Annex I

Summary of the Five Criteria (A–E) Used to Evaluate if a Taxon Belongs in an IUCN Red List Threatened Category (Critically Endangered, Endangered or Vulnerable)*

A. POPULATION SIZE REDUCTION. POPULATION REDUCTION (MEASURED OVER THE LONGER OF 10 YEARS OR 3 GENERATIONS) BASED ON ANY OF A1 TO A4				
		Critically Endangered	**Endangered**	**Vulnerable**
A1		**≥90%**	**≥70%**	**≥50%**
A2, A3 & A4		**≥80%**	**≥50%**	**≥30%**
A1	Population reduction observed, estimated, inferred, or suspected in the past where the causes of the reduction are clearly reversible AND understood AND have ceased.	based on any of the following:	(a) direct observation [*except A3*] (b) an index of abundance appropriate to the taxon (c) a decline in area of occupancy (AOO), extent of occurrence (EOO) and/or habitat quality (d) actual or potential levels of exploitation (e) effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites	
A2	Population reduction observed, estimated, inferred, or suspected in the past where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.			
A3	Population reduction projected, inferred or suspected to be met in the future (up to a maximum of 100 years). [*(a) cannot be used for A3*]			
A4	An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.			
B. GEOGRAPHIC RANGE IN THE FORM OF EITHER B1 (EXTENT OF OCCURRENCE) AND/OR B2 (AREA OF OCCUPANCY)				
		Critically Endangered	**Endangered**	**Vulnerable**
B1	Extent of occurrence (EOO)	**<100 km²**	**<5,000 km²**	**<20,000 km²**
B2	Area of occupancy (AOO)	**<10 km²**	**<500 km²**	**<2,000 km²**
AND at least 2 of the following 3 conditions:				
(a)	Severely fragmented **OR** Number of locations	=1	≤5	≤10
(b)	Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals			
(c)	Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals			

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C. SMALL POPULATION SIZE AND DECLINE		Critically Endangered	Endangered	Vulnerable
Number of mature individuals		**<250**	**<2,500**	**<10,000**
AND at least one of C1 or C2:				
C1	An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future):	25% in 3 years or 1 generation (whichever is longer)	20% in 5 years or 2 generations (whichever is longer)	10% in 10 years or 3 generations (whichever is longer)
C2	An observed, estimated, projected or inferred continuing decline AND at least 1 of the following 3 conditions:			
(a)	(i) Number of mature individuals in each subpopulation: (ii) % of mature individuals in one subpopulation =	≤50 90–100%	≤250 95–100%	≤1,000 100%
(b)	Extreme fluctuations in the number of mature individuals			

D. VERY SMALL OR RESTRICTED POPULATION		Critically Endangered	Endangered	Vulnerable
Number of mature individuals		**<50**	**<250**	**<1,000**
D1	*Only applies to the VU category* Restricted area of occupancy or number of locations with a plausible future threat that could drive the taxon to CR or EX in a very short time.	–	–	D2. typically: AOO <20 km² or number of locations ≤5

E. QUANTITATIVE ANALYSIS	Critically Endangered	Endangered	Vulnerable
Indicating the probability of extinction in the wild to be:	**≥50% in 10 years or 3 generations, whichever is longer (100 years max.)**	**≥20% in 20 years or 5 generations, whichever is longer (100 years max.)**	**≥10% in 100 years**

Note: * Use of this summary sheet requires full understanding of the IUCN Red List Categories and Criteria and Guidelines for Using the IUCN Red List Categories and Criteria. Please refer to both documents for explanations of terms and concepts used here.

Source: IUCN (2012, pp. 28–9)

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Annex II

Summary Table of Ape Diseases, Infections and Other Health Issues

The list of diseases presented in this annex is not exhaustive; rather, it is designed to illustrate the developing knowledge in this area and to provide a quick and accessible overview of key ape diseases, infections and other health issues. The information is drawn from chapters in this volume, primarily Chapter 1, and from personal experience of the veterinary contributors, unless otherwise indicated.[1]

While all apes, including humans, may be susceptible to the diseases described in this annex, a few caveats apply:

- Exposure depends on the geographical range of pathogens, which constantly shifts in response to climate change, the wildlife trade and other anthropogenic factors.
- Most disease data for non-infectious conditions come from captive situations.
- Significant data gaps preclude verification in many identified disease situations and, consequently, raise uncertainty in disease risk management decisions.
- Parasite–host balance is an ecological process that is necessary for life. The presence of parasites does not always indicate disease, nor is it always a cause for concern. Conversely, a lack of parasites is unnatural and could actually increase the risk of infection by pathogenic parasites.
- The table does not consider effects of trauma or accidental injuries, common occurrences in all ape species, both in captivity (ex situ) and in their natural habitat (in situ).
- The relative risk of each disease occurring in an ape population depends on the interaction between host, parasite (potential pathogen) and the environment. The diseases of concern in a sanctuary in Sierra Leone differ from those in a national park in Uganda, a rehabilitation centre in Kalimantan, an entertainment facility in Thailand or a zoo in Australia, for example.

The reader is recommended to review the *Manual of Procedures for Wildlife Disease Risk Analysis* when making actual risk-based decisions for ape disease (Jakob-Hoff *et al.*, 2014).

1 For an extensive disease list for apes, see Volume 8 of *Fowler's Zoo and Wild Animal Medicine*; see also the ape chapters in the subsequent volumes (Miller, Calle and Lamberski, 2023; Miller and Fowler, 2015; Miller, Lamberski and Calle, 2019). Specific aspects of ape parasitology and gorilla pathology are covered in Cooper and Hull (2017) and Modry et al. (2018).

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Health issue	Description	In situ	Ex situ	Location	Consequences	Notes
AGE-RELATED ISSUES						
Age-related cardiovascular disease	Degenerative conditions that affect the cardiovascular system (heart and blood vessels)	Suspected	Confirmed	Global	Progressive and fatal. Signs are mild to severe, including aortic dissection, congestive heart failure, malignant arrhythmia, myocardial fibrosis, strokes.	
Age-related dental disease	Degenerative diseases that affect the teeth and jaw	Suspected	Confirmed	Global	Dental attrition, enamel hypoplasia (thin or missing tooth enamel) of deciduous and permanent teeth, tooth loss.	
Age-related liver disease	Degenerative diseases that affect the liver	Suspected	Confirmed	Global	Can be progressive and fatal. Mild to severe signs, including cirrhosis, decreased activity, lethargy, hepatic fibrosis, hepatitis, weight loss.	
Age-related ocular conditions	Degenerative diseases and conditions that affect the eyes	Confirmed	Confirmed	Global	Cataracts and retinal disease, potentially leading to blindness.	
Osteoarthritis	Degenerative condition that results in stiff, painful joints	Confirmed	Confirmed	Global	Commonly affects knees, hips, elbows and lower spine, thereby affecting mobility, which may result in injury and/or malnutrition.	
Age-related renal disease	Degenerative conditions that affect the renal system (kidneys, ureters, bladder and urethra)	Suspected	Confirmed	Global	Progressive and fatal. Mild to severe signs, including chronic interstitial nephritis and glomerular lesions.	
INFECTIOUS DISEASES						
Anthrax	Bacterial infection (*Bacillus anthracis*). Skin, lung and bowel disease	Confirmed	Unknown	Central and West Africa	Fatal. Rapid onset, fever, septicemia (blood poisoning) and a high fatality rate.	
Air sacculitis	Resulting from bacterial infection of the respiratory system	Probable	Confirmed	Global	Can be fatal. Purulent material accumulates within the tiny sacs off the laryngeal tubes,	Part of a syndrome that often includes sinusitis (which often goes undetected) and can also lead to pneumonia. ►

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Health issue	Description	In situ	Ex situ	Location	Consequences	Notes
					with the potential for serious complications, including fatal bronchopneumonia and sepsis.	
Candidatus Sarcina troglodytae	Bacterial infection of the neural and gastrointestinal systems	Unknown	Confirmed	Sierra Leone	Can be fatal. Neurologic and gastrointestinal signs.	A new, highly virulent bacterial *Sarcina* strain has been linked to disease in captive, rehabilitant chimpanzees, termed "epizootic neurologic and gastroenteric syndrome (ENGS)." Potentially emerging.
Clostridium tetani	Neuro-muscular bacterial disease	Unlikely	Confirmed	Global	Death, jaw cramping, muscle spasms and hypertonia, seizures, trouble swallowing.	
"Common cold"	Viral infection of the respiratory system (human rhinovirus C)	Confirmed	Confirmed	Global	Dyspnea (labored breathing), wheezing, mild to heavy cough, lethargy, nasal discharge.	Can make the body susceptible to bacterial infections.
COVID-19	Viral infection of the respiratory and gastrointestinal systems (SARS-CoV-2)	Unknown	Confirmed (gorillas and chimpanzees)	Global	Dyspnea, wheezing, mild to heavy cough, lethargy, nasal discharge.	Identified in gorillas in the zoos of San Diego and Prague. Identified in captive chimpanzees in the Democratic Republic of Congo (L. Flores, personal communication, 2023).
Ebola virus disease, formerly known as Ebola hemorrhagic fever	Viral (ebolaviruses)	Confirmed	Unknown	Central, East and West Africa	Fatal. Bleeding (internal and sometimes external), diarrhea, emaciation, fever, lethargy and vomiting.	Of the six ebolaviruses, only four cause disease in humans (Bundibugyo, Sudan, Taï Forest and Zaire ebolaviruses). No human-pathogenic ebolaviruses are known from Asia; however, Reston ebolavirus, which circulates in bats in the Philippines, can cause disease in apes.

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Health issue	Description	In situ	Ex situ	Location	Consequences	Notes
Encephalomyo-carditis	Viral disease that tends to affect the central nervous and cardiovascular systems	Unknown	Confirmed	Several zoos around the world	Sudden death is the most common consequence. Clinical signs may include fever, anorexia, listlessness, trembling, staggering, dyspnea and paralysis.	Gaskin (2022)
Hepatitis A virus	Viral infection of the liver and gastrointestinal system	Confirmed	Confirmed	Global	May be asymptomatic but has caused fulminant hepatitis in chimpanzees and has been a likely cause of death in gibbons (awaiting confirmation).	Can be from zoonotic transmission, but chimpanzees and other apes have been shown to have their own strains.
Hepatitis B virus	Viral infection of the liver	Confirmed	Confirmed	Global	Often asymptomatic. Can potentially lead to increased liver enzymes and hepatic neoplasia, typically in aged animals.	Chimpanzees, gorillas, orangutans and gibbons all have their own strains, which are distinct from human strains.
Herpes simplex virus	Viral infection of the skin and nervous system	Confirmed	Confirmed	Global	Can be fatal, with mortality reported in captive gibbon, gorilla and orangutan populations. Systemic infections with encephalitis; signs include blisters and sores.	
Human coronavirus OC43	Viral infection of the respiratory and gastrointestinal systems	Suspected	Confirmed	Global	Dyspnea, wheezing, mild to heavy cough, lethargy, nasal discharge.	
Human orthopneumovirus	Viral infection of the respiratory system	Confirmed	Confirmed	Central, East and West Africa	Dyspnea, wheezing, mild to heavy cough, lethargy, nasal discharge.	
Human respirovirus 3	Viral infection of the respiratory system	Confirmed	Confirmed	Global	Can be fatal, especially with secondary bacterial infection. Dyspnea, wheezing, mild to heavy cough, lethargy, nasal discharge.	

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Health issue	Description	In situ	Ex situ	Location	Consequences	Notes
Influenza (flu)	Viral infection of the respiratory system	Unknown	Confirmed	Global	Unknown	There is no confirmation of apes being infected with human influenza strains, but the chimpanzee adenovirus shell is used in influenza vaccines for humans. Data are limited on confirmed infection with influenza A, B, C and D. See Annex III for confirmed infections in apes.
***Klebsiella* pneumonia**	Bacterial disease (*Klebsiella pneumoniae*)	Unknown	Confirmed	Global	Can be fatal. Signs depend on which organ is affected, they include air sacculitis, gastrointestinal inflammation, pneumonia and septicemia (blood poisoning).	It is unclear whether the disease can be a primary infection, but it appears to be related to immunosuppression. In humans it is typically a secondary infection related to health or medical care.
Leprosy	Bacterial infection of the nerves, skin, eyes and lining of the nose (*Mycobacterium leprae*)	Confirmed	Confirmed	Sub-Saharan Africa	Lesions, including nodules on the face; hair loss and skin depigmentation; abnormal nail growth and hand deformity; disfigured faces and crippled limbs.	
Meliodosis/ Whitmore's disease	Bacterial infection (*Burkholderia pseudomallei*)	Confirmed	Confirmed	Southeast Asia and northern Australia	Can be fatal, with a wide range of signs of varying severity, from subclinical to subacute. Signs include wasting with subcutaneous and soft-tissue abscesses.	Can be challenging to diagnose and treat because the organism can remain latent for years; it can be mistaken for other infections, such as tuberculosis, and is resistant to many antibiotics.
Monkeypox	Viral infection (*Orthopoxvirus*)	Confirmed	Confirmed	Central and West Africa	Can be fatal. Diverse clinical manifestations, such as maculopapular rash; mild to severe respiratory signs with absent or limited (1–2) skin lesions; or no signs.	

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Health issue	Description	In situ	Ex situ	Location	Consequences	Notes
Pasteurella multocida	Bacterial infection of the respiratory system	Confirmed	Confirmed	Global	Can be fatal. Infections include air sacculitis and pneumonia.	
Poliomyelitis	Musculoskeletal viral disease	Confirmed	Suspected	East Africa	Infection of bones and muscles, resulting in paralysis and influencing survival and reproductive success.	Although not definitively diagnosed, a disease with clinical signs similar to polio in humans was seen in 1966 in Gombe chimpanzees (Morbeck *et al.*, 1991). Williams *et al*. (2008) highlight the issue in diagnosing infectious disease in apes, that continues today, the lack of disease surveillance.
Pseudomonas spp. infection	Bacterial disease	Confirmed	Confirmed	Global	Responsible for air sacculitis infection in orangutans and even death after a wound infection (Kanamori *et al.*, 2012; Lawson, Garriga and Galdikas, 2006).	These bacteria do not appear to cause disease in healthy animals or humans.
Retrovirus	Viral infection: simian immunodeficiency virus in chimpanzees (SIVcpz)	Confirmed	Confirmed	Central, East and West Africa	Fatal; carrier state possible. Disease is usually not seen until long past infection. AIDS-like illness similar to human immunodeficiency virus (HIV) in humans. The latter stages of infection develop into simian acquired immunodeficiency syndrome (SAIDS).	
Salmonella/ *Shigella* infection	Bacterial disease of the gastrointestinal system	Confirmed	Confirmed	Global	Can be fatal. Most common signs are abdominal pain and watery diarrhea. May also cause dehydration, fever and vomiting.	
Streptococcus pneumonia	Bacterial disease (*Streptococcus pneumoniae*)	Confirmed	Confirmed	Global	Can be fatal. Dyspnea (labored breathing), wheezing, mild to heavy cough, lethargy,	This is a secondary infection that occurs after an individual has been weakened by a

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Health issue	Description	In situ	Ex situ	Location	Consequences	Notes
					nasal discharge. Can result in pneumonia.	respiratory viral infection.
Tuberculosis	Bacterial infection of the respiratory system, but granulomas can appear elsewhere, including in the gastrointestinal system (*Mycobacterium tuberculosis* complex)	Confirmed (chimpanzees)	Confirmed	Global	Can be fatal. May be asymptomatic in early stages; signs are progressive. First signs may include lethargy, decreased activity, wasting, weight loss. Advanced cases can present with respiratory signs (coughing, dyspnea). Gastrointestinal cases can present with diarrhea.	Warning: Extremely complicated to diagnose and confirm. Impacts on apes differ from those on humans. This infection should be considered in all cases of respiratory or gastrointestinal infection and weight loss. Securing an expert opinion is recommended. Tuberculosis can spread from humans to animals and vice versa.
Typhoid fever	Bacterial disease (*Salmonella typhi/paratyphi*)	Unlikely	Confirmed	Global (more common in developing countries)	High fever, headaches, gastrointestinal signs (diarrhea or constipation) and lethargy.	
Yaws	Musculoskeletal bacterial disease (*Treponema pallidum* subspecies *pertenue*)	Confirmed	Suspected	Sub-Saharan Africa	Infection of the skin, bones and joints, resulting in non-cancerous lumps and ulcers.	
PARASITES						
Filariasis	Nematodes that affect the heart and lungs	Unknown	Confirmed	Global	Mild to fatal signs, including loss of appetite, weight loss, lethargy and difficulty breathing.	*Dirofilaria immitis* has been described in orangutans (Sandosham, 1951). A recent case in an orangutan was detected during a necropsy.
Gastrointestinal protozoa	Protozoa that affect the gastrointestinal and other systems, including *Entamoeba histolytica* (amebic dysentery); *Giardia duodenalis* (giardiasis); *Balantidium coli* and *Dientamoeba fragilis*	Confirmed	Confirmed	Global	Some can be fatal. Mixture of signs, from mild to severe. Acute to subacute necrotizing or granulomatous meningoencephalitis, bloating, cramping, diarrhea, lung or liver abscesses, ulcerative colitis and vomiting.	Consequences are much more severe in captivity. Untreated *Entamoeba histolytica* and *Giardia duodenalis* cause diseases in captive apes, mostly in infants. *Ballantidium coli* is commensal in captive apes and rarely causes diseases.

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Health issue	Description	In situ	Ex situ	Location	Consequences	Notes
Internal helminths	Worms—roundworms (nematodes), tapeworms (cestodes), flukes (trematodes)—that tend to affect the gastrointestinal system, with occasional respiratory phases of the life cycle that lead to disease in multiple organs	Confirmed	Confirmed	Global	May be asymptomatic. Heavy burdens may be associated with weight loss, weakness, failure to thrive, diarrhea and, occasionally, blood in feces (hematochezia).	These parasites are most common in captive apes and include *Ankylostoma, Ascaris*, *Capillaria, Enterobius, Oesophagostomum, Strongyloides and Trichuris.* The consequences of an infection by gastrointestinal parasites depend on the parasitic load and the animal's immune status. Parasites are commensal agents in ape intestines; their presence is not necessarily a risk to health. Problems arise when there is a lack of control of the parasitic load, such as when an animal is in captivity, when natural habitats are overpopulated or when an animal's immune status is deficient.
Malaria	Protozoa (single-celled organisms) that affect various organs, with liver and brain infection leading to the most serious consequences (*Plasmodium* spp.)	Confirmed	Confirmed	Tropics	Potentially fatal. Mostly causing asymptomatic infections in apes, but documented signs of malaria range from moderate to severe. Consequences depend on the species of *Plasmodium*, the protozoal load of *Plasmodium*, the species of ape and which organ system is affected (Sanchez *et al.*, 2022).	The disease is caused by parasites transmitted through the bites of infected female *Anopheles* mosquitoes.
Mange/scabies	Ectoparasites (mites: *Sarcoptes scabiei*) that affect the skin	Confirmed	Confirmed	Global	Rarely fatal. Flaky, sore and itchy skin. Can make young apes more susceptible to other diseases.	

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Health issue	Description	In situ	Ex situ	Location	Consequences	Notes
PSYCHOLOGICAL DISORDERS						
Behavioral disturbances similar to post-traumatic stress disorder (PTSD) following traumatic experiences	Mental/emotional disorder affecting the nervous system	Unknown	Confirmed	Global	Potential for long-term behavioral and physiological issues if not identified. Could manifest many months or years after inciting incident.	To be taken into consideration in the context of orphan ape rescues, translocations of "displaced" apes and confinement of apes in captivity (see Chapter 8).
Chronic stress	Mental/emotional issues affecting the nervous system	Confirmed	Confirmed	Global	May create lethargy, stereotypical behaviors (such as pacing) and other psychopathologies, which also require managing, as well as impairment of the immune system in its ability to fight off certain infections or regulate the microbiome. The combination of these factors usually results in a higher disease prevalence under captive conditions.	Limited opportunity or ability to engage in natural behavior, physical exercise and, most importantly, mental exercise increases the chances of the development of psychological disorders, including stereotypical behaviors, accompanied by increased levels of stress hormones such as cortisol.
OTHER ISSUES						
Alcohol, drug and tobacco dependency	Due to abusive captivity	Unknown	Confirmed	Global	Like humans, apes can show behavioral changes and neurocognitive deficits, such as memory loss and cognitive impairments.	Such dependency has been documented in illegally kept apes used as photo props and tourist attractions, such as young gibbons at Thai beaches, bars and restaurants and smoking chimpanzees in zoos (Guarino, 2016). They are given alcohol, cigarettes and drugs, such as amphetamines, to keep them awake and ensure they "perform."
Burns	Due to forest fires or contact with uninsulated power lines (see electrocution)	Probable	Confirmed	Africa and Asia	Can be fatal. Depending on their severity, burns can lead to disfigurement; leave individuals susceptible to infection at burn sites; impact mobility, potentially	Most fires in ape ranges are intentionally set by humans or due to human error (Kimbrough, 2020).

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Health issue	Description	In situ	Ex situ	Location	Consequences	Notes
					resulting in starvation or exposure to predation; impair the immune system, leaving individuals open to other infections.	
Dental issues	Resulting from a poorly balanced diet	Confirmed	Confirmed	Global	The high-energy content in a poorly balanced diet served in captivity or based on "crop raiding" in situ can lead to dental problems such as cavities, associated toothache and tooth loss.	Anthropogenic disturbances in ape habitat can lead to a decrease in food supply, forcing apes to "crop raid."
Drowning	Related to crossing drainage channels in search of food, clean water or other apes, including potential mates	Confirmed	Confirmed	Global	If the drowning is not fatal, the damage to the respiratory system can make an individual more susceptible to other respiratory infections.	Drainage channels are used in commercial plantations and may run through ape ranges. If they divide populations and cut them off from food, clean water and other apes of the same species, apes may be forced to cross channels, which can result in drowning, even though some apes can swim.
Electrocution	Due to contact with uninsulated electricity pylons or cables	Confirmed	Probable	Global	Can be fatal. Can result in burns, shock, damage to the heart, and falls that cause physical injury, all of which can be immediately fatal or can result in secondary infections, which can then be fatal.	Apes may use electricity pylons and cables to get around in the same way that they use trees, which can result in electrocutions if the pylons and cables are not insulated.
Heart (cardiovascular) disease (non-age-related)	Possibly related to poorly balanced diet and reduced activity levels	Probable	Confirmed	Global	Can be fatal. Fibrosing (replacement of heart muscle by fibrous tissue) or idiopathic cardiomyopathy (reduction in heart's ability to pump blood around the body due to abnormalities in the ventricular wall and/or cavity).	Heart disease is among the leading causes of death in captive great apes, yet the causes are not fully understood. In the long run, the disease could affect the genetic viability needed to sustain a healthy captive population.

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Health issue	Description	In situ	Ex situ	Location	Consequences	Notes
Malnutrition: obesity	Related to a poorly balanced diet	Confirmed	Confirmed (more probable in captivity)	Global	Overconsumption leading to obesity predisposes an individual to diseases such as diabetes and heart disease due to high blood pressure.	In zoos, obesity is the most common form of nutritional disorder in apes, due to a high intake of simple carbohydrates, combined with limited physical exercise. In the wild, anthropogenic disturbances can lead to a decrease in food supply, forcing apes to "crop raid" and thus rely on a poorly balanced diet.
Malnutrition: undernutrition	Related to a poorly balanced diet	Confirmed	Confirmed	Global	Can be fatal. Undernutrition leads to emaciation and starvation.	Applicable to apes stranded in very small forest fragments, or even individual trees, within a clear-felled area for plantation agriculture, as well as to captive apes suffering from neglect.
Physical injury: competition and territoriality	Due to intra- or intergroup aggression	Confirmed	Confirmed	Africa	Can lead to physical injuries and subsequent infections, which may be fatal.	Intragroup aggression can involve fighting to contest the position of alpha male or in response to attempts by underlings to procreate. In such cases, apes can be expulsed from a group and thus be left vulnerable, without support.
Physical injury: human–wildlife conflict	Related to confrontations between farm-owning humans and "crop-raiding" apes, or communities and apes	Confirmed	Unknown	Africa and Asia	Can lead to physical injuries, which may be fatal.	The likelihood of conflict between humans and apes is exacerbated by habitat destruction and degradation, which brings them into closer contact.
Physical injury and loss of limbs: hunting snares	Due to snares set by hunters	Confirmed	Unknown	Africa and Asia	Can be fatal. Can result in injury or loss of limbs.	Apes sometimes fall victim to snares that are set by hunters to legally catch other species.

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Health issue	Description	In situ	Ex situ	Location	Consequences	Notes
Physical injury and loss of limbs: road and rail accidents	Resulting from the need to cross roads or railway tracks to access food, water and other apes of the same species	Confirmed	Unknown	Africa and Asia	Often fatal. Can lead to physical injuries and loss of limbs.	Roads and railway tracks that run through habitat directly affect apes by dividing populations, cutting them off from food, water supplies and other apes of the same species, including potential mates, and forcing them to cross roads and tracks, which can result in traffic or train accidents.
Poisoning: agriculture	Related to pesticide use in agriculture	Confirmed	Unknown	Africa and Asia	Signs attributed to pesticides include facial dysplasia (abnormal growth) in chimpanzees in Uganda.	In Uganda, DDT/pp-DDE, chlorpyrifos and imidacloprid levels in maize have exceeded recommended limits (Krief *et al*., 2017).
Poisoning: mining	Related to mining and ore processing that poison soil and water	Confirmed	Unknown	Africa and Asia	Can be fatal. Poisoning can lead to neurological or renal malfunctions.	Mining and ore processing can poison soil and water supplies. Gold ore processing often involves the uncontrolled use of mercury, for example.
Smoke inhalation	Due to forest fires	Confirmed	Confirmed	Africa and Asia	Can be fatal. Smoke inhalation can impair the ability to breathe and make an individual more susceptible to other issues, such as respiratory infections.	Most fires in ape ranges are intentionally set by humans or due to human error (Kimbrough, 2020). Smoke can carry a very long way, impacting apes across wide geographies, both in situ and in captivity. An example is the smog in Singapore that resulted from fires in Indonesian Borneo.

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Veterinary contributors: Marc Ancrenaz, Luis Flores, Karen Payne, Karmele Llano Sánchez and Steve Unwin

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Annex III

Confirmed Transmissions of Viral Pathogens from Humans to Apes in Their Natural Habitats

Host genus	Host species	Virus family	Virus name	Location	Consequences of infection*	References
Pan	Bonobo (*Pan paniscus*)	*Pneumoviridae*	Human orthopneumovirus A and B	Malebo Community Reserve, DRC	Severe clinical signs; up to 40% morbidity; 8 fatalities recorded over 2 outbreaks; secondary bacterial infection with *Streptococcus pneumoniae*	Grützmacher *et al*. (2018b)
	Eastern chimpanzee (*Pan troglodytes schweinfurthii*)	*Paramyxoviridae*	Human respirovirus 3	Kibale National Park, Uganda	Severe clinical signs; 69% morbidity; 1 fatality attributed to weakness and conspecific aggression	Negrey *et al*. (2019)
		Picornaviridae	Human rhinovirus C	Kibale National Park, Uganda	Severe clinical signs; up to 71% morbidity; 5 fatalities over 3 epidemic phases	Scully *et al*. (2018)
		Pneumoviridae	Human metapneumovirus	Mahale Mountains National Park, Tanzania	Severe clinical signs; 34% morbidity; 3 fatalities	Kaur *et al*. (2008)
				Kibale National Park, Uganda	Severe clinical signs; 44% morbidity; 25 fatalities	Negrey *et al*. (2019)
	Western chimpanzee (*Pan t. verus*)	*Coronaviridae*	Human coronavirus OC43	Taï National Park, Ivory Coast	Mild clinical signs; 27% morbidity; 0 fatalities	Patrono *et al*. (2018)
		Pneumoviridae	Human metapneumovirus	Taï National Park, Ivory Coast	Severe clinical signs; up to 100% morbidity; 8 fatalities recorded over 2 outbreaks; secondary bacterial infection with *S. pneumoniae*	Köndgen *et al*. (2008)
			Human orthopneumovirus A and B	Taï National Park, Ivory Coast	Severe clinical signs; up to 100% morbidity; 9 fatalities recorded over 4 outbreaks (more suspected); secondary bacterial infection with *S. pneumoniae* (of human origin in one instance)	Köndgen *et al*. (2008, 2010, 2017)

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Host genus	Host species	Virus family	Virus name	Location	Consequences of infection*	References
Gorilla	Mountain gorilla (*Gorilla beringei beringei*)	*Pneumoviridae*	Human orthopneumovirus A	Volcanoes National Park, Rwanda	Severe clinical signs; up to 87% morbidity; 0 fatalities over 2 outbreaks	Mazet *et al*. (2020)
		Pneumoviridae	Human metapneumovirus	Volcanoes National Park, Rwanda	Severe clinical signs; 92% morbidity; 2 fatalities; secondary bacterial infection with *S. pneumoniae* and *Klebsiella pneumoniae*	Palacios *et al*. (2011)
	Western lowland gorilla (*Gorilla gorilla gorilla*)	*Pneumoviridae*	Human orthopneumovirus A	Dzanga Sangha Protected Areas, CAR	Severe clinical signs; 88% morbidity; 0 fatalities	Grützmacher *et al*. (2016)

Notes: Ex-situ examples are discussed in Chapter 1; for a more comprehensive list, see Miller and Fowler (2015).

* Severe clinical signs include frequent coughing, sneezing, shortness of breath, oculo-nasal discharge, lethargy and loss of appetite. Mild clinical signs include sporadic coughing and sneezing.

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Annex IV

Example of a PEESTOLM Risk Register for Zoonosis in Apes[2]

PEESTOLM covers political, environmental, economic, social, technical, operational, legal and media and communications-related risks.

Hazard: Zoonotic disease.

Context: Zoonosis is known or highly likely to cause mortality and significant disease in apes and humans. Historically, zoonotic diseases such as Ebola in gorillas have caused mortality and debilitating disease.

Objective: Conservation of apes and their habitat using PEESTOLM to assess the full range of zoonotic risks to apes.

Risk type	Risks related to zoonotic disease	Consequences
Political: Risks arising from each level of elected officials and chief executives of large corporations and agencies.	1. In response to zoonosis-related economic fallout, policy or legislative changes are introduced to sustain or enhance the economy, but these changes effectively reduce protective measures for apes or ape habitat.	▪ Ape health declines; apes die due to habitat loss or degradation; reduced availability of food and shelter ▪ Decline in ape numbers due to increased exposure to humans with zoonoses ▪ Increase in hunting and poaching of apes ▪ Greater competition for food and habitat between individual apes and between ape populations ▪ Increased potential for illegal resource extraction from ape habitat
	2. In response to zoonosis-related economic fallout, reduced funding results in cutbacks in resources, such as rangers to manage conservation areas.	
Environmental: Risks to the natural environment arising from zoonosis and from response measures that address the consequences of zoonosis.	1. A reduction in or loss of ape tourism revenue and a reduction in related conservation activities lead to environmental degradation of ape habitat.	▪ Conservation outcomes are set back years or declines are irreversible
	2. A reduction in or loss of ape tourism revenue and cuts in related conservation activities undermine local communities' environmental stewardship in protected areas.	▪ Increased degradation of habitat leads to decline of biodiversity, including apes ▪ Increased exposure of apes to infection ▪ Increase in hunting and poaching of apes ▪ Greater competition for food and habitat between individual apes and between ape populations ▪ Decline in ape numbers
Economic: Risks to the local, regional and national economies as a result of revenue shortfalls and zoonosis response costs.	1. A reduction in ape tourism results in a drop in economic benefits to local communities.	▪ Reduction in funds for ape conservation ▪ Local communities place less value on the apes and habitat ▪ Increase in mental health issues among people and communities that usually benefit from ape tourism ▪ Increase in poverty due to the absence of ape tourism ▪ Communities that usually support ape tourism are fragmented or move away ▪ Reduction in protections for apes and their habitat (see the consequences of environmental risk 2, above)
	2. The full recovery of ape tourism takes an extended period of time.	
	3. A drop in overall funding outside the local communities—such as discretionary spending and donations for ape conservation—leads to a significant decline in ape habitat.	▪ Ape conservation programs are set back or curtailed ▪ Ape populations decline ▪ Loss of expertise for ape conservation

2 Created by Kevin Cooper.

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Risk type	Risks related to zoonotic disease	Consequences
Social: Risks arising from impacts on health, safety, wellbeing and social fabric of local and regional ape and human populations.	1. The prevalence of mental health and wellbeing issues increases among people who usually benefit from ape tourism or have a connection to apes.	▪ Reduction in care and responsibility for apes and their habitat
	2. Local communities move into or return to ape habitats to secure food and shelter materials or to sustain their livelihoods.	▪ Apes and humans compete for resources such as food and shelter materials ▪ Increase in hunting and poaching ▪ Dislocation of local ape populations ▪ Apes exposed to humans and infected
Technical: Risks linked directly to zoonosis, and the risk arising from the control and containment measures used to manage the zoonosis.	1. Local communities that support ape preservation or ape habitat are not protected from zoonotic infection.	▪ Local community is infected with zoonosis ▪ Increases the likelihood that local apes will be infected
	2. Apes are infected with zoonosis and mortality is significant.	▪ Ape population declines to the point at which natural population recovery is impossible ▪ Ape absence has a ripple effect on biodiversity in the habitat
	3. Potential control measures for zoonosis-infected apes are limited.	▪ Ape population declines to the point at which natural population recovery is impossible ▪ Apes lost from local, regional and national habitat: extinction
	4. Zoonosis in apes is poorly understood or unknown.	▪ Likelihood and consequences of zoonosis in apes increase
Operational: Risks around the timeliness and adequacy of resource capability and capacity; health, wellbeing and safety; and structures and management systems of the response.	1. Infection or a high potential for infection of compliance personnel such as rangers causes absences.	▪ Reduction of protections for apes ▪ Increased poaching and hunting results in a decline in ape numbers ▪ Increased potential for exposure of apes to zoonosis from people due to human encroachment into ape habitat ▪ Increased potential for illegal resource extraction from ape habitat
	2. Infection or a high potential of infection among veterinarians and animal keepers causes absences.	▪ Apes exposed to increased likelihood of infection ▪ Direct spread of infection in apes results in decline in ape numbers
	3. Isolation (self- or imposed) of veterinarians and animal keepers reduces the ability to undertake surveillance and monitoring of apes.	▪ Reduced capacity for early detection of disease in individual apes and timely implementation of mitigation treatment measures for apes ▪ Ape infections lead to mortality and decline in ape populations
	4. Inadequate supplies or a lack of personal protective equipment and related stores for veterinarians and animal keepers limits their ability to manage health and safety risks and biosecurity risks when working with apes.	▪ Increased exposure of veterinarians and animal keepers to zoonosis results in the same consequences as operational risk 3 (above) ▪ Increased possibility of exposure of apes to zoonosis and infected apes ▪ Increased possibility of spreading zoonosis between and within ape populations
	5. Management absences (due to reduced funding, and actual and potential infection) lead to a reduction in the management of ape populations, including normal animal health management, disaster preparedness and population management.	▪ Increased exposure of apes and ape habitat to pressure (such as fires and human–wildlife conflict) that would usually be controlled through everyday management ▪ Decline in ape habitat and ape numbers

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Risk type	Risks related to zoonotic disease	Consequences
Legal: Risks relating to the legal authority to complete the mitigation activities and to the alignment of legal obligations.	1. Mitigation activities do not comply with legislative requirements or the equivalent for the conservation of apes and ape habitat.	▪ Decline in ape numbers and their habitat translates into decline in overall biodiversity ▪ Ape population unable to recover naturally
Media and communications: Risks that arise from the need to provide stakeholders with timely and accurate information.	1. The local human population does not support the management or control measures because they do not receive timely and appropriate information.	▪ Increased likelihood of the local community becoming infected with zoonosis ▪ The management or control measures fail in the absence of local community support ▪ Increased likelihood of apes being infected with zoonosis ▪ Failure of community support leads to inaction on conservation measures and an increased likelihood of degradation of ape habitat, which can lead to a reduction in ape numbers

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Annex V

Reputational Risk Assessment for Animal Sanctuaries and Crisis Communications: A Planning Workbook

Emergency Preparedness and Response Questionnaire

Question	Yes (check)	No*
Do you have an emergency response plan that has been updated in the past three years?		
Does your emergency response plan include a crisis communications plan for internal and external audiences?		
Do you, at least twice per year, conduct emergency response drills that cover a range of potential emergency response scenarios?		
Are staff members routinely cross-trained to work in multiple areas to ensure all animals receive appropriate care and management in an emergency?		
Are apes routinely desensitized to crates or trained to shift in and out of enclosures when asked, so that they can be moved with minimal stress?		
Do you have an adequate number of transfer crates or temporary housing options for all sanctuary residents?		
Do you have secure shelter for all apes, including access to supplemental off-grid heating or cooling and water options, if needed?		
Do you have an established evacuation site and coordinated transportation options for moving apes if needed?		
Do you have provisions available for staff members if they must stay overnight? Do you have round-the-clock veterinary care available during an emergency?		
Have you developed a trusted working relationship with local fire and police agencies to ensure effective collaboration in the event of an emergency at the sanctuary?		
Do you have access to reliable legal counsel?		
Are managers trained to handle emotional situations with their teams?		
Can the sanctuary easily access counseling resources if needed?		
Score*		

Notes: * Guide for "No" column: low risk=0–3; medium risk=4–7; high risk=8 or more.

Source: PCI (2022, p. 10)

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Annex VI

Risk Assessment and the Disaster Management Continuum in Relation to Case Study 6.1

Case Study 6.1 outlines reactive response and recovery actions aimed at overcoming the 2020 flood crisis that affected the apes and staff of the Ngamba Island Chimpanzee Sanctuary in Uganda. Risk reduction through prevention and preparedness is essential in the face of potential hazards, such as the one described in the case study. Typically, however, response measures and, subsequently, recovery measures are given priority over prevention and preparedness.

The following risk assessment is based on the risks described in Case Study 6.1. The disaster management continuum presented thereafter may help to mitigate these—as well as other—risks.

a. Risk Assessment

Table A6.1 ranks and describes the risks identified in Case Study 6.1. This type of risk assessment is best informed by ongoing risk mapping, informed by such tools as modeling, as well as regular reviews including consideration of projected climate change-induced extreme weather events.

TABLE A6.1

Risk Assessment on the Basis of Case Study 6.1*

Risk	Likelihood (LH)	Consequence/ Impact (CS)	Risk Rating (RR)	Description
Flooding	High	Medium–high	Medium–high	Ngamba Island has a history of flooding, with the 2020 event characterized by the highest water levels on record. Extreme weather events, including increased rainfall linked to climate change, result in higher water levels and ongoing flooding events, which are expected to last longer as the planet warms. Potential consequences beyond those described in the case study include an inability to evacuate animals or people, as the external support may not be available due to widespread local and regional flooding, an inability to obtain adequate provisions, more permanent damage to infrastructure, and more sustained and prolonged submersion of habitat. In turn, inundated habitat may exacerbate the deterioration or loss of natural food sources for the animals. Anticipated major floods present an increased threat to the chimpanzees and the staff.
Significant disease among the chimpanzees and humans	Low	Medium	Medium	Significant disease was not reported in the case study. The likelihood of disease affecting the chimpanzees and staff is currently low, but emerging diseases and longer-term flooding may increase disease risk. Based on other situations in similar settings, the consequences, once a significant disease is present, are at least medium.

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Risk	Likelihood (LH)	Consequence/ Impact (CS)	Risk Rating (RR)	Description
Inadequate food and poor conditions for the chimpanzees and humans	Low	Low	Low	This risk reflects an inability to secure the delivery of food and other provisions to the island at times of crisis, as well as flood-related damage to infrastructure housing chimpanzees and staff. Future extreme weather events may affect the availability of transport to and from the island and thus the delivery of supplies and opportunities for evacuation. Extreme weather may also result in more substantial damage to infrastructure.
Inadequate care for the chimpanzees	Low	Low–medium	Low–medium	Under what were previously considered normal conditions, this risk was not reported, yet future extreme weather events that are landscape-wide may reduce the staff's ability to care for the chimpanzees.
Injury to staff or chimpanzees during tasks associated with rescuing or evacuating chimpanzees	Low	Low–medium	Low–medium	Increases in the frequency and duration of flooding have the potential to increase the risk of injuries sustained during rescue operations and evacuations.

* This risk assessment is based on the information presented in the case study and should therefore not be taken as a full risk assessment because a more in-depth review would likely identify other risks. The authors aimed to build the information included here around the "experiences" in the case study rather than attempting to be comprehensive. Risk assessment steps consider LH independent of CS and then CS independent of LH. The RR = LH × CS. The final RR typically reflects the higher value for either LH or CS (always go up with RR). Treatments aim to reduce LH or CS—most commonly reducing LH in the first instance. However, where the LH of the risk materializing is reduced, if it still occurs the CS will remain the same unless some treatment is also aimed at reducing them.

b. Disaster Management Continuum

The disaster management continuum can be employed to address the abovementioned risks. Some of the following risk mitigation measures can also reduce risks associated with other hazard impacts, such as fire. Prevention and preparedness offer the greatest opportunities to mitigate the risks.

Prevention

Elimination is the preferred option for risk mitigation as it covers both likelihood and consequences. In Case Study 6.1, the relocation and re-establishment of island infrastructure at an elevation above the predicted worst-case-scenario water levels eliminate flood risks for infrastructure. This long-term objective removes the need for future response and recovery resources and actions linked to flooding of the infrastructure.

After elimination, substitution is the next best risk mitigation. It primarily reduces the likelihood of risks, although it can also minimize consequences. The substitution of the existing fixed-level pier with a floating pier that rises and falls with water levels ensures that boats can dock to deliver supplies or evacuate residents. Resupply by air, such as by helicopter, is also an example of substitution.

If neither elimination nor substitution can be applied to reduce risk, the next best option is isolation, such as via a barrier. On Ngamba Island, an example of isolation is the retainer wall between the water and the infrastructure, which reduces erosion caused by breaking waves. This approach can involve modifying the existing wall or constructing a new purpose-built wall (a levee) to hold the lake water back. Any new wall would be farther up the shoreline, closer to the infrastructure. The case study mentions temporary measures such as the use of sandbags and rocks to reduce the area of inundation; more permanent structures would be required for an isolation approach.

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Given that future extreme weather events are likely to further increase and intensify flooding, new walls and levees will not be fit for purpose unless they exceed the height of historical flood levels.

Engineering risk mitigation measures constitute a fourth option. They operate automatically to address an impending risk. On Ngamba Island, such a measure might involve installing an automatic pump-out system to remove water from designated areas that are at risk of being inundated. Pumps can work with a retaining wall around high-value infrastructure. In some areas, automated sanitary treatment is an engineering control that—when used every day as well as during floods—reduces the disease risks associated with waste.

Safe places can be identified and prepared in advance of any flooding. On Ngamba Island, designated safe places would need to be clearly identified, known to all those on the island, readily accessible and designed to accommodate all staff and visitors—and potentially the chimpanzees. One or more safe places may be needed.

In the absence of a safe place, a "lifeboat" can provide support if flood waters are life-threatening. The boat could also be used for other purposes, as long as it is well maintained and ready for use during flooding, with trained personnel to crew it.

Preparedness

Capacity and Capability

Case Study 6.1 alludes to the need to train staff to ensure the safe rescue of chimpanzees and the safety of personnel. Suitable resources and upkeep are similarly required for higher-risk tasks. Sanctuary staff and regular visitors who are suitably trained are able to minimize the risks associated with rescues and other high-risk activities.

The stockpiling of provisions—including reserves or supplies for use during an emergency—reduces risks that can arise from an inability to get timely deliveries to the sanctuary. Having arrangements in place for alternative delivery methods, such as by air, if needed, can help to ensure the delivery of provisions if the usual arrangements fail.

Documentation

The case study mentions an evacuation plan. Triggers for activation of the plan are essential, such as the prediction of an extreme weather event, to ensure all stakeholders know when and why the plan will be activated. Triggers ensure activation of the plan before and in response to a hazard impact. The timing of the activation trigger must ensure there is adequate time between the activation and the predicted weather event to complete a full evacuation.

With respect to high-consequence mitigation, which may be applied in life-threatening situations, it is good practice to identify more than one possible response measure. The evacuation plan can suggest alternative evacuation pathways, for instance.

Effective contingency plans are developed in consultation with all stakeholders, including local communities; once validated by exercise and finalized for use, their currency can be maintained by review at specified intervals or following actual events or exercises. The responsibility for a contingency plan is best assigned to a person who has the authority to ensure its ongoing relevance and currency.

Documentation of procedures and policies for high-risk tasks associated with the Ngamba Island chimpanzees—especially during flooding, but also for less frequent routine tasks—is best developed in consultation with the individuals who are to implement the procedures and policies. The clarification of procedures in different formats, such as pictures or cartoons, can enhance the effectiveness of training and exercises. This documentation becomes the basis for continuous improvement, training and the sharing of knowledge (one generation to next) – a "how to." Users will seldom refer to the documentation during an event – it is all about preparedness.

A condition of entry for all those who come to the island is an induction, which should include the procedures to be followed in case of an imminent or actual emergency situation, health and safety requirements and logging the relevant emergency/crisis skills and abilities of those arriving on the island.

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Management Systems

An automated warning system can be installed to support early intervention actions in the case of flooding. Such a system detects the rising water levels and automatically issues an alarm. Cameras may be part of the system.

A resource management system is essential for the tracking of resources including personnel, stores and equipment before and during a flood. This system supports the maintenance of the stockpile of provisions for use during flooding when the usual deliveries may not be possible. It should be integrated with the standard resource management system used every day at the sanctuary.

Exercises and Drills

Regular exercises and drills are routine for staff and anyone who is part of any plan or procedure for the sanctuary. The evacuation plan, for example, is only effective if it is routinely and regularly practiced. High-risk procedures can be exercised to inform review at specified intervals, to ensure their ongoing relevance and the ability of staff to complete the procedures.

There may be some merit in exercising the animals as part of the preparedness for actions to be undertaken during a flood. High-risk tasks are likely to challenge most animals and their staff if they are carried out for the first time during a flood emergency. Exercising is an opportunity to explore all options, learn the lessons and provide opportunities for animals and their carers to become familiar and comfortable with actions in a controlled environment compared with the challenges of undertaking these actions for the first time in a response context.

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Annex VII

Expected Prevalence of Industrial Development Projects for the Period 2020–2025 and Corresponding Risks to Apes

Ape taxon	Industry sector				
	Agribusiness	Hydroelectric dams	Infrastructure	Logging	Mining
Bonobo	**++** Of all of great ape ranges, the bonobo range has the highest overlap with land suitable for oil palm development (99.2%), suggesting that such development could become prevalent in the future (Wich *et al.*, 2014a).	**Not available** No known project is active or planned within the bonobo range.	**++** As most of the bonobo range is fairly remote, any improvement of roads or the creation of new access roads associated with logging, agribusiness or other projects poses a threat to bonobos, mainly by facilitating access for poaching (Arcus Foundation, 2018).	**+** About 10% of forests in the Democratic Republic of Congo (DRC) are under logging concessions, but a moratorium on the attribution of any new industrial logging titles has been in place since 2002, theoretically limiting this threat. Despite the moratorium, however, the government granted two new logging concessions to Chinese companies in 2018—in areas that overlap with bonobo habitat (Belmaker, 2018).	**+** Commercial mining is not currently a prominent threat, but since the bonobo range is rich in mineral reserves, the situation could change. Any construction of infrastructure to facilitate the export of such commodities would pose a risk to bonobo populations (Arcus Foundation, 2014).
Chimpanzee	**++** Countries in the chimpanzee range are suitable for the cultivation of industrial-scale crops, such as coffee, cocoa, rubber and oil palm (Wich *et al.*, 2014a). Most of this development is concentrated in West African countries, where the expansion of oil palm and cocoa plantations has already had severe impacts on chimpanzees (Bitty *et al.*, 2015).	**+++** Many dams are planned throughout the chimpanzee range. Some of them may have significant impacts on chimpanzee populations. One example is the Koukoutamba dam in Guinea, which could lead to the deaths of up to 1,500 western chimpanzees (*Pan troglodytes verus*) (Watts, 2019).	**+++** "Development corridors" are planned across Africa and the chimpanzee range, mainly in the form of new roads and highways (Laurance *et al.*, 2015). The construction of other linear infrastructure, such as power lines, also occurs alongside dams and other development projects.	**++** Threats from logging are most prevalent in Central Africa, where 47% of the central chimpanzee (*Pan troglodytes troglodytes*) range falls within timber concessions (Arcus Foundation, 2014).	**++** The mining threat is most significant for the western chimpanzee, whose range overlaps with high-grade mineral deposits (such as gold, bauxite and iron ore) and many active and planned mines (Arcus Foundation, 2014).

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Ape taxon	Industry sector				
	Agribusiness	Hydroelectric dams	Infrastructure	Logging	Mining
Gibbon	++ Agricultural concessions overlap with most gibbon ranges. They pose particularly significant threats to species found in Indonesia and Cambodia (Arcus Foundation, 2014).	+++ Fifty-five hydroelectric dams have been installed in gibbon ranges. A further 165 dams are either planned or under construction (Arcus Foundation, 2018).	++ Two of the six planned corridors under the Belt and Road Initiative are to cut large swaths through gibbon habitat: the Bangladesh–China–India–Myanmar corridor and the China–Indochina corridor (Hughes, 2019). The relocation of the Indonesian capital within gibbon habitat may also pose direct and indirect threats to several species (Teo *et al.*, 2020).	++ Exact data surrounding the size and location of timber concessions, and their overlap with gibbon ranges, is scarce.	++ Only two species of gibbon have no industrial mining projects within their range: the Hainan gibbon (*Nomascus hainanus*) and the Cao Vit gibbon (*Nomascus nasutus*) (Arcus Foundation, 2014).
Gorilla	++ Many commercial crops threaten gorilla habitat. Oil palm production in Africa is expected to intensify and could become an increasing threat, mainly for the western lowland gorilla (*Gorilla gorilla gorilla*) (Wich *et al.*, 2014a).	++ Several dams have already impacted gorillas throughout their range, including in Cameroon. Many more dams are planned, increasing the risks to the gorilla population (Arcus Foundation, 2018).	+++ The development of roads, railways and power lines is expected to fragment gorilla habitat, while also facilitating access for hunters and farmers to some of the more remote areas of their range (Arcus Foundation, 2018).	++ A large number of timber concessions are within the range of the western lowland gorilla (Morgan and Sanz, 2007).	++ Since mineral deposit extraction is not as formalized in East and Central Africa as it is in West Africa, range overlap with commercial mining activities is limited. In the eastern DRC and other areas where such activities do occur, they tend to be poorly regulated. The impacts from artisanal mining are more significant for this genus (Arcus Foundation, 2014).
Orangutan	+++ Industrial agriculture (mainly oil palm and paper pulp) overlaps with a large part of the orangutan range (Arcus Foundation, 2015).	++ Many dams are already operational in orangutan habitat. Significant impacts may result from several others that are being planned, including the well-publicized Batang Toru hydropower project in the range of the Tapanuli orangutan (*Pongo tapanuliensis*) (Wich *et al.*, 2019).	++ Several linear infrastructure development projects are planned in orangutan habitat. Among them is the Trans-Sumatra Highway, which is to pass through the north-eastern area of the Leuser ecosystem (Sloan *et al.*, 2019).	++ Logging concessions overlap with 29% of the range of the Bornean orangutan (*Pongo pygmaeus* spp.) and 4% of the range of the Sumatran orangutan (*Pongo abelii*) (Wich *et al.*, 2012b).	++ Mining activity overlaps with 9% of the range of the Sumatran orangutan (Meijaard, 2014). Only one project—the Martabe gold mine—is present in the Tapanuli orangutan range. Its expansion could have a significant impact on the species (Wich *et al.*, 2019).

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Notes: Agribusiness includes large-scale oil palm, cocoa and rubber plantations; infrastructure includes roads, railways and ports. Prevalence and associated risks are scored[3] as follows:

+++ **High prevalence/risk:** could lead to a significant decrease in ape populations that is difficult to mitigate.

++ **Intermediate prevalence/risk:** could lead to a decrease in ape populations.

\+ **Low prevalence/risk:** could lead to a decrease in ape populations, some of which can be mitigated.

3 The scoring system is based on a Google search using a combination of keywords to assess the approximate number of each type of project within each taxon's range.

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Annex VIII

Application of the Mitigation Hierarchy in Practice: The Mako Gold Project in Senegal[4]

The Mako Gold Project in southeastern Senegal is owned and operated by the Petowal Mining Company, a subsidiary of Resolute Mining Ltd, in which the Government of Senegal has a 10% interest (Figure A1). The western chimpanzee (*Pan troglodytes verus*) is among the priority species in the project area. To accomplish its corporate goal of achieving a "net gain" for chimpanzees, the project implemented the mitigation hierarchy. In particular, it used the following measures to avoid and minimize impacts related to the construction of the mine and associated infrastructure, rehabilitate or restore damaged habitat, and offset residual impacts (Earth Systems, 2015).

FIGURE A1

Mako Gold Project, Senegal



Sources: Protected area—UNEP-WCMC (2021d); country boundaries—GADM (n.d.); other base map detail—OpenStreetMap (n.d., © OpenStreetMap contributors, published under Creative Commons Attribution License CC BY; for more information see http://creativecommons.org)

Avoidance

To **reduce the size of the mine footprint**, the Mako Gold Project made significant changes to the mine design and layout in the feasibility study. The changes resulted in the consolidation and containment of all major mine infrastructure—the open pit, waste rock, tailings and the processing plant—within one catchment area measuring about 3 km² (300 ha), or about half the size of the original design footprint. As a result, the project avoided some

4 Annex VII is written by Vanessa Evans, general manager of environment and community at Resolute Mining Limited, based on her experience leading and implementing biodiversity aspects of the Mako Gold Project.

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direct loss of chimpanzee habitat and prevented land disturbance within adjacent catchments that drain into core nesting habitat.

The project **re-routed the main access road** to the mine as it would otherwise have impacted chimpanzees by fragmenting their habitat and impeding access to an important dry-season water source, a gallery forest and foraging habitat at the eastern extent of their range. Re-routing involved co-aligning the road with existing local community infrastructure to avoid these impacts to chimpanzees.

Minimization

The Mako Gold Project minimized disturbance to chimpanzees from **noise, vibration and air blasts** by restricting the use of particular machinery and vehicles at dusk, dawn and during the night. Wherever possible, staff retained natural barriers—such as stands of tree and mounds—during land clearing to buffer noise and vibration, especially near sensitive chimpanzee habitats.

The project also introduced reduced **speed limits** for its vehicles and developed an **injured wildlife protocol** to be followed in the event of an incident. The protocol included a mandatory reporting system to prompt further actions or mitigation measures, if required.

Project staff and contractors were **banned from hunting, buying and trading** chimpanzees, and **environmental education** and awareness programs were conducted for project staff and contractors.

Rehabilitation/restoration

To mitigate impacts on chimpanzees and other fauna during its decommissioning and closure, the project intends to implement rehabilitation measures. The aim is for rehabilitation and closure to reestablish an ecosystem that functions much like it did before mining-related disturbance. Wherever feasible, revegetation efforts are to include the establishment of self-sustaining tree savannah, wooded savannah or shrub savannah vegetative communities to promote connectivity between areas of natural habitat, benefiting foraging, nesting and commuting chimpanzees and other wildlife. The rehabilitation is to be "like for like" to minimize the loss of high-value habitat from the project footprint, and revegetation is to utilize native species of local provenance. Species selection is to include vegetation known to provide nesting or foraging value for chimpanzees, and riparian corridors are to be planted to provide cover for migration, to the extent feasible. The project does not expect to achieve like-for-like habitat restoration in the medium term, however.

Offsetting

To mitigate the residual impacts of the Mako mine on biodiversity, Resolute Mining is implementing the Petowal Biodiversity Offset Program (PBOP). The PBOP encompasses areas within and adjacent to Niokolo-Koba National Park, with the goal of achieving a net gain in biodiversity, including species protection and improved habitat connectivity. The PBOP is being implemented through an innovative partnership that comprises protected area authorities, communities and non-governmental organizations, based on integrated and participatory approaches to land use planning. The design and implementation of the PBOP is guided by an independent advisory panel comprising national and international conservation and resource management experts (Resolute, 2019).

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Annex IX

Positive Developments in Wildlife Welfare Legislation

This annex discusses recent developments in Malawi and Costa Rica, both of which recently passed legislation and regulations designed to meet and surpass best practice standards for captive wildlife welfare.

Malawi

Under the revised version of Malawi's National Parks and Wildlife Act 2017, it is an offense to cause unnecessary or undue suffering to any wild animal, whether that animal lives in the wild or is kept in captivity (Ministry of Natural Resources Energy and Mining, 2017, s. 83). The Wild Animal Captivity Licensing Regulations that bring the legislation into effect are two-fold. First, wild animals may not be kept in captivity without a license. The license application process involves an inspection and regular spot checks are to be conducted once a license has been granted. Second, new captive care standards define the requirements and conditions for obtaining an animal captivity license and for the keeping of captive wildlife. The standards classify species according to their requirements and whether they are suited to being kept in captivity. They cover enclosure, health and safety, husbandry, management, and nutritional and veterinary requirements. Minimum care standards are provided for each taxonomic family of mammal species, as well as for individual species with specific requirements. The standards can also be used in assessing potential offenses associated with unnecessary or undue suffering (Lempena and Sal, 2018).

The Wild Animal Captivity Licensing Regulations target individual persons, small non-commercial operations and facilities that could potentially operate as sanctuaries. Commercial breeding facilities are to be covered under ranching guidelines, which remain to be developed (J. Vaughan, personal communication, 2020).

The Lilongwe Wildlife Trust (LWT) established an enforcement unit to support the government with implementation of the revised legislation and regulations. The regulatory system issues warnings to first-time offenders, most of whom do not reoffend; those who go on to commit a crime may be charged. Since the Wild Animal Captivity Licensing Regulations were passed in 2018, six inspections have been conducted and only two licenses have been granted. Two cases of wildlife trafficking, involving a baboon and pangolin, have gone to court on charges of welfare crime (J. Vaughan, personal communication, 2020).

LWT worked closely with the government to support the amendment of the law and the development of the regulations to strengthen conservation and curb wildlife trafficking. The issue of welfare crime had not featured prominently in LWT's campaigning as it was not expected to resonate with policy-makers. While welfare offenses are still treated as lesser crimes in Malawi, more focused lobbying for the inclusion of welfare crime may be able to attract media attention and raise public awareness of the issue (J. Vaughan, personal communication, 2020).

Costa Rica

Driven by mass tourism, about 250 captive wildlife facilities (known as wildlife management sites) operate across Costa Rica (S. Ramirez, personal communication, 2020). In 2017, the country was ranked as the seventh worst country for selfies with wild animals. Efforts by the government and non-governmental organizations are underway to stop direct and inappropriate contact between visitors and wildlife, including through the #StopAnimalSelfies campaign launched in 2019 (Stop Animal Selfies, n.d.; WAP, 2017; 2019; C. Dent, personal communication, 2020).

Animal welfare laws in Costa Rica only cover companion and farm animals, yet the updated Wildlife Conservation Law No. 7317 helps to bridge the legislative gap for captive wildlife (MINAE, 2017b; Silva, 2018). In view of the large number of wildlife management sites, the initial challenge faced by the authorities was to categorize them according to purpose and develop associated requirements and standards (G. Delgadillo, personal communication, 2020). The regulations that accompany the law separate the facilities into four categories: rescue centers, which

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focus on rehabilitation and release; zoos—both commercial, which can take in animals from other countries, and non-commercial, which can serve as a sanctuaries; breeding programs—be they commercial, conservation-driven, or consumption- or subsistence-based; and aquariums. The regulations outline requirements for each set of facilities (MINAE, 2017a).

If a facility operates both as a rescue and rehabilitation center and as a sanctuary, it must have two separate permits and fulfil distinct requirements (G. Delgadillo, personal communication, 2020). This double requirement reflects an understanding that the rehabilitation of animals for release is fundamentally different from lifetime care. Among the regulations designed to safeguard the rehabilitation process is a ban on public visits to rescue centers that are focused on the rehabilitation and release of wildlife. All wildlife management sites must develop a management plan that includes animal care and operational considerations, such as animal diet and health, contingency plans for emergencies, contraception, enclosure design and size, an organizational chart, species carrying capacity, staff training and a contingency plan in case of facility closure. Regardless of registration status, a facility must also have a conservation focus and an education program for species conservation (MINAE, 2017a). At this writing, 30 facilities had been closed down due to poor welfare standards (S. Ramirez, personal communication, 2020).

While all wildlife management facilities require permits to operate legally, rescue centers that wish to be officially recognized by the government as priority sites that receive confiscated wildlife must be accredited by the Global Federation of Animal Sanctuaries. The special status and external validation enable facilities to play a greater conservation role in rehabilitating native wildlife and potentially allow them to attract funding. Humane Society International is collaborating with GFAS to enable effective execution of the accreditation process; together with the government, it is also developing a range of accompanying protocols on animal intake, biosecurity (animal and human), emergency and evacuation, euthanasia, quarantine, rehabilitation and release (G. Delgadillo, personal communication, 2020).

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Annex X

Understanding Barriers to and Opportunities for Good Captive Ape Welfare

Level	Issue	Barriers	Opportunities and action
Legislation and supporting regulations, articles (national, regional)	■ Inadequate legal mechanisms due to omission of captive wildlife welfare in animal welfare legislation (covering domestic and farm animals only) or conservation legislation (covering wild animals in the wild or in trade).	■ Animal welfare is not seen as a priority; lack of political will. ■ Funding bias towards wildlife conservation.	■ Raise awareness of the links between animal, human and environmental health and wellbeing (One Welfare–One Health). ■ Adopt appropriate language that reflects current knowledge on animal sentience among conservation, environmental, human and animal health, sustainable development and trade bodies. ■ Acknowledge the role of confiscation and captive facilities in the law enforcement chain; add associated activities to conservation or illegal wildlife trade grant budget lines. ■ Include welfare components in lobbying campaigns when seeking to amend legislation to ensure welfare is included. ■ Undertake gap analysis of policy, legislation, regulations, and control and enforcement capacity underpinning captive wildlife welfare and management options.
	■ Limited understanding of legislation and the role of different agencies. ■ Excessively demanding regulations (including the detention of animals in short-term stay transit centers as evidence for court cases).	■ Animal welfare is not seen as a priority; lack of political will. ■ Poor understanding of how welfare is negatively impacted by excessive regulations. ■ Lack of resources (human and financial).	■ Communicate clearly and appropriately with stakeholders (from the government to the public) about legislation and the role of different agencies. ■ Raise awareness of any negative welfare impacts of regulations. ■ Add to appropriate curriculums for sustainability of learning outcomes.
	■ Lack of formally articulated CITES National Action Plans (NAPs) for the seizure and management of live animals.		■ For CITES parties: develop NAPs, including clear messaging on the importance of welfare to conservation. ■ Ensure the NAP is developed in a way that supports national ownership to aid implementation and that is appropriate for the context. ■ Connect the relevant agency to collaborating experts.
	■ Lack of resources among national enforcement agencies for effective seizure and management of live animals, and for oversight of wildlife in captivity generally.		■ Conduct a needs assessment; an articulation of resources (financial, human, infrastructure) is required to implement the NAP and to provide oversight of relevant legislation and regulations. ■ Develop appropriate management protocols, guidelines, standards and a welfare assessment system with species-specific requirements. ▶

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Level	Issue	Barriers	Opportunities and action
			▪ Create a learning environment in which approaches and standards are reviewed and updated in line with emerging research and practice. ▪ Provide training on animal handling and care during seizures for government personnel, as appropriate. ▪ Facilitate animal transfer by using clemency periods during which owners can surrender animals without penalty to minimize the animals killed or hidden. ▪ Minimize mass confiscations by using a clause for owners to keep animals (uniquely identified) who are already in their possession for a fixed time period. ▪ Strengthen capacity for agency and partner staff: embed knowledge and skills required into existing professional training programs for the broad range of agencies involved (including the police, customs, rangers and the judiciary) and into other relevant government, academic and professional training or courses on sustainability. Include a blended approach to embedding capacity—such as through training, secondment and mentoring—and evaluate impact. ▪ Collaborate with relevant experts and partner organizations. ▪ Lobby for inclusion of resources into national budgets.
	▪ Inadequate deterrents to conservation and welfare crimes.	▪ Wildlife conservation and animal welfare are not seen as a priority. ▪ Provision of inadequate welfare services not seen as a crime. ▪ Lack of resources (human, financial) and technical expertise. ▪ Substandard investigations into criminal activity. ▪ Corruption.	▪ Include dialogue on the full range of costs (environmental, social, conservation and animal welfare), action and resources required in high-level intergovernmental forums on combatting the illegal wildlife trade. ▪ Support the development of a legal system that allows for criminal actors to bear the financial costs for the seizure and management of live animals. ▪ Capture and communicate the full cost of seizure and management options for each animal (in terms of financial, human and infrastructure costs). ▪ Strengthen capacity (in operational procedures, skills and competencies, and financial resources) to conduct investigations. ▪ Develop appropriate guidelines, standards, indicators and a welfare assessment system with species-specific requirements to facilitate identification of a welfare crime.

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Level	Issue	Barriers	Opportunities and action
Professional accreditation systems (international, regional)	▪ Limited understanding of what is required to create and manage an active governance structure and organization.	▪ Lack of resources (human, financial). ▪ Competing and conflicting interests. ▪ Unfavorable cultural context. ▪ Fear of losing face and control. ▪ Difficulty in finding board members and keeping them active and engaged.	▪ Seek expert input into good and appropriate governance systems; include a focus on how to engage and manage a board, working groups or steering committees. ▪ Ensure governance structure members are independent and without competing interests. ▪ Reach out and collaborate with other accreditation systems elsewhere to learn what works and why; adapt practice to the context.
	▪ Inadequate systems and standards supporting the accrediting system.	▪ Lack of resources (human, financial). ▪ Lack of technical expertise. ▪ Animal welfare not seen as a priority. ▪ Need to accommodate the diversity of constituents.	▪ Reach out and collaborate with other accreditation systems to learn what works and why; adapt best practice to the context. ▪ Establish technical committees or working groups. ▪ For zoo systems: explicitly acknowledge that any role in conservation is underpinned by good animal welfare. ▪ Develop appropriate guidelines, standards, indicators and a welfare assessment system with species-specific requirements to ensure the overall system is outcomes-based and permits adaptation to the context. ▪ Develop specific guidance, standards and indicators for rehabilitation and post-release support and monitoring. ▪ Create a learning environment in which approaches and standards are reviewed and updated in line with emerging research and practice.
	▪ Inadequate capacity to support and enforce the system and standards.	▪ Lack of resources (human, financial). ▪ Fear of reprisal.	▪ Develop detailed guidelines and standards with accompanying programs to strengthen capacity (blended approach) to ensure the system is transparent and consistently applied. ▪ Take a phased approach to implementation. ▪ Partner with relevant organizations.
	▪ Poor uptake by the community (captive facilities).	▪ Inappropriate system. ▪ Value not seen by the community. ▪ Community unwilling to feel judged or afraid to fail. ▪ Lack of resources (human and financial) to go through the process.	▪ Demonstrate the value of accreditation. ▪ Ensure the system is supportive and appropriate for the context; have regional representation if the overarching body is based outside the region. ▪ Solicit input into standard development from targeted practitioners to facilitate buy-in. ▪ Create a system of peer-to-peer learning and co-support.
	▪ Lack of awareness among relevant partner organizations (such as tourism providers).	▪ Lack of understanding and trust in the system of accreditation. ▪ Lack of resources (human, financial).	▪ Demonstrate the value of accreditation. ▪ Ensure the system is appropriate for the context. ▪ Solicit input into the development of the standards and accreditation process from targeted partners to facilitate buy-in. ▪ Ensure targeted and transparent communication on the system and results.

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Level	Issue	Barriers	Opportunities and action
Individual facility (governmental and non-governmental)	▪ Need for better understanding of what is required to create and maintain an active, strong governance structure, management team and effective and workable policies.	▪ Lack of resources (human, financial). ▪ Competing and conflicting interests. ▪ Fear of losing control. ▪ Unfavorable cultural context. ▪ Difficulty in finding board members and keeping them active and engaged.	▪ Seek expert input into developing and maintaining an effective and appropriate governance system. Reach out to other facilities and accreditation systems to learn what works and why; adapt practice to the context. ▪ Ensure that the difference between governance and management is understood; transition to a system in which the director is a non-voting member of the board. ▪ Prepare and distribute a board information pack to ensure that board members know the organization and requirements of the role. ▪ Develop a board self-assessment process to guide understanding of gaps in knowledge, skills and performance. ▪ Seek input from other facilities and accreditation systems on effective management systems and essential policies. ▪ Develop a system to keep the board, working groups and steering committees active and engaged. ▪ Ensure the management team shares responsibility, potentially by creating departments to spread responsibility.
	▪ Lack of planning.	▪ Planning (strategic, succession, action) not seen as valuable or a priority. ▪ Lack of management expertise. ▪ Lack of resources (human, financial). ▪ Fear of losing control.	▪ Seek expert input from other facilities and accreditation systems on how to develop a strategic plan and succession plan; reach out to learn what works and why; and adapt practice to the context. ▪ Ensure that plans are used and updated. ▪ Develop operational processes, systems and policies for organizational sustainability; engage staff in their development and keep them informed. ▪ Ensure the board or a coach supports the director to facilitate a vision of sustainable services.
	▪ Lack of an employee-oriented human resources approach to support staff retention.	▪ Limited expertise in and poor appreciation of the importance of looking after and investing in staff. ▪ Lack of management expertise. ▪ Limited resources (human, financial).	▪ Seek expert input from other facilities and accreditation systems to understand appropriate ways to look after and invest in staff; consider economical ways to demonstrate appreciation and value. ▪ Ensure each position has a job description, including board members and the director. ▪ Ensure that all key tasks and roles can be carried out by more than one person for succession and sustainability. ▪ Assess different ways to strengthen capacity (through a blended approach) and ways to benefit more than one staff person.
	▪ Reliance on a single donor or funding mechanism.	▪ Complacency. ▪ Lack of resources (human, financial). ▪ Limited professional fundraising expertise. ▪ Competitive market.	▪ Seek expert input from other facilities and accreditation systems to understand appropriate ways to diversify fundraising sources. ▪ Develop a fundraising plan. ▪ Create a financial reserve and add to it as possible.

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Level	Issue	Barriers	Opportunities and action
	☐ Lack of technical expertise.	☐ Poor awareness and skill gaps. ☐ Lack of planning to fully understand and predict knowledge and skills required—currently and in the future. ☐ Lack of resources (human, financial).	☐ Explicitly acknowledge the importance of animal welfare. ☐ Seek partnerships with organizations with the required expertise. ☐ Understand the potential complex needs of the animals in the facility and the required knowledge and skills to properly manage them—currently and in the future. ☐ Develop appropriate standards and a welfare assessment system with species-specific requirements for captive and released apes. ☐ Create a learning environment in which approaches and standards are reviewed and updated in line with emerging research and practice. ☐ Recognize the funding required to employ people with the necessary expertise; consider what benefits can be offered to people in lieu of higher salary scales. ☐ Plan ahead for knowledge and skills required, keeping in mind the geriatric requirements of aging apes, the complex medical needs of chimpanzees from laboratories, and the need for post-release monitors or trackers with the knowledge and skills to assess welfare.
	☐ Carrying capacity exceeded.	☐ Policy on carrying capacity absent or not followed. ☐ Planning not conducted or not followed. ☐ Government pressure to accept more animals.	☐ Create a policy on carrying capacity (per enclosure, species, and for the facility generally); review the policy if situations arise that would lead the facility to exceed its carrying capacity and determine how to acquire the resources required for intake. ☐ Communicate with the relevant government agencies about the facility's carrying capacity and what it means to exceed it—for the facility's reputation, animal welfare, and financial and other resources.
	☐ Inadequate government understanding of the requirements that underpin good welfare and good outcomes for release.	☐ Government pressure to accept more animals ☐ Government pressure to release animals in contravention of IUCN guidelines, in ways that undermine welfare and conservation outcomes.	☐ Raise awareness of the links between animal, human and environmental health and wellbeing (One Welfare–One Health). ☐ Work with and get support from the relevant accrediting body to communicate what good practice looks like for care, welfare, rehabilitation and release. ☐ Communicate with the relevant government agencies about the facility's carrying capacity and what it means to exceed it—for the facility's reputation, animal welfare, and financial and other resources.

Sources: Based on author observations, supplemented by Baker *et al*. (2013); D'Cruze and McDonald (2016); Farmer (2012, 2018); IUCN (2019a); Mitman *et al*. (2021); Phelps *et al*. (2021a); Pinillos (2016); Rivera, Knight and McCulloch (2021); Rodriguez *et al*. (2019); Ronfot (2016); Sherman and Greer (2018); Sinclair and Phillips (2018b); Sollund (2022); Wyatt *et al*. (2022); personal communication in 2020 with N. Maddison, O. Martin and J. Vaughan

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Annex XI

Selected Tools for Assessing Captive Ape Welfare: Key Features

Name of tool	Details
Animal Welfare Assessment Grid (AWAG)® University of Surrey and Reuben Digital	**Focus** ▪ Originally designed to monitor laboratory primate welfare; adapted for individual and groups of primates (and other species) in zoos. ▪ Used for daily welfare monitoring of Siamang gibbons (*Symphalangus syndactylus*) and several non-ape species at Marwell Zoo, UK. ▪ Trialled on gorillas at Safaripark Beekse Bergen, the Netherlands. ▪ Currently being adapted for farm and pet animals. ▪ Intended for use by captive facility staff.

	Indicators and parameters
	▪ Input and output indicators. Factors can be adapted for the species based on adaptations made for gorillas.
	▪ Four parameters, each with several factors:
	  ▪ environmental: access/events, enclosure furnishings, group size, housing, nutrition;
	  ▪ physical: activity level, clinical assessment, food/water intake, general condition;
	  ▪ procedural: change in daily routine, restraint, sedation/anesthesia, vet procedures; and
	  ▪ psychological: abnormal behaviors, aversion to routine events/animal training, enrichment provision/use, response to catching events, social disruption within groups.

	Tool development and application ▪ Development: Factors are scored 1–10 (good to poor) and chosen/adapted by zoo staff (animal welfare advisors, keepers, veterinarians, zoologists). Research into known abnormal behaviors for each species is conducted to facilitate recognition and scoring. Each scoring sheet is independently scored by three people. ▪ Application: Previously the score was calculated retrospectively from the daily reports generated by animal staff members. Cloud-based software enables staff to score in real time, with the option to add comments. ▪ The software analyses the data and presents it in graphical form.
	Outputs ▪ Software outputs are numerical scores and a visual polygon. The averages of the four parameters can be plotted as a radar chart to form a two-dimensional polygon, representing the impact of each category on an animal's welfare. The cumulative welfare assessment score (CWAS) is equal to the surface area of this polygon (not just the average) and increases when parameter classes are compromised, indicating a potential welfare issue. ▪ The radar chart can be used to capture long-term trends, whereas the CWAS can be plotted over time to identify short-term events that impact welfare.
	Additional information ▪ By monitoring the changes in the aggregate scores over time, users can determine the factors affecting the welfare of an animal or group. AWAG can also be used to assess the potential welfare impact of planned interventions. The software is best used to highlight perceived positive and negative welfare impacts, complemented by more traditional auditing methods. ▪ AWAG does not allow comparison between species or between individuals held in different institutions, but it could be used for individuals within institutions (for example, to monitor moves to different enclosures). ▪ An adapted version for gorillas was tested for usability and reliability. AWAG provided a good indication of individual and group welfare, and potential welfare issues. Daily audits may not be required as welfare appeared to be stable in the long term. Inter-rater agreement (between keepers and researcher) was good. More frequent and longer observations, reduced scoring options, regular staff meetings and staff training to make scoring unambiguous could improve usability and increase accuracy. ▪ The aim is to make the tool available for other facilities and species, and to integrate it with the Zoological Information Management System (ZIMS). ►

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Name of tool	Details
Great Ape Welfare Index (GAWI)	**Focus** ■ The GAWI focuses on the assessment of chimpanzee welfare at the group level, with ongoing work to include individual welfare. ■ This description is focused on input measures as the validation of output measures is ongoing. ■ Derived from expert opinion and validated by behavioral observations, the GAWI identified the most important attributes of a great ape captive management system.
	Indicators and parameters ■ Current input indicators: dietary provision, the physical and social environment, and management aspects (including indoor/outdoor enclosure availability and staff qualifications). ■ The following output measures are being created and validated: body condition score* (correlated with hematology and other physiological values), bilateral alopecia and fecal cortisol as indicators of stress, and wounds (frequency, location, presence), in conjunction with behavior.
	Tool development and application ■ Development: JGI Tchimpounga Chimpanzee Rehabilitation Center (Republic of Congo) refined and tested the GAWI. It was further tested at three other range state chimpanzee sanctuaries but found to be open to subjective interpretation. To combat this issue, a working group of experts from African sanctuaries, European and North American zoos and an Australasian university was established to review and adjust the welfare index. Input on welfare indicators was further validated by a range of persons including caregivers, managers and veterinarians. ■ Application: Each chimpanzee group is scored on a scale of 1 to 5 (poor to good) on each input indicator. The average score represents a welfare index for each group. ■ Data are manually collected and entered onto an Excel spreadsheet.
	Outputs ■ Input indicators are scores for each indicator and group, and an average index. ■ Graphical representation of results would need to be manually generated.
	Additional information ■ The index was found to be helpful for assessing the welfare of chimpanzee groups but not individuals, hence the ongoing work to develop output indicators. ■ The GAWI places emphasis on useability for African facilities, by caregivers with non-academic backgrounds and in the relevant resource context. The tool also aims to ensure that caregivers can see the results of their efforts.
Project ChimpCARE Chimpanzee Assessment Lincoln Park Zoo Lester E. Fisher Center for the Conservation of Apes	**Focus** ■ Designed to provide a practical yet empirical assessment tool that can add an extra species-specific (chimpanzee) layer to a full organizational assessment and facilitate comparisons across facilities. ■ Data are predominately collected by an external person or assessor.

	Indicators and parameters
	■ The tool is predominantly input indicator-focused, with a smaller proportion of output measures designed to present a comparative assessment of how chimpanzees utilize the resources.
	■ Three areas of assessment, each comprising several variables:
	  ■ programs: daily management practices, diet, staff experience and veterinary care;
	  ■ social: composition, size and stability; and
	  ■ space: complexity and size.

	Tool development and application ■ Development: Specific metrics underlying the design of the assessment are derived from a process that gathered 20 experts in captive chimpanzee care, working in research centers, sanctuaries and zoos around the world. ■ Application: Each of the three areas has several variables that are scored and weighted, with a resulting score between 0 and 100 (poor to good). The assessment has been trialled at Project Chimps and scores were compared with spontaneously chosen observations of practice from AZA zoos and GFAS-accredited sanctuaries. ■ Data are collected during scheduled and unscheduled site visits, as well as by the organization under the direction of the assessor. In the latter case, measures are verified by the assessor during unscheduled visits.

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Name of tool	Details
	Outputs □ The result is a score for each area and an overall score that is the average of the three, representing the overall capacity of the organization to address the welfare of the chimpanzees. □ The scores reflect what was seen and assessed during scheduled and unscheduled site visits only.
	Additional information □ During the trial, two key challenges were experienced: ■ The first was difficulty in objectively measuring what represents sufficient complexity of space, relative to space availability. This step involves assessing which resources make the space complex enough and functionally relevant for chimpanzees. Based on scientific literature and expert opinion, key elements include elevated resting areas, substrate coverage, vertical climbing opportunities and visual barriers. ■ The second challenge relates to characterizing and assessing spaces according to the standard binomial "indoor" and "outdoor." In response, a "mixed/hybrid" category was added, defined by the proportion of the perimeter that is open-air. It allows for better assessments of spaces that provide some, but not all, of the benefits of outdoor access. □ The assessment will be refined as it is tested at other facilities, with the aim of expanding it to other types of chimpanzee facilities and helping to create similar tools for other species.
WelfareTrak® Created and managed by the Chicago Zoological Society's Center for the Science of Animal Care and Welfare As of November 2022, the program had begun to close down. New customers were no longer being accepted.	**Focus** □ This web-based application provided a mechanism for tracking zookeepers' assessments of individual animal welfare over time, across multiple species (20 species-specific surveys). □ It was designed to monitor individuals over time (weekly), not to compare animals within or between facilities.
	Indicators and parameters □ Species-specific, animal-based output (positive and negative) indicators. Each species-specific survey was composed of 10–15 indicators rated on a five-point Likert-type scale. □ WelfareTrak® was used more than 60 times to run species-level surveys, for animals ranging from geckos to gorillas.
	Tool development and application □ Development: A panel of experts (comprising zookeepers, animal managers, veterinarians and wildlife biologists) helped to develop each species-specific tool; the chimpanzee version, for example, solicited input from 17 experts. Questionnaires were used to establish a consensus of opinion on the most useful welfare indicators and definitions (including emotional, mental and physical states). □ During the initial trial period, the application was tested with nearly 50 animal care specialists representing five AZA-accredited facilities. □ Application: Staff members provided input into a species-specific welfare survey that could only be used online. Observers rated indicators on a five-point Likert-type scale (1–5 for poor to excellent *or* never to always). It was also possible to document special events that may have impacted welfare scores. □ The tool permitted entry of score ratings from multiple raters for comparison. □ A nominal fee was collected for each species that was monitored and this fee was used to cover server and site maintenance costs. Data were stored on the Center's server but users' data were confidential and not viewed unless requested (for example, if a user had a question about interpretation).
	Outputs □ Two types of reports could be viewed: ■ Trend reports generated separate graphs for each welfare indicator over time and gave users the ability to view scores of individual raters and mean scores. ■ Reports on individual wellbeing generated separate tables for each welfare indicator and "flagged" potential changes in scores using symbols and banners. □ Both options permitted viewing of special events.

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Notes: This table includes selected examples of tools used to assess captive ape welfare; it does not provide an exhaustive list.

* A study in zoo gorillas found that environmental variables (visitor density and noise levels) and modifications showed significant effects on behavior but not on fecal glucocorticoid measurements, demonstrating the importance of aligning fecal hormone studies with behavioral monitoring (Clark *et al.*, 2012). The body condition score has been used to assess body weight of orangutans without touching or weighing to avoid intervention and to reduce stress (C. Nente, personal communication, 2020; see Chapter 4). Although the body condition score represents a reliable system for comparing scores over time and can provide for some objectivity in multiple situations, challenges remain, such as effectively assessing body condition in large, long-haired males.

Sources: Based on author knowledge and experience, supplemented by the following: AWAG®: Brouwers and Duchateau (2021); Justice *et al*. (2017); Wolfensohn *et al*. (2018); D. Free and S. Wolfensohn, personal communication, 2021; GAWI: Fernie (2008); Fernie *et al*. (2012); R. Atencia, personal communication, 2020; Project ChimpCARE Chimpanzee Assessment: ChimpCARE (n.d.-b); Project Chimps (2020); Ross (2020); S. Ross, personal communication, 2020; WelfareTrak®: CZS (n.d.); Whitham and Wielebnowski (2015); J. Whitham and L. Miller, personal communication, 2021 and 2022

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