the transmission of novel or high-consequence pathogens for humans. Reptiles, amphibians, and fish are known to carry and transmit some important endemic pathogens (e.g., *Salmonella*), but are unlikely to be the source of emerging infections of epidemic or pandemic potential in humans.

Within marine protected areas (MPAs), studies have been conducted involving disease risk in some invertebrates and fish but there remains a major knowledge gap for most marine species..[7] Although aquatic animal populations may move in and out of the boundaries of MPAs to a greater extent than in terrestrial PCAs, thus limiting effectiveness of disease control measures in some cases, they can play a role in monitoring populations and potentially in managing disease emergencies.[8] Marine animal strandings and die-offs can signal a possible disease event, which may be linked to infectious or non-infectious (e.g., chemical, starvation, etc.) causes.

As with species and populations occurring within and outside of PCAs, the circulation, spillover, and spread of pathogens can occur in and outside of set park boundaries. However, as also seen with biodiversity monitoring, existing or potential observer networks in and around PCAs can provide value for disease and pathogen monitoring (Table 1). This may be for detection, prevention, and response to immediate threats, as well as to better understand pathogens circulating that could become epidemic in the future via introduction or spread to other regions or species (such as Zika virus).

Table 1. Examples of diseases where PCAs played a role in detection of events.

Disease/Pathogen	Main Transmission route(s)	Link to PCAs
Zika virus	Vector-borne (*Aedes* mosquitos)	First detected in a non-human primate at a research station in Uganda's Zika forest (1947) [9]
Yellow Fever	Vector-borne (*Aedes aegypti)*	Detected in Bolivia in howler monkeys for the first time through

[7] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4760140/pdf/rstb20150210.pdf
[8] https://royalsocietypublishing.org/doi/10.1098/rstb.2015.0364
[9] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5610623/

		reports of dead animals near the park by wildlife sanctuary staff [10]
Pneumoviruses	Humans to Mountain Gorilla	Outbreak investigation in national parks in the Democratic Republic of Congo, Rwanda, and Uganda [11]
Plague (*Yersinia pestis*)	Rodent fleas to humans	Detection of epizootic plague in Yosemite National Park, USA through visitors reporting illness and subsequent environmental investigation[12]

Other types of infections, such as water-borne diseases, as well as non-infectious disease threats (e.g., chemical contamination) may be of concern as humans encroach into and degrade ecosystems. Increased capacity related to disease prevention, detection, and response could thus potentially be transferrable to a range of issues.

PCAs perimeters range from signage or fencing to completely open borders. Migratory species may regularly travel between PCAs. For example, some bat species can fly hundreds of kilometers per night, and some birds and marine mammals travel thousands of kilometers annually, across continents and oceans. Additionally, changes to habitat or resource availability may result in food or water seeking or other behavior in new areas. These interactions are increasingly documented for human-wildlife conflict but can also affect disease risk. Rangers and local communities may notice changes in species abundance or movement in and out of the park that could be indicative of changing disease risk.

Recent outbreaks of H5N1 Highly Pathogenic Avian Influenza (HPAI) virus have been associated with unusual wild bird mortalities in Africa, including in reserve areas.[13] The occurrence in migratory birds emphasizes the need for preparedness beyond the boundaries of a given site. The global early warning system for avian influenza allowed biodiversity managers in southern Africa to be aware of the situation and take preventative measures for seabird health, including the safe removal of carcasses and sick birds to minimize the spread of infections, quarantine periods for birds needing to be admitted for rehabilitation, and monitoring and supportive actions for penguin chicks to promote their survival.[14] H5N1 HPAI can also present a threat to human and domestic animal health, reinforcing the importance of a One Health approach.

Disease risk analysis is a critical tool for reducing disease risk and can be flexibly applied based on the specific goals and setting as well as available information, technical expertise, and resources. In general, the goal is to better anticipate and mitigate disease risks, whether to human or wild animal populations. There are several guidelines available from international organizations regarding human and domestic animal health; with the addition of a conservation lens these can

[10] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7149069/
[11] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7750032/
[12] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5189142/
[13] https://www.unep-aewa.org/en/news/alert-increased-risk-highly-pathogenic-avian-influenza-outbreaks-wild-bird-populations-africa
[14] https://sanccob.co.za/suspected-avian-influenza-hpai-outbreak-along-the-coast-of-the-western-cape/

be relevant to PCAs. In 2014 the *IUCN-OIE Guidelines to Wildlife Disease Risk Analysis* and accompanying *Manual of Procedures for Wildlife Disease Risk Analysis* were published. Together these provide detailed guidance on how to approach disease risk analysis (DRA), from 1. Problem Description, 2. Hazard Identification, 3. Risk Assessment, 4. Risk Management, 5. Implementation and Review, and 6. Risk Communication (Figure 1).

The present guidelines build on the Wildlife DRA process, which is typically tailored to specific pathogens or species, to examine broader actions that can be taken to address infectious disease risk. Components of DRA are referred to throughout the document, and DRA will be a valuable tool to guide practitioners in identifying risks and developing appropriate solutions. At the same time, DRA is not requisite for some of the actions identified in these Guidelines to prevent, detect, respond, and recover from disease risks, which can be considered general good practices for PCAs.

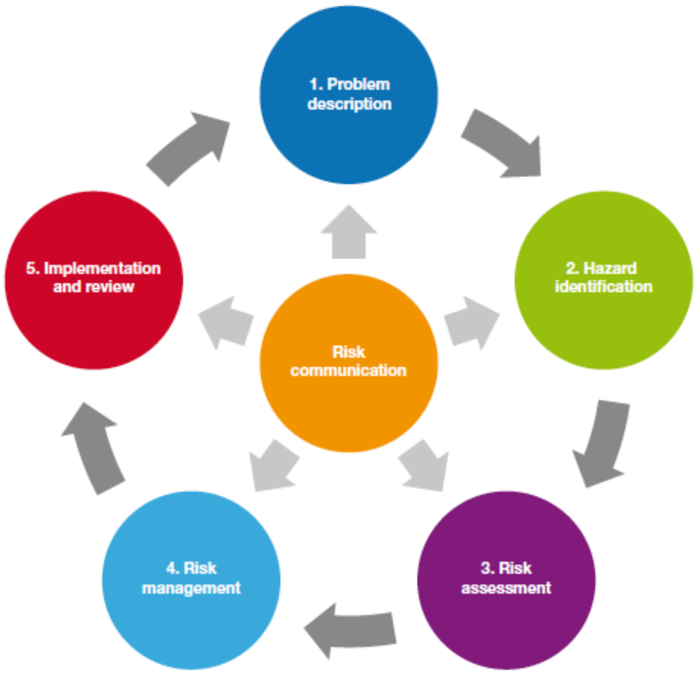


Figure 1. Overview of steps for Wildlife Disease Risk Analysis. IUCN and OIE, 2014.

Risk communication (applies throughout all disease risk analysis steps)

Purpose: Engage with a wide group of technical experts, scientists and stakeholders to maximise the quality of analysis and probability that recommendations arising will be implemented.

Questions: 'Who has an interest, who has knowledge or expertise to contribute and who can influence the implementation of recommendations arising from the DRA?'

1 Problem description

Purpose: Outline the background and context of the problem, identify the goal, scope and focus of the DRA, formulate the DRA question(s), state assumptions and limitations and specify the acceptable level of risk.

Questions: 'What is the specific question for this DRA, and what kind of *risk analysis* is needed?'

2 Hazard identification

Purpose: Identify all possible health hazards of concern and categorise into 'infectious' and 'non-infectious' hazards. Establish criteria for ranking the importance of each hazard within the bounds of the defined problem. Consider the potential direct and indirect consequences of each hazard to help decide which hazards should be subjected to a full risk assessment. Exclude hazards with zero or negligible probability of release or exposure, and construct a scenario tree for remaining, higher priority hazards of concern, which must be more fully assessed (Step 3).

Questions: 'What can cause disease in the population of concern?', 'How can this happen?' and 'What is the potential range of consequences?'

3 Risk assessment

Purpose: To assess for each hazard of concern:

a) the likelihood of release (introduction) into the area of concern;

b) the likelihood that the species of interest will be exposed to the hazard once released;

c) the consequences of exposure.

On this basis the hazards can be prioritised in descending order of importance.

Questions: 'What is the likelihood and what are the consequences of an identified hazard occurring within an identified pathway or event?'

4 Risk management

Purpose: Review potential risk reduction or management options and evaluate their likely outcomes. On this basis decisions and recommendations can be made to mitigate the risks associated with the identified hazards.

Questions: 'What can be done to decrease the likelihood of a hazardous event?' and 'What can be done to reduce the implications once a hazardous event has happened?'

5 Implementation and review

Purpose: To formulate an action and contingency plan and establish a process and timeline for the monitoring, evaluation and review of risk management actions. The review may result in a clearer understanding of the problem and enable refinement of the DRA.

Questions: 'How will the selected risk management options be implemented?' and, once implemented, 'Are the risk management actions having the desired effect?' and, if not, 'How can they be improved?'

Relevant situations for decision making:

Disease risk can be considered in many potential policies, practices, and planning initiatives involving already protected or proposed protected and conserved areas, including:

- Land or sea use planning (expansion or contraction of PCAs)
- Multiple-use determinations (such as hunting and other natural resource uses by local communities, commercial activities, or strict conservation-only use)
- Land rights and tenure (land ownership, management, and governance)
- Regulation development (policies and enforcement for practices that may or may not occur at sites)
- Research permitting (determining whether research is safe to occur, and any precautions needed to protect personnel and animals)
- Concessions (reviewing time-bound rights to sites for extractive industries such as timber logging, minerals, oil and gas, fisheries, and plantations)
- Tourism and recreation planning
- Site management plans

Increased human activity in PCAs can lead to changes in disease risk. Habitat protection and preservation are potential interventions to avoid changes associated with disease risk, thereby decreasing the likelihood of emergence and spread of pathogens. At the same time, activities such as tourism allow people to access the health benefits and economic revenue that many PCAs provide.[15] There is a need to balance trade-offs in line with a One Health approach.

Disease considerations are not intended to overshadow other important aspects of PCA management, including biodiversity conservation, gender equity, land rights, and climate resilience. However, health status and disease occurrence are affected by and can affect each of these PCA objectives, in some cases with particular concerns for the future, such as with climate-sensitive diseases. Disease risk reduction approaches should be designed in ways that ensure buy-in and minimize negative trade-offs. Participatory engagement processes that address rights and equity concerns can help to positively resolve access, tenure and decision-making issues. The acceptable risk threshold, and acceptable alternatives, will have to take into account and balance stakeholder preferences, including priorities and need of local communities.

[15] https://portals.iucn.org/library/node/47918

2) Relevant interfaces for zoonotic disease transmission: Transmission to and from humans

Zoonotic infection can result from exposure to animal blood, urine, feces, saliva, or other infectious material (for example, during handling, hunting or slaughter), via airborne or droplet transmission (coughing or sneezing), or indirect contact (fomites on contaminated objects). Additionally, some pathogens can be moved physically from one setting to another on an object such as a vehicle or even footwear. Vector-borne diseases result from the transmission by a mosquito, tick, or other arthropods. Viruses, bacteria, fungi and prions can be carried and transmitted by a living host, and some are able to persist to be infective for long periods of time in the environment, dead animals and food products.

PCAs vary in their legal designations and day-to-day management (i.e., fully preserved, mixed-use, high access for hunting, or significant human presence). These have practical implications for the types of disease risk to be expected in a site based on relevant interfaces (see Table 2).

Table 2. Examples of key interfaces that may be associated with zoonotic disease risk.

Interface	Examples	Description
Tourism	*Encroachment into caves; wildlife selfies*	*May involve close contact with wildlife, whether direct or via urine/feces/aerosolized infectious materials*
Communities living in/around conserved areas	*Agriculture (e.g., livestock rearing, crops); housing; food acquisition and food preparation/consumption*	*May involve new wildlife-domestic animal interactions, food-seeking behaviors by wildlife, and increased demand on natural resources; seasonal migration*
Natural resource extraction	*Commercial/concession-based logging, mining, and oil and gas extraction; guano harvest*	*May involve encroachment into wildlife habitat, with commercial activities often associated with new roads and expanded access, leading to increased hunting and other utilization by workers and/or local communities, contamination via poor waste management, and in-migration of workers with no immunity to local pathogens*
Access and resource use	*Informal (e.g., artisanal) mining; local clearing (e.g., for charcoal); subsistence and non-subsistence wildlife hunting and fishing; guano harvest*	*May involve encroachment into wildlife habitat, often leveraging roads and other expanded access points created by active or prior concessions, as well as changing water flows/ drainage with potential for vector breeding*
Research	*Biological sampling and disease investigation*	*May involve close contact with wildlife in the process of taking biological specimens, whether direct or via urine/feces/aerosolized infectious materials*
Biodiversity management	*Reintroduction/translocation; Introduction and establishment of invasive alien species (and biological measures to control them)*	*May introduce pathogens from one population into another; invasive or introduced species may alter ecosystem dynamics, including food webs, affecting species abundance and richness and thus pathogen prevalence*

3) Key Indicators and Guidance

This section provides guidance on ten topics common to public and domestic animal health practice, put into a PCA lens. The topics align with the overall scope and intent of the Green List Standard, including Good Governance, Sound Design and Planning, and Effective Management, which collectively lead to Successful Conservation Outcomes. The content spans across the interfaces and situations presented in the previous sections and are intended to support implementation. A set of high-level, cross-cutting indicators and sample means of verification are also included. While PCAs have varying mandates and roles in disease investigation and management, these high-level indicators should be viewed as a minimum best practice for area-based conservation across PCA contexts.

<u>Guidance topics:</u>

Sound Design and Planning
1) Disease risk assessment
2) Animal introductions
3) Site use planning and buffer zones

Effective Management
4) Surveillance
5) Disease reporting and investigation
6) Safe wildlife viewing, handling, and use
7) Biosafety and Biosecurity
8) Control measures

Good Governance
9) Risk communication
10) One Health coordination

Sources of risk and appropriate management actions may be dynamic. Thus, the guidance covers various aspects of prevention, detection, response, and recovery from disease risks. For example, effective risk communication – involving the flow of information to guide appropriate understanding and action if needed – is important at all times but may need to be targeted to specific stakeholders depending on the situation. In some cases, implementing control measures in one species will help to prevent disease in other species.

The present guidelines are intended as general standards that can be applied and adapted by context as relevant. They do not replace other guidelines and action plans for specific species or taxonomic groups (e.g., great apes) or practices (such as working with free-ranging mammals during COVID-19), which are typically more precise and detailed for a particular setting, industry, or set of practices.[16,1718] Although the concepts may be new for a PCA audience, they are well established in public and domestic animal health.

[16] https://portals.iucn.org/library/sites/library/files/documents/ssc-op-038.pdf
[17] https://portals.iucn.org/library/node/45793
[18] http://www.iucn-whsg.org/COVID-19GuidelinesForWildlifeResearchers

Disease Risk Assessment	<u>Indicator</u>: Planning process includes disease risk as a criterion prior to site use changes and species introductions	
	Approaches	*Sample means of verification*
	• Ensure process is in place to conduct and utilize findings from risk assessment • Conduct risk assessment prior to land and sea use, reintroduction, or other relevant planning decisions • Review and update risk assessment at least annually, and more frequently as needed	Risk assessment process in place with criteria for use. Risk assessment report made available. Consultation with relevant stakeholders. Latest assessment(s) reflected in annual review of disease threats.

Environmental impact assessments (EIA) do not routinely include a robust set of health considerations, and zoonotic diseases are a key gap area. Additionally, the need for an EIA may not be triggered by certain changes, particularly if they do not relate to large-scale ecosystem conversion. Changes in zoonotic disease risk, however, could be linked to major or minor ecosystem modifications, making it important to consider disease risk on an ongoing basis. *Disease risk assessment* is a practical way to help determine the likelihood of a disease occurring from a given action, and the extent of impact it could have. This can help guide appropriate management decisions.

The risk assessment process fits into a larger Disease Risk Analysis (DRA) process, which also involves possible risk management actions and ongoing communication (see page 7). However, risk assessment is a distinct step that considers available information to make an informed judgement about risk. Various tools are available to support risk assessment and other steps in the DRA process. The IUCN-OIE *Manual of Procedures for Wildlife Disease Risk Analysis* provides a detailed, step-by-step guide.[19]

Risk assessment is initiated when a DRA question has been described and a hazard or set of hazards have been identified and determined to warrant assessment. A simple way to approach risk assessment is to consider whether 1) there is a source of a pathogen (or pathogens, depending on the breadth of the assessment) ("introduction"), 2) an exposure that could facilitate spillover ("release"), and 3) a potential impact on health, economy, and other aspects of the site and society ("consequence assessment"). The likelihood of the event occurring, and the extent of its impact, together provide an estimation of risk. Depending on the information and resources available, the risk assessment process can produce a quantitative, semi-quantitative, or qualitative estimate.

The question examined for a risk assessment can be as specific or broad as needed, ranging from a particular pathogen of concern or zoonotic disease risk more broadly. For example, consider the potential question: *"What is the risk of disease spillover from a cave used for ecotourism activities?"* In this case, examples of relevant information would include the species present in and around the cave, the type and frequency of interactions with humans, and the likely

[19] https://portals.iucn.org/library/node/43386

pathogenicity of known and novel pathogens, based on findings locally or elsewhere and knowledge of the types of pathogens harbored by different species and taxonomic groups and human susceptibility to them. The assessment could also theoretically identify protective factors that people are already taking to reduce their exposure, such as people only going into caves during seasons when certain species are not present. Together, a risk assessment can help piece together the general understanding to estimate risk as well as identify important knowledge gaps.

Depending on the determination of the level of risk, management strategies can be considered. While it may not be considered feasible to eliminate disease risk, the likelihood of spillover events and their impacts can be substantially reduced. Thus, risk assessment has great value to identify and better understand specific high-risk factors and transmission pathways. This could help to anticipate, and mitigate, risk proactively. A risk assessment may also find that the level of risk is low and no follow-up action is warranted at that point in time. New findings, such as those from research activities, could change the risk estimation. As such, risk assessments should be reviewed and updated as needed to ensure they reflect the latest knowledge base.

Ideally, risk assessment will be conducted prior to a proposed change, such as a new or expanded use of a PCA. Disease risk assessment could also be conducted for any existing practices that put humans into direct or indirect contact with wildlife, helping to identify risks that may warrant attention.

Public and animal health authorities may conduct risk assessments, and thus PCA authorities should have general familiarity with the process to be able to weigh in and ensure conservation-minded considerations are taken into account in line with a One Health approach. The risk assessment process should be transparent and free from undue influence. It is also important to remember that disease risk is one, but not the only, consideration that may be relevant to guide management decisions. The goal is to incorporate disease risk assessment, and overall disease risk reduction, into conservation, economic, land tenure, and other decisions involving PCAs, toward sustainable development objectives as a whole.

The translocation of animals can be a key part of rewilding, restoration, or other conservation efforts. This may involve animals confiscated from the trade, particularly in the case of endangered species, or those living in captive settings. This could inadvertently present risk of disease introduction into a new area, including to a previously unexposed (and therefore more susceptible) population. Disease risk assessment is therefore an important process prior to all translocation efforts.

Animal Introductions	Indicator: Planning process includes disease risk as a criterion prior to site use changes and species introductions	
	Approaches	*Sample means of verification*
	• Disease screening and risk assessment conducted prior to introduction into a new population • Preventative vaccination, where relevant • Isolation and/or quarantine • Limit release of captive/rehab animals -restrict to highly endangered species (very specific and strict procedures), to low conservation value areas, etc.	Process is in place for screening and risk assessment. Rationale is documented for vaccination or non-vaccination where considered. Designated area for isolation. Protocol in place for isolation/quarantine. Records of animal isolation/quarantine. Relevant strategies with criteria for release. Consultation with stakeholders, including local and national knowledgeable experts.

Animal translocations can be important components of biodiversity management. However, disease risk analysis should be conducted prior to the translocation decisions, and disease screening should be conducted prior to introduction into a new population or the determination to return confiscated animals into their native or other suitable habitat.[20] The IUCN *Guidelines for Reintroductions and Other Conservation Translocations* provide detailed guidance, including criteria for assessing disease risk.[21]

In any introduction, there is a potential risk for the introduced species, risk for receptor population, and risk of establishment of new parasitic cycles or zoonotic relevance. Unfortunately, there are proven examples of each of these situations, sometimes with serious consequences to populations or ecosystems.[22,23,24]

Animal holding and transport conditions should be considered, including biosecurity measures to limit close placement of multiple species together. Stressful and unsanitary or poor welfare conditions (e.g., inadequate nutrition) may affect the immune status of animals, which could increase pathogen shedding or susceptibility to infection. In the process of captivity animals may become habituated with humans, which may also present disease risks and make them unsuitable for release into some settings. Translocation efforts should consider these factors as well as appropriateness of available options to reduce disease threats, such as preventative vaccination.

Isolation and quarantine are basic precautionary measures in animal translocations. Isolation involves holding incoming animals separately before release to monitor for disease. Quarantine involves keeping apparently sick animals (or animals testing positive for infections) away from

[20] https://portals.iucn.org/library/sites/library/files/documents/2019-005-En.pdf
[21] https://portals.iucn.org/library/sites/library/files/documents/2013-009.pdf
[22] https://www.sciencedirect.com/science/article/abs/pii/S1471492212000517
[23] https://www.sciencedirect.com/science/article/pii/S1090023314002366
[24] https://rewildingargentina.org/tapires_mal_caderas_ibera/

other animals until resolution of the event and determination that it is safe to rejoin them. The appropriate isolation and/or quarantine period varies by species and specific diseases of concern.

Active epidemics may make it necessary to postpone reintroduction efforts, or take intensive response actions once introduced. For example, following a reintroduction of Howler Monkeys in Brazil's Tijuca National Park, population reinforcement was not possible based on a Yellow Fever outbreak.[25]

As part of a major rewilding project ongoing in Argentina, tapirs were introduced, only to find them dying from Trypanosomiasis (caused by *Trypanosoma evansi)* - a well-known parasitic disease sustained by capybara. *T. evansi* was introduced to the Americas from Africa via imported horses centuries ago, and now is widespread in the environment. All reintroduced tapir had to be captured again and placed in captivity and the program put on hold since there seem to be no disease-free areas for introduction. This example reinforces the importance of considering disease risk prior to introduction.

[25] https://portals.iucn.org/library/sites/library/files/documents/2021-007-En.pdf

<table>
<tr><td rowspan="3">Site Use Planning</td><td colspan="2"><u>Indicator</u>: Planning process includes disease risk as a criterion prior to site use changes and species introductions</td></tr>
<tr><td>Approaches</td><td>Sample means of verification</td></tr>
<tr><td>• Zoonotic and wildlife disease risk considered in land and/or sea use decisions
• Buffer zones established along the perimeter of PCAs
• Zoning to designate activities and use based on disease risk</td><td>Documentation of disease risk considerations in land/sea use decision process.
Consultation with experts.
Maps of site and surrounding area.
Documentation of permitted uses in management plan or equivalent.</td></tr>
</table>

Site (whether land and sea) use decisions are typically informed by multiple criteria, including ecological and economic gains, cultural or religious values, and other stakeholder preferences or priorities. Disease risk is not routinely considered in site use decision processes, whether for protecting or developing land. As a result, disease-related consequences can end up having health and economic burden that in some cases exceeds benefits from use. At the same time, the broader value of land protection for disease risk reduction (in addition to conservation benefits) is not fully appreciated. The goal of restoration, though important for many reasons, also requires appropriate measures to reduce potential disease risks where relevant. Zoonotic and wildlife disease risk should be considered in the process of evaluating possible use options, including those relating to the type, location, and extent of land conversion.

Changes in the configuration of landscapes, particularly forest areas, can affect disease risk. Fragmentation can lead to more ‘edges’ where ecosystems may abruptly change and where there may be greater potential for wildlife-human interaction.[26] Habitat loss, as well as interruption of migratory corridors, may result in displacement of wild animals as well as a change in species composition. The presence of humans and human activities (e.g., crop growing) can also mean that wildlife may alter their food-seeking and other behavior. Buffer zones along the perimeter of critical wildlife habitat are a general good practice for PCAs, serving multiple functions.[27] In particular, they help to maintain separation between interior forests and areas with a high presence of humans or domestic animals.

Sea uses may include a range of commercial and non-commercial activities, potentially within some MPAs. Disease considerations should be taken into account when considering MPA uses, including threats to the health of native fauna if disease introduction occurs, in addition to wider ecosystem degradation. Land-sea connections are also important considerations for MPAs, as disease threats to aquatic species can result from land-based practices.

Zoning policies in and around sites should consider the effects of current and potential use with regard to disease transmission. Areas may need to be designated off-limits for some activities based on risk. Concession activities, such as logging, mining, and oil and gas extraction, often lead to a range of direct and indirect ecological and anthropogenic changes. The influx of people

[26] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7088109/
[27] https://www.fs.usda.gov/nac/buffers/docs/conservation_buffers.pdf

associated with these activities requires additional acquisition of food and water resources, potentially with hunting pressures to meet increased local protein demands. Road building and other transport may increase access to wildlife-rich areas and thus encroachment and extraction, as well as greater connectivity to urban markets (e.g., to supply wildlife trade demand). These conditions can also increase potential for the introduction of invasive species. As an alternative, parks are increasingly supporting the sustainable use of forest products, such as nuts and honey. Beyond extractives which are high-value undertakings, these smaller-scale, usually locally driven initiatives should be promoted and guided by best practices to avoid disease risk (for example, in some cases of plant uses, such as Brazil nuts, risk is associated with an increase in migrant workers, oftentimes with livestock because they are not allowed to hunt).

After the emergence of Nipah virus, Malaysia designated land as pig-safe farming areas where bat-borne disease risk is low. Pig farmers located outside of safe areas were encouraged to take up other livelihoods. In addition, the country established requirements for distancing between pig farming and orchards to minimize potential bat-pig contact. These important measures have helped to avoid subsequent outbreaks in the country.

<table>
<tr><td rowspan="3">Surveillance</td><td colspan="2"><u>Indicator</u>: Reporting system in place for information flow with relevant authorities for wildlife disease events in/around protected and conserved area</td></tr>
<tr><td>Approaches</td><td>Sample means of verification</td></tr>
<tr><td>• Surveillance plan developed in collaboration with human and animal health experts for wildlife, domestic animals and humans
• Site assessment (e.g., observational studies) for relevant interfaces for disease transmission
• Select sampling methods that are as minimally invasive as possible to achieve surveillance objectives
• Monitor disease/pathogens as well as contact practices in wildlife, domestic animals and humans
• Use of proper hygiene and biosafety protocols for collection of biological specimens, if occurring at site</td><td>Documentation of surveillance plan, including sampling and biosafety protocol.
Consultation of experts.
Training records on sampling and biosafety protocols.
Records of disease/pathogen surveillance data.
Documentation of observational studies.</td></tr>
</table>

Surveillance is the systematic ongoing collection, collation, and analysis of information related to health and the timely dissemination of information so that action can be taken.[28] In PCAs, surveillance is an important component of monitoring how disease risk may be changing, determining the need for action, and evaluating whether risk reduction interventions are sufficiently working. It also informs reporting and investigation.

Each site should have a surveillance plan. This may be developed by a national authority, with relevant aspects undertaken at site level (for example, standardized surveillance occurring in all PCAs or at selected sentinel sites). The plan should cover surveillance in wildlife, domestic animals, and humans as pertinent. Depending on pathogens of concern, vectors (e.g., ticks, mosquitos) may also be important. Surveillance scope can vary widely, from annual collection of samples to short-term efforts to address key knowledge gaps and establish baseline measurements. Community engagement can provide important inputs to the surveillance system, including for sentinel surveillance and ongoing monitoring. Surveillance plans should be examined every few years, and more often as needed, to reassess needs as more information is gained and risks evolve. Plans may also identify knowledge gaps in epidemiological understanding.[29]

A citizen science initiative was launched in Chile to monitor the geographic distribution and species affected by sarcoptic mange, a disease caused by infestation with the *Sarcoptes scabiei* mite. The disease, which can have devastating effects on some naïve wildlife populations, typically presents with abnormal alopecia, allowing for visual identification. A web platform was set up for

[28] Adapted from OIE Terrestrial Animal Health Code, 2019. https://www.oie.int/app/uploads/2021/03/a-wildlifehealth-conceptnote.pdf
[29] See e.g. Queen Elizabeth National Park General Management Plan

photo and event submissions by rangers within protected areas over a fifteen-year period. Members of the public outside of protected areas were also invited to submit reports. Together, this provided crucial information to document changing trends in the occurrence of sarcoptic mange over time and species, particularly in the absence of a national wildlife health surveillance system.[30]

Sampling methods should be selected that are as minimally invasive as possible to achieve surveillance objectives (while not excluding samples passively collected from hunters and other sources where relevant).[31] This helps balance impacts on endangered populations and animal welfare with the utility of information gained from surveillance. It also addresses logistical challenges often present in remote settings, such the availability or safety of administering field anesthesia. Additionally, some countries and sites may not permit hands-on sampling in certain wild species. Several alternative approaches have been successfully trialed, such as fecal sampling, saliva sampling from primates using a jam-soaked rope, and urine collection under bat roosts.[32]

Surveillance should monitor disease (the clinical signs from infection) and/or pathogens (microbes that can cause disease) as well as practices affecting contact between species, including how people interact with wildlife and domestic animals to identify ways that spillover could occur. Several terms, such as passive and active surveillance, help to distinguish surveillance approaches (see Box). In addition to biological surveillance, behavioral surveillance can help to understand human knowledge, attitudes, and practices regarding disease risk, including socio-economic, cultural, occupational, and other factors. Questionnaires, focus groups, community consultations, and observational studies are common behavioral surveillance methods.

<u>Common surveillance terms</u>

- *Event-based surveillance* is aimed at detecting outbreaks.
- *Indicator-based surveillance* can detect and track a number of possible outcomes, including outbreaks as well as trends, burden of disease, and risk factors.
- *Sentinel surveillance* often refers to collection of information from specific, designated sites; when used in a One Health context is typically refers to detection in another species or population that can signal a potential threat to public health.
- *Passive surveillance* relies on reporting of information to public or animal health officials. For example, park rangers may observe suspected disease events in wild animals and report them. Healthcare providers may see patients with undiagnosed fever and report them.
- *Active surveillance* is initiated by health officials to collect specific information. Contact tracing is an example of active surveillance. Because it involves epidemiological investigation, active surveillance provides more comprehensive information but is more resource intensive.

Different types of tests provide different information. For example, antibody testing (serology) indicates exposure occurred at one point in time, whereas PCR testing determines if the infection is occurring at that point in time. Genomic sequencing can identify specific strains of pathogens and help elucidate transmission dynamics between species. PCR and gene sequencing methods also allow for broad screening to detect novel pathogens. Testing methods vary widely in cost,

[30] https://www.sciencedirect.com/science/article/pii/S2530064420300560

[31] https://www.oie.int/fileadmin/Home/eng/Internationa_Standard_Setting/docs/pdf/WGWildlife/OIE_Guidance_Wildlife_Surveillance_Feb2015.pdf

[32] Kelly et al. 2017: https://www.sciencedirect.com/science/article/pii/S0167587716306419

availability in laboratories, and logistical considerations such as suitability for different sample types and storage methods (including cold chain). National and provincial laboratories, as well as university and other research centers, can provide guidance on optimal testing strategies. The OIE, under its Wildlife Health Framework, is also working to support guidance and capacity development, including for disease surveillance and diagnostics in wildlife.[33]

In many cases, site staff will not be directly involved in the physical collection of samples but can still be integral to surveillance activities. Examples include the design of appropriate capture techniques and methods to reduce stress and other detrimental effects on animals and identifying where wildlife congregate or where wildlife-human or wildlife-domestic animal interactions occur. Additionally, surveillance information can also be generated from research activities through partnership with other agencies, organizations, and academia.

Because the capture and sampling of animals can put people at risk of exposure to infectious materials, biological surveillance should only be conducted by persons trained in appropriate sampling and biosafety techniques.[34] In general, sampling teams should be under the supervision of a veterinarian. The appropriate use of personal protective equipment (PPE), such as disposable gloves, masks, dedicated clothing and shoe covers, plus protective eye wear, coveralls in certain situations, is a critical occupational health and safety measure.[35] Human PPE use can also help to keep wildlife safe from human diseases. Beyond PPE basic use (e.g., routine surgical mask wearing), training on proper PPE and other biosafety (e.g., hazardous waste management) protocols is necessary. Use of incorrect practices can be dangerous, including during the PPE removal step.

In Côte d'Ivoire's Taï forest, a researcher was infected with an ebolavirus while performing a necropsy on a dead chimpanzee. This was the first and only known transmission of this species of ebolavirus (*Taï Forest Ebolavirus)* to a human. A wildlife biologist was also fatally infected with Plague when conducting a necropsy on a dead mountain lion in the United States. Disease transmission has also been documented from live animals shipped to laboratories for research activities. Taking appropriate biosafety measures is essential for safe research and veterinary care.

A common misconception is that disease-related surveillance is always costly. In fact, the design of surveillance efforts will take into account available resources and the intended objectives. For example, certain sampling and testing methods, such as pooling samples by species or site, can maximize detection efforts. Collaboration with human and animal health and laboratory experts can design surveillance efforts to be as cost-effective as possible. Additionally, some laboratory capacity and infrastructure can serve multiple purposes, including wildlife health monitoring, disease detection, and forensics for wildlife crime investigations.

---

[33] https://www.oie.int/fileadmin/Home/eng/Internationa_Standard_Setting/docs/pdf/WGWildlife/A_Wildlifehealth_conceptnote.pdf
[34] https://pubs.usgs.gov/tm/15/c02/tm15c2.pdf
[35] https://www.nps.gov/subjects/policy/upload/RM-50B_Chp54_Safe_Work_Practices_Handling_Wildlife-508.pdf

Disease Reporting and Investigation	Indicator: Reporting system in place for information flow with relevant authorities for wildlife disease events in/around protected and conserved area	
	Approaches	*Sample means of verification*
	• Develop system for reporting of wild animal disease events by relevant stakeholders (e.g., rangers, researchers, community networks, hunters) • Monitor and record disease event information (species, number of animals affected, clinical signs, length of event, testing conducted, suspected or confirmed cause, and control measures applied) • Report event(s) to public and animal health (including wildlife health) authorities to support appropriate investigation	Documentation of appropriate system of management of disease event data. List of documented disease events. Confirmation of event reporting with recipients. Consultation with authorities.

Disease reporting is an important input to the surveillance system. Reporting provides two main functions 1) to establish a baseline and help elucidate disease transmission pathways, and 2) alert on immediate events that could be of public and animal health concern as well as conservation significance. Improved detection and tracking of disease events can help to develop a baseline understanding Tracking and reporting of event details can inform species or population threats assessments (e.g., the Red List of Threatened Species) as well as appropriate prevention and control measures. Even minimal data collection, such as event location, date, species, and number of affected animals can provide essential info for retrospective analysis of trends and potential threats.[36] The absence of reporting also means that potentially important inputs to disease risk assessment, early warning systems, and epidemiological investigation are likely to be missed. This is particularly relevant because the role of a species as the reservoir or an intermediate host of a pathogen may not always be known, and information from disease events can help to understand transmission pathways. Reports can prompt investigation, supporting event determination, appropriate control measures, and ideally a quick resolution of the situation.

Engaging rangers, hunters, and communities in the reporting of ill or dead animals as part of wildlife disease surveillance and epidemiological trace-back in outbreak investigations can expand the surveillance system, often at low or no cost. Reporting from sites to official channels can improve awareness by national and international authorities and inform resource allocation needs. Member countries to the World Organisation for Animal Health (the OIE) have a National Focal Point for Wildlife, who supports a national Delegate in international reporting of wildlife disease

[36] See example: https://www.nature.com/articles/s41598-020-66484-x

events. National databases may also be in place for required or voluntary reporting of wildlife disease events.

Investigation of events, which typically employs epidemiological analysis to try to trace back events and identify important risk factors, can elucidate the cause and the conditions contributing to the situation. There are well established steps for outbreak investigations, which are available in the OIE's *Training Manual for Wildlife Disease Outbreak Investigations*.[37] Depending on veterinary capacity available within the PCA, event investigation may or may not be within the scope of the site's operations.

Mortality events may be caused by a range of infectious and non-infectious (e.g., poisoning, starvation) causes. This information can aide in the prevention of future outbreaks. Emergency response requires rapid sample collection and screening for determination and/or rule-out of causes. If not available through national authorities, local or regional universities or international human and animal health reference laboratories (such as those under the OIE, or Food and Agriculture Organization of the United Nations, or FAO, or World Health Organization, or WHO) have various testing capacities. For biological specimens that must be shipped to international laboratories for diagnostics, particularly in emergency situations, early outreach to the national CITES[38] Management Authority is recommended. This can help to raise awareness about the urgency of the situation and potentially help to avoid permitting delays for CITES-Listed Species. There are often cold chain and other considerations that make rapid movement important to prevent sample degradation, in addition to reaching a timely diagnosis to enact proper control measures. Simplified procedures through CITES may be available to support this timely movement.[39]

In northern Congo, hunters and community members were recruited to report morbidity and mortality events in wild animals. In the region, great ape die-off events were found to precede human cases of Ebola virus disease by several weeks. Through the program, reporting channels were developed, relaying information from small villages to connector communities in radio or other contact with national authorities. This facilitated information flow to veterinarians so that sampling could occur in the short timeframe needed before carcasses degrade. Reporting of these events expanded the surveillance system to allow for early warning through sentinel surveillance. The outreach also helped to raise awareness about the dangers of hunting certain species or eating animals found dead, particularly in epidemic periods, thereby promoting safer practices.

In Bolivia, staff at a wildlife sanctuary previously trained in One Health approaches reported finding several dead howler monkeys in the surrounding area. An investigation was rapidly mobilized with national, university, and nongovernmental partners, leading to detection of yellow fever virus as the cause. Because of the proactive information sharing and effective multi-sectoral coordination, this information led to a preventive vaccination campaign and other risk reduction measures (e.g., mosquito control), helping to prevent any human cases. This was especially notable given that yellow fever had not previously been reported in howler monkeys in the country and response was mobilized within seven days.

[37] https://www.oie.int/en/document/a_training_manual_wildlife_4/
[38] Convention on International Trade in Endangered Species of Wild Fauna and Flora
[39] https://cites.org/sites/default/files/eng/com/sc/73/E-SC73-020.pdf

Safe Wildlife Viewing, Handling, and Use Practices	<u>Indicator</u>: Occupational and visitor health and safety programs incorporate zoonotic disease considerations	
	Approaches	*Sample means of verification*
	• Redirect visitor flow to build in distancing between people and wildlife at key interfaces • Regulate hunting and other extraction, sale, consumption, and direct contact with highest-risk species • Include zoonotic and wildlife disease risks in worker health, safety, and education programs • Conduct awareness and behavior change campaigns to support uptake of safe practices	Documentation of visitor management strategy. Documentation of observational studies. Documentation of regulations. Enforcement records. Documentation of worker health, safety, and education program materials or plans. Documentation of campaigns. Pre- and post- knowledge, attitude, and practice surveys.

There may be many uses of PCAs that potentially involve proximity to, or direct contact with, wildlife. Even if the spillover of emerging diseases is rare relative to the number of interactions with wild animals, the high impact of these events makes a precautionary approach prudent. Additionally, endemic diseases present an ongoing risk and can also be minimized to promote improved health of staff, visitors, and community members. Promoting safe practices when viewing, handling, and using wildlife is key to reducing both emerging and endemic zoonotic disease risk and can help maintain positive perceptions about wildlife.

Maintaining safe distance between people and wild animals is a priority to avoid transmission of disease to and from humans and other species. Safe distancing when viewing wildlife is already recommended as best practice (IUCN Tourism guidelines), particularly for species that are highly susceptible to human infections or known to transmit zoonotic diseases, with appropriate distances varying by species. For great apes, a distance of 7 meters or more is typically required for visitors.[40] Distancing should also consider animal behaviors and movements, such as locating trails adjacent to, rather than directly under, bat roosts or migratory corridors. Clearly marked trails or roads, signage, designated viewing areas, and the use of guides can help to promote visitor flow to maintain safe distancing.

In some cases, park staff, veterinarians, or researchers may require closer distances, such as during biodiversity and disease surveillance efforts or routine wildlife health screening or ecological studies. These can be important for monitoring the health and wellbeing of species. In these cases, washing hands and other hygiene best practices should be adopted and appropriate personal protective equipment (PPE) should be worn. During epidemic periods in humans or animals, increased precautions may need to be taken, such as full PPE and requiring staff vaccination as relevant (such as in the case of Ebola virus epidemics or in areas where rabies is endemic).[41] If

[40] IUCN. Best Practice Guidelines for Health Monitoring and Disease Control in Great Ape Populations
[41] Guidelines for Working with Free-Ranging Wild Mammals in the Era of the COVID-19 Pandemic. https://www.oie.int/app/uploads/2021/03/a-whsg-and-oie-covid-19-guidelines.pdf

staff are handling wildlife, gear should be sanitized and not worn home to minimize the potential movement of infectious material.

Regulating the hunting, sale, consumption, and direct contact with highest-risk species can drastically reduce risk. Highest risk generally includes species of non-human primates, bats, rodents, carnivores, and other species as determined by national and site-specific risk assessments and priority disease lists. When evaluating possible options, decision makers should consider the availability of adequate alternatives (nutrition, livelihoods, cultural significance) and buy-in of affected stakeholders. Participatory approaches that engage stakeholders - such as communities with rights to the land or tourism operators - can help increase the likelihood of successful uptake. While in some cases bans (and their enforcement) may be appropriate, the best course of action will depend on the specific context, including the needs and priorities of local communities. For example, in some circumstances the benefits derived from subsistence hunting by Indigenous Peoples will outweigh disease concerns. In that case, engagement with trusted leaders and communities may seek other ways to achieve target outcomes, such as avoiding specific species during epidemic periods or making food preparation practices safer.

In addition to wildlife harvest, other extractive uses of wildlife in and around PCAs should be monitored for disease risk. For example, bat guano harvest can involve the aerosolization of zoonotic pathogens. Caves linked to prior zoonotic disease events, or with known circulation of high-consequence pathogens, should have harvest restricted.[42] Where permitted, harvest should be focused when bats are not present or in high-ceiling areas a sufficient distance from where bats are roosting. Use of personal protective equipment is essential, including respirators filtering dust particles down to one micron in diameter, with daily filter changes.

The rising popularity of wildlife "selfies" (e.g., photos showing people with wild animals, and often non-human primates) as part of tourism activities also puts people into close contact with wild animals and should be discouraged. In addition to conservation and welfare considerations, such practices can result in scratches and bites, or even serious injuries. Animals may also be stressed or in poor condition, resulting in weakened immune status that further puts them at risk. Additionally, the process of sourcing animals for photos can perpetuate extraction practices associated with significant zoonotic disease risks.[43]

A possible exception to viewing and handling practices may be "ambassador" or rehabilitated animals used for educational purposes. In these cases, the benefits of controlled interactions (i.e., in the presence of a keeper) between certain species and humans may exceed the risks. However, even taxonomic groups that are not a high concern for emerging pathogens, such as reptiles, can still be an important source of gastrointestinal diseases (e.g., *Salmonella* infection). Thus, appropriate hygiene measures such as handwashing should be in place.

Worker health, safety, and education programs in and around PCAs should take into account zoonotic disease risks. The standard provision of a protein source for workers in forest areas, for example, can reduce reliance on wildlife hunting. The keeping of wildlife as pets should also be prohibited at PCA sites (and in the community). Injured or sick wildlife should be brought to the

[42] https://portals.iucn.org/library/sites/library/files/documents/Rep-2014-002.pdf
[43] https://human-primate-interactions.org/wp-content/uploads/2021/01/HPI-Imagery-Guidelines.pdf

attention of a veterinarian who can advise on its proper care, handling and placement (e.g., rehabilitation, release, or a sanctuary).

Awareness and behavior change campaigns can help to support uptake of safe practices. Behavior can be shaped by many factors, including economic considerations (e.g., income and food security), cultural and religious practices and norms, and personal preferences. When interventions involve individual behavior change, knowledge, attitudes, and practices studies can be extremely informative, helping to understand perceptions and possible barriers to change as well as acceptability of proposed changes. Pre-and post-intervention feedback can help determine their effectiveness and refine approaches as needed. Depending on the objectives and resources available, these could be in the form of surveys (community members, tourists, or workers), focus groups, town halls, or conversations with trusted leaders.

Python cave in Queen Elizabeth National Park's Maramagambo forest hosts tens of thousands of Egyptian fruit bats (*Rousettus aegyptiacus*), as well as African rock pythons (*Python sebae*). It is a popular tourist attraction. Following cases of Marburg virus linked to the cave, the Uganda Wildlife Authority and the U.S. Centers for Disease Control and Prevention developed a safe viewing platform in a glass enclosure 65 yards away from the cave roost site. This platform allows visitors to enjoy the splendor of the bats while avoiding direct exposure that increases risk of pathogen transmission. The intervention is paired with signage and training of ecotourism operators on disease risk reduction. This approach has allowed tourism to safely continue, while having the added benefit of helping to protect an ecologically sensitive habitat from human disturbance.

<table>
<tr><td rowspan="3">Biosafety and Biosecurity</td><td colspan="2"><u>Indicator</u>: Disease management protocols and risk reduction measures included in site management plan</td></tr>
<tr><td>Approaches</td><td>Sample means of verification</td></tr>
<tr><td>Domestic animals kept separate from wild animals to minimize contact
Waste management in place to prevent access by wild animals and avoid environmental dissemination of waste
Housing and food storage/preparation/consumption areas secured against wildlife access
Decontamination or replacement of gear between visits to different animal populations
Risk reduction measures applied when in close proximity to mammals and birds (i.e., use of proper personal protective equipment)
Handwashing/hand sanitizer available and used before and after handling animals, animal products, and soil
Foot washes for footwear required (e.g., at trailheads and walkways)</td><td>Management plans for domestic animals, waste management, food storage, gear and footwear decontamination, and handwashing/hygiene. Documentation of observational studies. Consultation with experts. Documentation of policies. Enforcement records.</td></tr>
</table>

Biosafety and biosecurity broadly refer to actions aimed to prevent the introduction and spread of infectious agents. In domestic animal production systems, improving biosecurity is recognized as a key priority. In public health and healthcare settings, the concept is more commonly referred to as infection prevention and control.

The separation of domestic and wild animals is an important measure to minimize contact and potential for disease transmission. Biosecurity should be emphasized where risk is particularly high, such as along the periphery of forested areas, near wetlands or other waterfowl habitat, and in range of bat roosts or bat migration routes.

Complete separation may not be practical in all situations, and not all interactions present the same type or level of risk. As such, separation should prioritize sources of greatest risk. In general, major concerns linked to transmission of zoonotic disease relate to the mixing of wild birds (especially waterfowl) and domestic poultry, carnivores with domestic dogs, and bats with pigs and horses. Other important species interactions can be determined from consultation with local public and animal health authorities and researchers.

The emergence Nipah virus in Malaysia in 1998 occurred via a bat-pig-human transmission chain. *Pteropus* bats likely fed on fruit near an open pig enclosure, contaminating the partially eaten fruit with saliva or other infectious materials, which then was consumed by the pigs on the farm. This case demonstrates the importance of biosecurity measures to reduce contact and the flow of pathogens between wild and domestic animals. For example here, not keeping pigs under or close to trees where bats feed or roost greatly reduces risk of spillover.

Biosecurity measures should also be in place to avoid attracting wild animals into human settlements (e.g., rodents). Waste management practices should be put in place to prevent access by wild animals and avoid dissemination of waste into the surrounding environment. Food stores such as grains and animal feed should not be accessible to wild animals. Grain storage buildings and containers should therefore be designed to be rodent proof to prevent contamination by rodents and other wildlife.

Many biosafety and biosecurity measures are broad and can reduce overall disease risk. In addition, in areas with known endemic or emerging disease risks additional specific actions can be taken. For example, in the United States plague transmission has occurred from infected rodents and their fleas to humans in national parks. Signage and park zoning can help to reinforce the importance of plague risk reduction measures, such as using insect repellent to avoid flea bites, not feeding wildlife, not handling dead rodents, and not camping or preparing food near rodent burrows.[44]

Those in close contact with animals or potentially infectious bodily fluids or tissues, such as during animal necropsy, should ensure proper training on and consistent use of biosafety protocols, including hygiene measures, handling and waste management of hazardous materials, and the proper selection of and use of personal protective equipment (PPE). Attention should always be paid to safely putting on and removing PPE, often referred to as donning and doffing, to avoid inadvertent exposure risks. Correct procedures may vary depending on the type of PPE used.

Disinfection can help prevent movement of infectious materials (for example, on fomites such as vehicles) into and out of sites. This is already widely used at some sites to prevent biological invasion. For example, in Antarctica and other marine environments there are strict regulations for tourist gear/footwear cleaning, such as boot washing, and checking Velcro on jackets and clothes for potentially invasive plant seeds. Actions like these can also help to prevent the unintentional introduction of pathogens. The availability and use of hand washing stations or hand sanitizer before and after staff and visitors handle animals also helps to protect the animal and people.

The introduction of the fungus causing White Nose Syndrome (*Pseudogymnoascus destructans)* to North America is suspected to have been unknowingly brought into a cave on the boots of a visitor. The disease has caused catastrophic declines in bats, with losses of >90% in some populations, and has seen rapid expansion from its point of initial introduction. Decontamination of gear prior to caving is essential to prevent further spread and impact of the pathogen.

[44] https://www.nps.gov/yose/planyourvisit/plague.htm

<table>
<tr><td rowspan="3">Control measures</td><td colspan="2"><u>Indicator</u>: Disease management protocols and risk reduction measures included in site management plan</td></tr>
<tr><td>Approaches</td><td>Sample means of verification</td></tr>
<tr><td>• Response measures are science-based and take into account possible impacts on biodiversity
• Wildlife culling for disease response prohibited unless warranted by thorough assessment of risks and benefits
• Vaccines and therapeutics are considered in wild, domestic, and human populations to best prevent and control outbreaks
• Emergency preparedness and response plan in place</td><td>Documentation of scientific literature review.
Consultation with experts.
Documentation of assessment of proposed control measure(s).
Emergency preparedness and response plan.
Documentation of simulation exercise(s).</td></tr>
</table>

A suspected zoonotic disease outbreak can present a stressful situation, with a need to respond rapidly, even though there may be key knowledge gaps. In response to public concern about the source of disease (and often misconceptions on the part of the public or authorities), wildlife culling is sometimes proposed or carried out in response to outbreaks. These extirpation efforts are often ineffective, incorrectly targeted to the wrong species, and a waste of resources. They are also potentially detrimental to populations and ecosystems.

Response measures should be backed by evidence and take into account impacts on biodiversity. Often, a quick scientific literature review and guidance from global authorities (OIE, FAO, IUCN, UNEP, and WHO) can provide clarity on appropriate response measures when it comes to wildlife. Culling of wildlife for disease response should be prohibited unless warranted by thorough assessment of risks and benefits. While mass culling is indicated in livestock for specific disease situations, there are only select situations where its use in wildlife has been proven to be effective; thus, culling should not be considered a first-line option for the control of wildlife populations. Separate from population-level strategies, euthanasia may be necessary for disease investigation in individual animals (for example, brain tissue is required for confirmatory testing for rabies virus).

PCA agents may need to assess potential options and petition authorities for emergency use approvals. Examples of criteria to guide selection of emergency measures may include:

- Is there reasonable proof that the product is safe and effective in genetically similar species?
- Is there a substantial potential protective benefit to the population (including the animal to be vaccinated and/or to interrupt transmission to other species)?
- Are there risks to other species (non-target) minimal?

When outbreaks of rabies virus, a zoonotic disease, began affecting the already-threatened Ethiopian wolf (*Canis simensis*), oral rabies vaccines were not authorized for use in Ethiopia, and the parenteral vaccine had not been tested in the species. Rabies is fatal, and infections spread rapidly in wolf populations due to their highly social nature. As domestic dogs were suspected as the source of introduction, vaccination of dogs was conducted around Bale Mountain National Park. Outbreaks continued, and emergency use of the canine vaccination in Ethiopian wolves was authorized to limit transmission between wolf populations. However, intensive response efforts indicated the longer-term need for preventive measures to protect the species. Safety and efficacy testing was conducted on oral baiting with the vaccine. Based on findings from these studies and as a result of coordination efforts between the Ethiopian Wolf Conservation Project and the Government of Ethiopia, preventative oral vaccination was built into the National Action Plan for Conservation of the Ethiopian Wolf in 2017 and has been implemented since. The oral form increases feasibility of vaccination campaigns, avoiding the need for animal capture and cold storage infrastructure. For sites with known circulation of rabies in wild or domestic animals, availability of post-exposure prophylaxis for humans is a crucial employee and community health measure in the case of animal scratches or bites. Additionally, pre-exposure vaccination against rabies, which allows for fewer post-exposure doses, should be considered for those at high risk of exposure, such as veterinarians and biologists, those involved in cave exploration activities, and those likely to come into contact with rabid animals.

In addition to emergency response, control measures may be applied proactively. For example, modeling studies have been used to optimize prophylactic vaccination strategies in endangered Hawaiian monk seals to protect against morbillivirus introduction.[45]

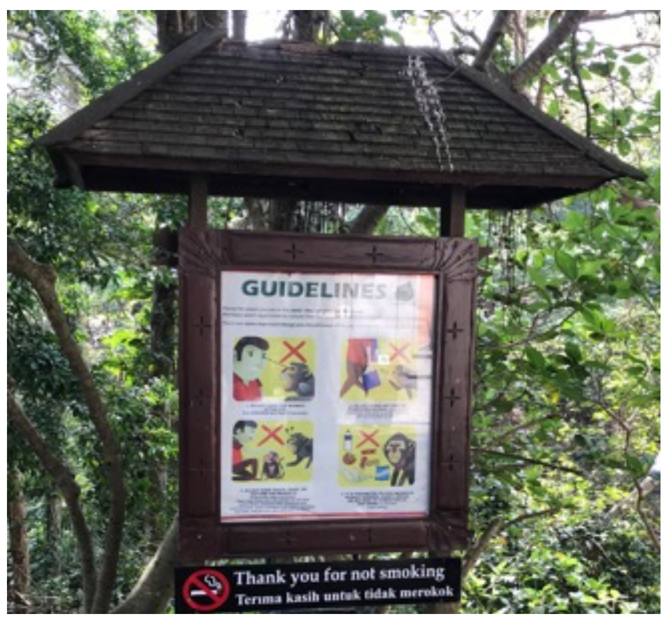
Spill over into other species can make long-term eradication or control more challenging, as seen with the introduction of SARS-CoV-2 into some wild species. Staff (and visitors) who are ill with respiratory disease or fever should not carry out duties involving wild mammals until their infections have cleared or determined not to pose a risk of infection to animals. Other guidelines, such as a wait period between international traveler arrival and visit to wildlife habitat, maintaining appropriate distances from wildlife, and use of N95 respirator masks, may be recommended. With COVID-19, additional protocols such as up-to-date vaccination, are warranted to reduce the risk of transmission to other tourists and staff as well as to wildlife. On the basis of zoonotic disease risk to both humans and animals, PCA staff or networks (e.g., rangers, veterinarians, researchers) may also be considered high priority for vaccines or other preventative resources. A key example is vaccination against Ebola virus by veterinarians working in Ebola-endemic areas, which can protect individuals and interrupt spread to community members and wildlife.

Emergency preparedness and response plans can help support timely and effective investigation, response, and resolution to suspected zoonotic disease events. Sites may consider developing their own plan or adopting one already developed by other government and non-governmental agencies. Having a solid plan in place and the readiness to deploy it provides confidence that a situation is under control. Plans should be reviewed frequently to ensure points of contact are up to date and roles and responsibilities are accurate. Awareness of the plan by potential users is crucial. While maintaining a plan may seem time-consuming, having it in place in advance of an event can ensure there is a clear and accepted chain of command, consistent information flow and communication to the public to maintain credibility, and timely resolution of an event. Together, this can help to minimize detrimental effects of an event, including the impacts from perceived or actual risk to human health, disruption of tourism activities, and other possible consequences. For example, a rumor in a community around a PCA of a reported outbreak spread by animals could prompt specific actions to investigate and communicate information, helping to alleviate concerns through clear guidance. Simulation exercises can help practice plans and refine them as needed.

[45] https://pubmed.ncbi.nlm.nih.gov/29321294/

Risk Communication	Indicator	
Risk Communication	<u>Indicator</u>: Signage or other visual cues to reduce risk (visitor and staff management)	
	Approaches	*Sample means of verification*
	• Coordination with animal and public health authorities for biodiversity-sensitive messaging • Signage to encourage safe practices with regard to zoonotic and wildlife disease risk • Information on responsible practices to reduce zoonotic and wildlife disease risk included in visitor code of conduct • Information about disease events (suspected or confirmed) conveyed to local community health workers and/or clinics	Records of coordination. Consultation with animal and public health authorities. Evidence of signage on-site. Documentation in visitor/staff code of conduct. Documentation of information sharing with government and healthcare focal points.

Effective risk communication should aim for clear and consistent messaging to promote protection of health and biodiversity. When an outbreak occurs, public trust may be diminished, and there may be immediate or ongoing safety concerns (perceived or actual). In the past, economic damages have occurred from inconsistent communication or incorrect understanding of risk. Additionally, based on poor understanding of transmission source and risk, associated with poor risk communication, wild animal killings (e.g., bats, birds) have been inappropriately conducted. For example, in response to a yellow fever outbreak in South America, many non-human primates were killed out of fear – despite the virus being transmitted to humans by mosquitos, not by primates.[46,47] Therefore, proactive risk communication is useful to ensure wild animals are not villainized, that the benefits of biodiversity are well recognized, and prevention and control measures are science-based.



Signage promoting safe tourist behavior at the Ubud Monkey Forest sanctuary, Bali, Indonesia. C. Machalaba, 2019.

Coordination with national and/or subnational authorities is also important to promote both awareness and consistent messaging. Depending on relevant stakeholder networks, contacting local community human and animal health workers or clinics can promote early warning and enhancement of infection

[46] https://www.science.org/do/10.1126/comment.195875/full/
[47] https://www.cdc.gov/yellowfever/transmission/index.html

prevention and control measures. For example, awareness about an outbreak in wild animals could help medical providers target their intake questions and differential diagnosis. These links are easily missed with poor information flow between sectors and levels of the public health and medical system.

Recovery may also require messaging to reassure the public, including tourists, that proper safeguards are in place and that adhering to PCA policies is in the best interest of visitors to ensure their safety. In other cases, different messaging is needed for sites where human activity is prohibited or discouraged based on disease risk.

Information campaigns should be sensitive to their potential effects on perceptions about wild animals in a variety of settings. Messaging that emphasizes practical actions to minimize risks can help to avoid feelings of helplessness, fear, and anxiety. Information about wildlife as a source of disease should also be paired with information about their wider benefits to avoid negative perceptions.[48] The design, roll-out, and evaluation of risk communication campaigns should thus strive to balance awareness about disease risk, living safely with wildlife, and an overall regard for biodiversity. One Health coordination is important to help ensure potential adverse outcomes are adequately considered, averted, and mitigated.

Simple, low-cost signage or markings can be important at sites (particularly visual cues given varying literacy levels and different languages). Behavioral "nudges" are increasingly recognized as being useful to promote safer practices.[49] Examples may include a free hand sanitizer and mask dispenser station in a convenient location for visitors with messaging about how they can help keep wild animals and their communities safe or marked trails to encourage people to stay in designated areas. Key stakeholders should be consulted to 1) raise awareness about reducing disease risk and protecting biodiversity, and 2) develop tailored messaging to best reach each sector or population.

The "Living Safely with Bats" book was developed to support risk communication and community engagement in settings with high human-wildlife exposures.[50] The book was translated and adapted for 13 different languages and contexts, and served as a tool for awareness and discussion about reducing disease risk at an individual, household, and community level while conveying the importance of protecting biodiversity. Examples include how to safely dispose of a dead bat, what to do if rodents are present in the household, and how to minimize contact around trees where bats roost. This approach has supported practical discussions around situations that shape interactions with wild animals, and is an important follow-up to surveillance efforts in communities to ensure communities have the benefit of increased awareness of safe practices. The book has also been taken up by the national primary school curriculum in at least one country. Tools like this could be use or adapted as a teaching tool for school visitors or communities living around a site.

[48] Leong, K.M, and Decker, D.J., 2020, Human dimensions considerations in wildlife disease management: U.S. Geological Survey Techniques and Methods, book 15, chap. C8, 21 p., https://doi.org/10.3133/tm15C8.
[49] https://www.nature.com/articles/s41559-020-1150-5?proof=t
[50] https://p2.predict.global/living-safely-with-bats-book

One Health Coordination	Indicator: Reporting system in place for information flow with relevant authorities for wildlife disease events in/around protected and conserved area	
	Approaches	*Sample means of verification*
	• Ensure participation in One Health coordination platform (if established and functional) • Ensure partnerships are in place to notify appropriate authorities and utilize the findings of an investigation as relevant.	Record of participation and official meeting documents. Consultation with focal points to One Health or other multi-sectoral platform(s). Documentation of partnerships. Records of event reporting and resolution. Consultation with appropriate authorities.

There are many potential ways that a One Health approach can support zoonotic disease risk reduction in PCAs. The previous chapters reflect One Health-informed strategies. Formalizing coordination is also a key component in the operationalization of One Health. PCAs often facilitate formal and informal governance structures, frequently involving local communities and many public and private stakeholder groups and entailing multi-sectoral coordination. A One Health approach can build on and strengthen existing coordination to more fully evaluate trade-offs and promote co-benefits.

A One Health approach should not be interpreted as everyone working together all of the time; rather, it seeks to add value by increasing coordination where necessary for a more comprehensive understanding of a situation and increased effectiveness and/or efficiency to tackle disease threats. This reflects the different roles, expertise, and resources that each sector brings, including the contributions of biodiversity and park managers in prevention and detection efforts in and around PCAs. The fragmentation of mandates among different sectors and agencies makes the need for formal coordination structures clear.

The multi-sectoral coordination provided by a One Health approach helps to adequately assess and minimize possible trade-offs of decisions (including adverse outcomes to wildlife and ecosystems) and maximize co-benefits. In PCAs, this is especially relevant given how public perceptions can be shaped by misinformation, which can lead to substantial indirect socio-economic and environmental impacts, ranging from negative impacts on tourism demand or the inappropriate killing of wildlife and degradation of ecosystems. These adverse impacts can take much longer to recover from than the disease event itself.[51] With that in mind, site managers should be aware of the importance of coordination with local and national authorities, including during emergencies and for longer-term risk reduction.

One Health coordination can also be important for identifying workforce development needs and offering joint training support to optimize resources. For example, epidemiology, the discipline

[51] https://www.ecologyandsociety.org/vol21/iss1/art20/

that studies the distribution and determinants of outbreaks and other disease outcomes,[52] is an important component of designing and interpreting surveillance findings and conducting outbreak investigations. Initiatives such as Field Epidemiology Training Programs can help strengthen the epidemiological capacity of public health, animal health, and wildlife and environmental managers.[53]

Many countries are establishing national and sub-national One Health Coordination Platforms. These multi-sectoral coordination mechanisms make the sharing of information more frequent and routine between line ministries or agencies (e.g., the ministry of health, veterinary services, and the wildlife department) as well as other key stakeholder groups.[54] While OH coordination platforms are relatively new, PA managers should be aware that wildlife and environment sector representation is usually weak. This means it is crucial for PA managers to proactively share information and raise concerns with other sectors to ensure ecological and biodiversity aspects are adequately taken into account.

In Cameroon, a national One Health Strategy and Zoonotic Program was developed with focal points from four ministries. Just a few weeks later, a rescue center reported illness in several chimpanzees to the Ministry of Health, with the zoonotic disease Monkeypox suspected as the cause. The One Health Strategy was put into use with a multi-ministry investigation, involving a literature review, on-site observations, sampling, laboratory testing, and reporting through official national and international channels. In particular, the plan allowed for a single government authorization of travel, rather than four separate ministry authorization processes, increasing the speed and lowering the cost of the investigation. Additional non-governmental partners with epidemiological and wildlife disease expertise also provided planning and response support. The effective response helped to contain the spread in the chimpanzees, resulting in only one chimpanzee death and no human cases.[55]

[52] https://www.cdc.gov/csels/dsepd/ss1978/lesson1/section1.html
[53] https://www.tephinet.org/training-programs
[54] https://www.who.int/initiatives/tripartite-zoonosis-guide
[55] https://www.ecohealthalliance.org/wp-content/uploads/2016/10/One-Health-in-Action-Case-Study-Booklet_24-October-2016.pdf

4) Further Resources and Guidance

The Guidelines reflect measures considered generally good practice for wildlife and public health based on key sources of risk, and knowledge is strong enough to take action to reduce risk substantially. They are generic enough to cover all settings and relevant species and can be adapted to specific sites for practical application. The evaluation of zoonotic disease risk reduction interventions relating to wildlife is limited so far;[56] thus, interventions can and should be refined from lessons learned and optimization strategies on a continual basis as the knowledge base expands in the future. Successful approaches, particularly those that are scalable, should be shared widely, including through the IUCN Commissions and the PANORAMA Solutions for a Healthy Planet *Species Conservation* portal.

- Green List Standard. https://iucngreenlist.org/standard/components-criteria/

- World Organisation for Animal Health (OIE) & International Union for Conservation of Nature (IUCN) (2014). – Guidelines for Wildlife Disease Risk Analysis. OIE, Paris, 24 pp. Published in association with the IUCN and the Species Survival Commission. https://portals.iucn.org/library/sites/library/files/documents/2014-006.pdf

- IUCN (2019). Guidelines for the Management of Confiscated, Live Organisms. Gland, Switzerland: IUCN. iv + 38 pp. https://portals.iucn.org/library/sites/library/files/documents/2019-005-En.pdf

- OIE WAHIS: immediate event reporting for Listed and unusual disease events in animals: https://wahis.oie.int/#/home

- OIE WAHIS-Wild: annual reporting on wildlife disease events by country: https://www.oie.int/en/the-oie-launches-wahis-wild-interface/ [to add new link when updated site is launched]

- PREDICT Sampling Protocols: Under "Guides": https://ohi.vetmed.ucdavis.edu/programs-projects/predict-project/publications

- PANORAMA Solutions for a Healthy Planet – Species Conservation portal: https://panorama.solutions/en/portal/panorama-species-conservation

[56] https://web.oie.int/downld/WG/Wildlife/OIE_review_wildlife_trade_March2021.pdf