INDEX

captive apes, infectious diseases in 30-36 captive apes, non-infectious diseases in 36-40 key findings 15 sampling 29 wild apes, infectious diseases in 15-28 wild apes, non-infectious disease in 28, 30 Ape Heart Project (Twycross Zoo) 39, 71 arboreal locomotion 89, 205, 209, 255, 257, 317 Abbott's gray gibbon (Hylobates abbotti) xviii, xxii, Ascaris spp. 283 xxvi-xxvii; see also gibbons (Hylobatidae); Asian apes see gibbons (Hylobatidae); orangutans Hylobates gibbons (Pongo spp.) abscesses 32, 36, 280, 282, 317 accreditation of captive facilities 235, 238, 244, 245, 247-248, 250, 259, 268, 304, 307 B Africa, number and status of captive apes in 261-264 African apes see bonobos (Pan paniscus); chimpanzees Bacillus anthracis 19-20, 277 (Pan troglodytes); gorillas (Gorilla spp.) Bacillus cereus biovar anthracis (Bcbva) 19-20 age-related diseases 4, 6, 37, 38-40, 277 bacterial diseases 16, 26-28, 277-282; see also agile gibbon (Hylobates agilis) xxii, xxvi-xxvii; specific diseases see also gibbons (Hylobatidae); Hylobates gibbons Balantidium coli 282 agriculture; see also domestic animals/livestock; Batang Toru, Sumatra xvi, 62, 299 industrial development projects; One Health bats 21, 22, 278 strategy Berlin Principles of One Health 48, 49, 58, 74 and disease risk to apes 53, 54-55, 66 best management practices (BMPs) 64, 80, 81, 91, 95, expected prevalence 2020-2025 and risks to apes 97-100, 105; see also standard operating procedures 298-300 (SOPs) and habitat loss/fragmentation/degradation best practice guidelines 26, 36, 97, 98, 99, 112, 128, 181, 28, 52, 54-55, 66, 67, 163-164, 165 210, 219-220, 225 human-ape conflict 30 Best Practice Guidelines for Great Ape Tourism poisoning from 287 (Macfie and Williamson) 98 pollution from 30 Best Practice Guidelines for Health Monitoring and sustainable farming 56-58, 60 Disease Control in Great Ape Populations air sacculitis 27, 35, 277-278, 281 (Gilardi et al.) 26, 98, 112 amplifying hosts 12, 317 Best Practice Guidelines for Responsible Images anemia 30-31, 125, 317 (Waters et al.) 97 anesthesia use 29, 115, 116, 117-118, 120, 122, 128, 139, 155, biopsies 29, 136, 317 biosafety practices 32, 107, 124, 133, 317-318 animal reservoir see reservoirs, disease biosecurity practices 68, 131, 181, 189, 318 animal welfare; see also captive ape welfare bloating 32, 282, 318 and animal trade 238 bonobos (Pan paniscus) barriers and challenges 247-250 anthrax 19 health care provision 156 cardiovascular disease 38, 71 indicators 250-252 CITES and IUCN listing xiv, xxi legislation and regulations 100, 240-241 climate change impacts 171, 172-173 and release programs 239 diet xiv, xxviii, 205 standards of practice 235, 240-247, 259-260 distribution xiv, xx, xxi, xxiv-xxv tools, technology and context 252-253 Ebola virus 21 understanding 234, 235-237, 259 habitat types xxvii, xxviii, 205 Ankylostoma spp. 283 home and day ranges xxx, xxxi Anopheles mosquitoes 30, 31, 283; see also malaria human orthopneumoviruses 288 anthelmintic treatments 32, 124-125 life expectancy xiv anthrax 19-20, 89, 277 locomotion 205

antibiotics 16, 17, 18, 20, 31, 69, 70, 115, 125, 155

ape disease and health, review of 10-15, 40-41, 276-287

antibodies 32, 33, 34, 36, 94, 126

nesting xxxi	Candidatus Sarcina troglodytae 278
overview xiv	canopy bridges 30, 209, 221
physiology xiv	Cantanhez National Park, Guinea-Bissau 18
reproduction xxxi, xxxii	Cao Vit gibbon (Nomascus nasutus) xviii, xxiii,
respiratory diseases 25, 35, 90	xxvi-xxvii, 299; see also gibbons (Hylobatidae);
social organization xiv, xx, xxii, 205	Nomascus gibbons
socioecology xx-xxxiii	capacity building 65, 66, 128, 130, 184-185
threats to xiv	Capillaria spp. 283
Bornean gray gibbon (Hylobates funereus) xviii, xxii,	captive ape welfare 233–261
xxvi-xxvii, 73; see also gibbons (Hylobatidae)	assessing 199, 235–236, 248–254, 261, 310–313
Bornean orangutans (Pongo pygmaeus); see also	balancing benefits/risks 156–158
orangutans (Pongo spp.); specific subspecies	Barber and Mellen welfare infrastructure 238
CITES and IUCN listing xvi, xxi	barriers and challenges 247–248, 250, 260, 305–309
diet xxix	Brando and Buchanan-Smith 24/7
distribution xxi, xxvi–xxvii	framework 236
habitat types xxviii	defining animal welfare 199, 234, 235
home and day ranges xxx-xxxi	enclosure designs 237, 240, 254, 255–257, 260
numbers xvi	ethics of ape care 151, 156–158
	Five Domains Model 199, 235–236, 250
parasites 33	
physiology xvi	key findings 234–235
reproduction xxxii	language 236, 237, 259 movement between facilities 233, 236, 238
social organization xvii	
threats to xvi	public concern for 233, 236, 260–261
tuberculosis (TB) 138	standards of practice
weaning age xxxii	failure to promote good welfare 247–248, 250
Bornean white-bearded gibbon (Hylobates albibarbis)	internally developed standards 245–246,
xxii, xxvi–xxvii, 73, 167; see also gibbons	259–260, 308–309
(Hylobatidae); Hylobates gibbons	international conventions and
Borneo; see also Indonesia	declarations 241-244, 259
community engagement 73	national legislation and regulations 240-241,
deforestation 67-68, 113	259, 303–304
forest fires 73, 165, 167, 180, 287	professional associations and
human-ape conflict 120	accreditation 244, 259, 304, 307
logging 299	for rehabilitation and release 246-247
One Health ecosystem conservation 72-73	welfare continuum 236
rescue/rehabilitation centers 87, 88, 95, 112-114	captive apes, status and number of 261-271
tourism 85, 87, 88, 95	Africa 261–264
bronchoalveolar lavage (BAL) 138, 318	Asia 264–267
buffer zones 68, 74, 75, 89, 178-179	data limitations 270-271
Bukit Baka Bukit Raya National Park, Borneo 67, 68, 72	Europe 267-268
Bukit Lawang rehabilitation site, Sumatra 87	key findings 235
Bukit Tigapuluh National Park, Sumatra 61, 62	Latin America 268
Burkholderia pseudomallei 36, 280	Oceania 269
burnout 159, 318	overview 261
burns 284-285	United States 269-270
Bwindi Impenetrable National Park, Uganda 16, 59–60,	captive/semi-captive settings; see also captive ape
68, 85, 87, 89, 99, 108–109, 174, 176, 181	welfare; captive apes, status and number of;
00, 03, 07, 03, 33, 100 103, 174, 170, 101	specific type of setting
	accreditation 235, 238, 244, 259, 304, 307
	ape health interventions 112–114
C	API scores 261–262, 264–265
calcium 37, 124	"captive facilities" defined 233, 318
Cambodia 84, 210, 266, 299	disaster management 168–170, 178, 186, 190, 195
Cameroon 19, 24, 32, 36, 199, 221–224, 225–226, 263,	disease prevention strategies
	anthelmintic treatments 32
264, 299	antiferimitie treatments 32

best management practices (BMPs) 99	cestodes 32, 33
biosafety practices 32	chimpanzees (Pan troglodytes); see also specific subspecies
enclosure designs 26, 30, 52	anthrax 19, 20
foraging-like "work" 37	behavioral and ecological characteristics 204, 205
good hygiene 26, 36	behavioral studies, landmark 115, 116
monitoring 26, 94	cardiovascular disease 37, 38, 71
nutritional management 36-37	CITES and IUCN listing xiv, xxi
One Health approach 52, 69–70	climate change impacts 164
plastic bans 100	COVID-19 278
quarantine 26	dental disease 40
staff health 26, 27	diet xv, xxviii, xxix, 205
staff PPE use 26, 27	disease transmission to/from humans 12, 90,
strict standard operating procedures	91, 288
(SOPs) 94	distribution xiv, xx, xxi, xxiv-xxv
UK Framework for Preventive Health	Ebola virus 12, 21, 22, 137, 151
Programming and Interventions 131-132	epizootic neurologic and gastroenteric
vaccination 25, 126, 127	syndrome (ENGS) 34, 278
disease risk factors	facial dysplasia 30, 287
diets 32	gastrointestinal parasites 32, 33
disease reservoir population densities 31, 36	habitat types xxviii, 204, 205
gut microbiome disturbances 31, 69	habituation 81, 88, 90, 91
human–ape interactions 4–5, 6, 30, 78, 79, 80,	health interventions 117, 118, 153-156, 156-158
92–95, 96–97, 114	hepatitis A 279
for illegally-trafficked apes 123-125	hepatitis B 279
malnutrition 6, 37	HIV-1 group M 12
old age 6, 38-40	home and day ranges xxix-xxx, xxxi
other animals-ape interactions 4-5, 6, 31, 34	human coronavirus OC43 288
plastics 100	in human environments 2–3
poor enclosure designs 94	human metapneumovirus (HMPV) 288
poor management 94, 95	human orthopneumoviruses 288
poor ventilation 35	human respirovirus 3 288
population density 30, 31, 32, 35	human rhinovirus C 288
small cages 35	hunting other mammals 12
smoke 35	in illegal captivity 238
stress 6, 30, 32, 40, 70, 83, 106, 158	industrial impacts and mitigations 209, 210,
substandard hygiene 31	214, 298
diseases/conditions in 30-40, 276-287;	leprosy 12, 18
see also specific condition; specific disease	life expectancy xv
ethics of ape care 151, 156–158	locomotion 205, 208
habituation 78, 79, 82-83	malaria 30
illegal captivity 40, 94, 96, 123–125, 267, 284;	meliodosis 36
see also trafficking, wild animal	monkeypox virus (MPXV) 10-11, 16, 36
indoor versus outdoor settings 83	nesting xxxi
sampling/testing 29, 69-70, 137-138	numbers xiv-xv
as tourist destinations 80	numbers in captive settings 262, 263-264, 265, 266,
welfare see captive ape welfare	267, 268, 269, 270
cardiologists 71, 318	overview xiv-xv
cardiomyopathy 37, 38, 71, 318	pesticide poisoning 287
cardiovascular disease 37, 38–39, 70, 71, 122, 277, 285, 318	physiology xv
Central African Republic 19, 25, 89-90, 221-224, 226	polio 117, 151
central chimpanzee (Pan troglodytes troglodytes)	poliomyelitis 281
xiv, xxi, xxiv–xxv, xxviii, 22, 24, 221–222, 298;	renal disease 39
see also chimpanzees (Pan troglodytes)	reproduction xxxi, xxxii, xxxiii
certification schemes 181, 202, 208, 215–218, 223, 226;	respiratory diseases 25, 26–27, 28, 34, 35, 90, 91, 102
see also accreditation of captive facilities	sarcoptic mange (scabies) 16

simian immunodeficiency viruses (SIVs)	impacts on conservation 87, 99, 174, 176, 264
24-25, 281	impacts on local communities 87, 99, 174, 176,
snare injuries 117, 153–156	181, 264
social organization xv, xx, xxii, 12, 205	impacts on understanding of animal
socioecology xx-xxxiii	welfare 259
species xxi	impacts on zoos 269
stress in captive settings 83	minimizing transmission risks 60, 87, 97–98, 130
territoriality 205	171, 209–210
threats to xv	Non Human Primate COVID-19 Information
vaccinations 117, 126–127, 151	Hub 66
vocalizations 103	preparedness documents 185
yaws (TPE) 12, 17	recognition as global problem 3, 45, 50
China 264–265, 298, 299	cramping 32, 282, 318
chlorpyrifos 30, 287, 318	crop-raiding 30, 68, 78, 86, 89, 120
circuses, animal use in 267	Cross River gorilla (Gorilla gorilla diehli) xv, xxi,
climate change 3, 45, 49, 109–110, 164, 167, 169, 171,	xxiv–xxv, 209; see also gorillas (Gorilla spp.);
172-173, 222-223	western gorillas (Gorilla gorilla)
Clostridium tetani 278, 282	cross-reactivity 24, 114, 319
colitis 32, 33, 69, 135, 282, 318	Cryptosporidium spp. 32
collectivism 147, 148, 321	cumulative welfare assessment score (CWAS) 310
"common cold" (human rhinovirus C) 13, 25, 278, 288	cysticercosis 33
communities, local	cytomegalovirus (CMV) 33, 124, 152, 319
conflicts with apes 78, 89, 118	cytomegatovirus (Civi v) 35, 124, 152, 319
COVID-19 impacts 87, 99, 174, 176, 181, 264	
disaster management/mitigation 176, 177–178,	
181–182, 182–183, 184–185, 187–188, 192–193, 194, 196	D
education and awareness programs 45, 48, 56,	data mining 187–188, 319
60, 65	DDT/pp-DDE 30, 287
	deciduous teeth 39, 277, 319
engagement with 48, 66 health initiatives 53, 55–60, 62, 64–65, 67–68, 86,	deficiencies and imbalances, nutritional 37, 40
	deforestation 53, 54–55, 61–62, 66, 88, 102, 112, 113,
97, 137	150, 216; see also habitat loss/fragmentation/
investing in 45, 59, 60, 178 involvement in conservation 60, 62, 70, 73, 86, 133,	degradation; logging
	Delphi method 251, 252
149–150, 178, 226	Democratic Republic of Congo (DRC)
tourism benefits/costs 85–86	behavioral studies, landmark 116
compassion fatigue 159–160, 326	climate change impacts 171, 172–173
compassionate conservation 7–8, 144, 146, 147–150,	community engagement 68, 137
152, 160, 236, 318	COVID-19 impacts 174–177, 181
compounding risks 174–177, 318	diseases in apes 17, 19, 21, 22, 25, 94, 137
Congo Basin 221–224	Gorilla Doctors 62–65, 115
conjunctivitis 94	Gorilla Rehabilitation and Conservation
Conservation, Mitigation and Biodiversity Offsets in	
Africa (COMBO) program 214, 230	Education Center (GRACE) 199, 257–258
conservation litigation 241, 318	Great Ape Welfare Index (GAWI) trials 311
Convention on International Trade in Endangered	Greater Virunga Transboundary
Species of Wild Fauna and Flora (CITES) xiv, xvi,	Collaboration 176, 178, 185, 186–187, 188
xvii, xviii, xix, xx, xxi–xxiii, 123, 237, 241–244, 269	habituation 89–90
Coronaviridae 288	logging 298
COVID-19	mining 299
in apes 278	numbers of apes in sanctuaries 263, 264
causative pathogen 7, 45	tourism 84, 85, 174–177
gorillas, risk to 35-36, 60, 181, 186	dental disease/issues 38, 39-40, 277, 285
impacts on ape rescue centers 171	dependency, alcohol/drug/tobacco 40, 284
impacts on ape tourism and research 87, 98,	depigmentation, skin 18, 280, 319
174–176, 181, 264, 270	dermatophytes 125, 319

diabetes 39	in captive/semi-captive settings see captive/semi-
diagnostic protocols 114, 319	captive settings, disease prevention strategies
diagnostics see sampling/testing	containment actions 191
Dientamoeba fragilis 282	distancing measures 60, 87, 91, 99, 103, 105, 176, 181
diet xiv, xv, xvi, xvii-xviii, xix, xxiii, xxviii-xxix, 36-37,	early warning systems 102, 137, 188-189, 191
171, 205	education and public awareness 26, 48, 62, 64-65,
Dirofilaria immitis 282	95, 99–100, 137, 180
disaster impacts; see also COVID-19	employee health programs 28, 62, 64-65, 131
climate change hazards 167, 168–170, 171	field laboratories 28
direct impacts 166–167	improved hygiene 26, 28, 36, 60
indirect impacts 167	improving human health 28, 48, 53, 64-65;
multiple threats 162–164, 165, 167	see also One Health strategy
stages 166–167	integrated approaches 46-47, 110, 111
terminology 166	legislation and regulations 95, 100
wildlife coping strategies 171–172, 172–173	multipronged approach 106–107
disaster management; see also risk assessments	overview 26
best practice guidelines 195–196	pathogen surveillance 36
capacity and capability 184–185, 296	PPE use 26, 27, 176
case studies 168–170, 174–176	primary prevention 144, 150, 324
command and control systems 182, 186, 191, 195,	quarantines 26, 28, 34, 87, 91, 99, 131, 181, 325
	risk assessments 26, 53, 62, 100–101, 136, 172, 174,
196, 318 community engagement 192–193	290-292
	risk mitigation 177, 181
compounding risks 174–177, 318	screening and testing 28, 32, 34, 64, 87, 94, 99, 100,
contingency plans 185–186	113, 114, 131, 137–138
continuum of 178, 185–186	secondary prevention 144, 150, 161, 325
cost-benefit analysis 174-177	tertiary prevention 144, 326
costs, financial 318	vaccination see vaccination
documentation 185–186, 296	diseases see Annex II; bacterial diseases; captive/semi-
early warning systems 188–189	captive settings, diseases/conditions in; parasites;
governance 186–187	viral infections; zoonoses; specific disease
key findings 164–166	distancing measures 60, 87, 91, 99, 103, 105, 176, 181
management systems 187–190, 297	Djéké Triangle, Republic of Congo 222, 223
monitoring and review 193-195	DNA (deoxyribonucleic acid) 17, 69-70, 102-103, 114,
multi-agency response 323	135, 137, 319
Ngamba Island flood crisis 104-105, 168-170,	documentation, disaster management 185-186, 296
294-297	domestic animals/livestock 34, 46-47, 62, 64, 65, 67,
PEESTOLM approach 164, 172, 174	68, 90, 92, 240
preparedness see preparedness, disaster prevention	drowning 170, 285
178–181, 295–296	dysbiosis 69-70, 319
recovery 191–192	dyspnea 278, 279, 281, 282, 319
responses 190–191	Dzanga-Sangha, DRC 89–90, 221, 222, 289
risk management 172–177	
risk mitigation 177–178	
terminology 166	E
usage exercises 190, 297	E
volunteers, management of 191	eastern chimpanzee (Pan troglodytes schweinfurthii)
disease ecology in natural habitats 102–103	xiv-xv, xxi, xxiv-xxv, xxvii, xxviii, 24-25, 288;
disease emergence 48, 52, 101, 102, 150, 319	see also chimpanzees (Pan troglodytes)
disease/injury prevention strategies; see also	eastern gorillas (Gorilla beringei); see also gorillas
interventions, ape health; One Health strategy	(Gorilla spp.); Grauer's gorilla (Gorilla beringei
best management practices (BMPs) 64, 91, 97-100	graueri); mountain gorilla (Gorilla beringei beringei)
biosafety practices 32, 107, 124, 133, 317-318	distribution xv
biosecurity practices 68, 131, 181, 189, 318	habitat types xxviii
canopy bridges 30, 209, 221	home and day ranges xxx, xxxi

physiology xv-xvi	Five Domains Model 199, 235–236, 250
reproduction xxxi	flooding 168–170, 192, 294–297
social organization xvi	flukes (trematodes) 283
threats to xv	fomites 89, 100, 320
eastern hoolock (Hoolock leuconedys) xvii, xxii,	food security 56-58, 126, 320
xxvi-xxvii; see also Hoolock gibbons	forest fires
Ebola virus disease (EVD) 12, 13, 14, 21–24, 126, 127,	impacts on apes 28, 164, 165, 166, 171, 266, 284, 287
137, 150, 151–152, 185, 192–193, 278	prevention and response strategies 73, 180, 183,
Echinococcus multilocularis (fox tapeworm) 33	188–189, 190
echocardiographers 71, 319	Forest Stewardship Council (FSC) 216-218, 219, 223, 226
ecoimmunology 139–140	formulation, diet 36, 320
ecosystem health 44, 45, 46, 48, 55, 58, 61–65, 70,	fungi 3, 6, 321
72–73, 150, 319	<i>6 5, 15</i>
ectoparasites 11, 29, 283, 319; see also sarcoptic mange	
(scabies)	
ectopy 39, 320	G
electrocution 285	Gabon 21, 85, 96, 263, 264
employee health programs 28, 62, 64–65, 131	Gaoligong hoolock (Hoolock tianxing) xvii, xxii,
encephalomyocarditis 126, 279, 320	xxvi-xxvii; see also gibbons (Hylobatidae);
Enclosure Design Tool (EDT) 52, 199, 246, 254, 255–257	Hoolock gibbons
enclosure designs 26, 30, 52, 94, 237, 240, 255–257	gastrointestinal diseases
endoparasites 69, 320	bacterial 34, 69, 278, 280, 281, 282
Entamoeba spp. 32, 282	parasitic 6, 7, 31–33, 64, 108–109, 282, 283
Enterobius spp. 32, 33, 283	Primate Microbiome Project 69–70
epizootic neurologic and gastroenteric syndrome	viral 278, 279
(ENGS) 278	gene sequencing 135–136, 137–138
Epstein–Barr virus 33	genetic sampling 102–103
Equator Principles 215	geriatric disorders 4, 6, 37, 38–40, 277
ethics of ape care 142–144, 159–160	Giardia spp. 32, 60, 125, 282
case studies 151–152, 153–155, 156–158	gibbons (Hylobatidae); see also specific genus;
compassionate conservation 147–150	specific species
-	abundance estimates xii
ethical importance of apes 211–212	behavioral and ecological characteristics 205
"first, do no harm" approach 110, 140, 149, 152	in captive/semi-captive settings 238, 240, 262,
general considerations 145–147	265–266, 267, 268, 269–270, 279
inclusivity 149	CITES and IUCN listing xxii
individual and collective importance 121, 145–147,	cytomegalovirus 124
148–149, 159, 211–212	dental disease 40
moral agency and moral courage 158–159, 159–160	dependency, alcohol/drug/tobacco 40, 284
peaceful coexistence 149–150	diet xxix, 205
in sanctuary settings 156–158	distribution xxii, xxvi–xxvii
secondary prevention 150, 153–156	emergency response plan 176, 178, 185, 190–191
tertiary prevention 156–158	forest fire impacts 167
vaccination 123, 126–127, 151–152	gastrointestinal parasites 32–33
in wild settings 29, 116–117, 121, 153–155	
	habitat types xxviii, 205 habituation 81, 90
F	health interventions 123–125
facial dvenlasia an ana	hepatitis R 122 124 279
facial dysplasia 30, 287, 320	hepatitis B 123, 124, 279
feral animals 64, 180	herpes viruses 33, 279
field laboratories 28	home and day range xxxi
fighting, inter- and intragroup 121, 286	illegal trafficking of 123–125
filariasis 282	industrial impacts and mitigations 221, 299
"first, do no harm" approach 110, 140, 149, 152	locomotion 205
fission-fusion dynamics 171, 205, 320	meliodosis 36

	overview xvii	monkeypox virus (MPXV) 36
	parasites 124-125	nesting xxxi
	privately-held 123–125, 238	numbers xv
	rehabilitation/release 238, 240	obesity 37
	reproduction xxxii	overview xv–xvi
	social organization xx, xxv, xxvii, 205	parasites 133, 135
	socioecology xx-xxxiii	as pets 96
	species xxii–xxiii	physiology xv–xvi
	territoriality 205, 240	renal disease 39
	tourism 84	reproduction xxxi-xxxii, xxxiii
	tuberculosis (TB) 34	respiratory diseases 25, 90, 289
	vaccinations 126	sarcoptic mange (scabies) 16, 59, 60
	vocalizations 103, 167	severe acute respiratory syndrome coronavirus 2
σl	ucocorticoids (GCs) 92, 136, 321	(SARS-CoV-2) 35–36, 60, 181
	ombe National Park, Tanzania 16, 24–25, 90, 91, 115,	simian immunodeficiency viruses (SIVs) 24
	116, 117, 281	snare injuries 121
G	orilla Doctors 60, 62–65, 68, 108–109, 114–115, 118,	social organization xvi, xx, xxii–xxiv, 22, 205
G,	121, 135, 151–152, 186	socioecology xx-xxxiii
G	orilla Rehabilitation and Conservation Education	threats to xv
0	Center (GRACE), DRC 199, 257–258	and tourism 81, 84–85, 85–86, 86–87, 92, 95, 98,
αc	orillas (Gorilla spp.); see also specific species;	99, 116, 176, 177–178, 181, 192
80	specific subspecies	vaccinations 126, 151–152
	age-related diseases 37	yaws (TPE) 12, 17–18
	anthrax 19	Goualougo Triangle Ape Project 221–224
	in captive situations 257–258, 262–263, 265, 266,	governance, disaster 186–187, 188, 190, 195, 196
	267, 268, 269, 270, 279, 310	Grauer's gorilla (<i>Gorilla beringei graueri</i>) xv, xxi,
	20/, 208, 209, 2/0, 2/9, 310 cardiovascular disease 37, 38, 71	xxiv-xxv, 62-65, 94, 115; see also eastern gorillas

	COVED to CO 27 to TO 28	(Gorilla beringei); gorillas (Gorilla spp.)
	COVID-19 60, 87, 174, 176, 181, 185, 186, 278	Greater Virunga Transboundary Collaboration 176, 178,
	dental disease 40	185, 186–187, 188
	diet xvi, xxviii–xxix, 205	Guinea 17, 68, 192–193, 199, 210, 214, 227–230, 263,
	distribution xv, xx, xxi, xxiv–xxv	264, 298
	Ebola virus 12, 21, 22–23, 137	Guinea-Bissau 18
	gastrointestinal parasites 32, 33, 108–109	Gunung Palung National Park, Indonesia 67–68, 74,
	Giardia diseases 60	75, 165
	habitat types 205	gut microbiome 6-7, 31, 32, 41, 69-70, 124
	habituation 81, 86, 88, 89–90, 92, 98	
	health interventions 117, 118, 119, 121, 133, 135,	
	151–152; see also Gorilla Doctors	H
	hepatitis B 279	habitat loss/fragmentation/dagradation.com also
	herpes viruses 33, 94, 279	habitat loss/fragmentation/degradation; see also
	home and day ranges xxx	agriculture; deforestation; industrial development
	human conflict with 68, 89	projects; logging; mining; resource extraction; roads
	human metapneumovirus (HMPV) 25, 289	and disease ecology 101, 102
	human orthopneumoviruses 289	due to tourism 88
	human respiratory syncytial virus (HRSV) 25	and genetic degradation 120
	industrial impacts and mitigations 209, 223-224,	and health risks 4, 28, 30, 52, 58, 66–67, 92, 101, 102
	226, 299	leading to human–ape conflict 14, 58
	inter- and intragroup fighting 121	leading to human–wildlife interactions 3, 4, 52, 58
	leprosy 12	and vulnerability to natural hazards 162-164
	life expectancy xv-xvi	habituation
	locomotion 205	benefits versus costs 83, 84
	malaria 12	best management practices (BMPs) 81
	measles 117	captive apes
	meliodosis 36	behavioral impacts 83

disease transmission risks 78, 79, 92-95	hunting/poaching see poaching/hunting
habituation process 82–83	hydropower 205, 206, 230, 298–300; see also
human reasons for 82–83	industrial development projects
reversing habituation 83	hygiene 26, 28, 36, 60, 86, 144
defining 81, 321	Hylobates gibbons; see also gibbons (Hylobatidae);
as disease risk factor 12, 62, 78, 79, 81, 88, 89, 90,	specific species
91, 92–95	CITES and IUCN listing xxii–xxiii
evidence-based risk assessments 100–101, 106	distribution xviii, xxii–xxiii, xxvi–xxvii
limitations and financial costs 87–90	home and day range xxxi
minimizing risks 79–80, 81	numbers xviii
overhabituation 78, 88–89	offset legislation 214
reversing 83	overview xviii
wild apes	physiology xviii
behavioral impacts 78, 79, 81, 87, 88	social organization xviii
benefits to apes 83–84	species xxii
best management practices (BMPs) 81	hyperendemic regions 19, 20, 321
disease transmission risks 78, 79, 81, 88, 89, 91	hypertension 38, 39, 71, 321
due to tourism and research 76–77, 78	• •
financial costs 89–90	hypertrophy 38, 321 hypoplasia 39–40, 277, 321
habituation process 80–81	
human reasons for 79, 80–81	hypotension 122, 321
increase in 89	hypothermia 122, 322
length of process 81	
negative consequences 78, 81, 87–88, 88–89	
overhabituation 88–89	idiopathic myocardial fibrosis 71, 285, 322
Hainan gibbon (Nomascus hainanus) xviii, xxiii,	imidacloprid 30, 287, 322
xxvi-xxvii, 176, 178, 185, 190-191, 299; see also	immunocompetence 90, 322
gibbons (Hylobatidae); Nomascus gibbons	immunofluorescence antibody assays 32
health interventions <i>see</i> interventions, ape health	India 84, 265, 266, 299
helminths 31, 32–33, 133, 135, 283, 321	Indigenous Peoples and Local Communities (IPLCs)
hepadnavirus 114, 321	see communities, local
hepatitis A 94, 279	Indonesia; see also Borneo; Sumatra
hepatitis B 94, 114, 123, 124, 126, 279	
herpes viruses 33, 94, 279	agribusiness 299 animal welfare 247, 265
histopathology 135, 321	deforestation 112, 113
HIV-1 12, 13, 24	, , , , , , , , , , , , , , , , , , ,
Hoolock gibbons; see also gibbons (Hylobatidae);	disaster management 180
specific species	forest fires 167, 180, 189
CITES and IUCN listing xxii	infrastructure development 299
distribution xvii, xxii, xxvi-xxvii	interventions, ape health 112–114
numbers xvii	lawsuit regarding captive wildlife 241
offset legislation 214	meliodosis 36
physiology xvii-xviii	rescue/rehabilitation centers 112-114, 240, 246,
social organization xviii	266–267
species xxii	tourism 84
human coronavirus OC43 25, 26, 279, 288	translocations 128–129
human coronaviruses (HCoV) 13	tuberculosis (TB) 34, 138
human immunodeficiency virus (HIV) 12, 13, 24, 64	industrial development projects 230; see also
human metapneumovirus (HMPV) 13, 25, 26, 27, 35,	agriculture; infrastructure development; mining;
288, 289	roads
human orthopneumoviruses 25, 279, 288, 289	biodiversity impacts 202
human respiratory syncytial virus (HRSV) 13, 25–26,	case studies 221–224, 225–226, 227–230
26–27, 35	critical threat to apes 200-201
human respirovirus 3 25, 279, 288	expected prevalence 2020–2025 and risks to apes
human rhinovirus C ("common cold") 13, 25, 278, 288	298–300

future needs	case studies 120, 121, 123-125, 130, 131-132, 137-138
conservationists-industrialists	conservation physiology toolbox 136, 139
communication 224	decision-making process 110, 112, 118-121, 140
defining ape priority areas 224	diagnostics, improving 135-136, 137
government engagement 224, 225-226	duty-of-care concept 112
policy improvements 224-225, 227-230	ecoimmunology 139-140
standardizing mitigation metrics 225	ethical considerations <i>see</i> ethics of ape care
impacts on apes 206–208	history and evolution of 112-118
industries in ape ranges 205–206	human-caused injuries 117, 121, 150, 153–156
legislation and regulations 202	radio telemetry 139
long-term research and monitoring 221–224	rescuing apes from illegal captive situations 118
managing cumulative impacts 220–221	risks for humans and apes 117
mitigation approaches 208–219, 228, 230	tools 127–140
mitigation factors to consider 202–206	translocations see translocations
mitigation guidelines 219–220	vaccinations see vaccination
mitigation hierarchy 301–302	intrinsic value 147, 211, 241, 322
mitigation issues linked to ownership	Ivory Coast 16, 17, 18, 19, 21, 25, 90, 262, 263, 264, 288
change 224–225, 227–230	1101/ 00000 10, 17, 10, 17, 21, 27, 70, 202, 203, 204, 200
strategic environmental assessments	
(SEAs) 220–221	
infanticide xxxii-xxxiii, 322	J
influenza (flu) 35, 50, 230, 280, 322	
infrastructure development 28, 66, 88, 164, 228,	
298–300; see also industrial development projects;	V
roads	K
interbirth intervals xxxii, 322	Kahuzi-Biega National Park, DRC xv
interferon-gamma assays 137–138, 322	Kalimantan, Indonesian Borneo 67-68, 72-73, 87, 88
international conventions and declarations 241–244;	113, 165, 167, 180
see also Convention on International Trade in	Klebsiella pneumoniae 280, 289
	Kloss's gibbon (Hylobates klossii) xxii, xxvi-xxvii;
Endangered Species of Wild Fauna and Flora (CITES); International Union for Conservation	see also gibbons (Hylobatidae); Hylobates gibbons
	Koukoutamba dam, Guinea 298
of Nature (IUCN)	
International Primate Heart Project (IPHP) 39, 71	
International Union for Conservation of Nature (IUCN)	1
Avoid, Reduce, Restore and Conserve (ARRC)	L
Task Force 199, 204, 218–219, 224	Lao People's Democratic Republic (Lao PDR) 84, 210
best practice guidelines 26, 97, 98, 128, 219–220,	266
239, 246–247, 248, 250	lar gibbon (Hylobates lar) xviii, xxii, xxvi-xxvii, 32-33
capacity building programs 65–66	see also gibbons (Hylobatidae); Hylobates gibbons
COVID-19 guidelines 130, 171, 176, 181	legislation and regulations
IUCN-CITES task force 243	on animal welfare 234, 240-241, 305-306
A.P.E.S. Database 1, 219	API scores 261-262, 263-265, 267
Primate Specialist Group (PSG) 97, 98, 176, 215,	on industrial development 226, 228, 230
218, 248, 250	positive developments in 202, 226, 303-304
Red List xiv, xv, xvii, xviii, xix, xx, xxi-xxiii, 97,	on protection of apes 210, 214
274-275	on strategic environmental assessments (SEAs)
Species Survival Commission, Primate Specialist	220-221, 226, 228, 230
Group 218	on tourism and research 98, 100
interventions, ape health 108–140	leprosy 12, 18, 280
anesthesia use 29, 115, 116, 117–118, 120, 122, 128,	lesions 16, 17, 18, 38, 39, 71, 125, 277, 280, 322
139, 155, 156–158	Leuser Ecosystem, Sumatra xvi, 62, 70, 229
behavioral studies, landmark 115-116	Liberia 19, 192–193, 263–264
best practice guidelines 112, 128	live ape trade see trafficking, wild animal
capacity building 128-129, 130-132	liver disease 38, 69, 114, 277, 279; see also hepatitis B
captive settings 112-114	livestock see domestic animals/livestock

locomotion	distribution xxi, xxiv-xxv
arboreal 89, 205, 209, 255, 257, 317	gastrointestinal parasites 33
terrestrial 205, 208, 326	habituation 81, 88, 89, 90, 98
logging 62, 66, 67–68, 133, 164, 206, 221–224, 225–226,	health interventions 114–115, 119, 121, 133, 135
298–300; see also deforestation; habitat loss/	home and day range xxxi
fragmentation/degradation; resource extraction	human metapneumovirus (HMPV) 25, 289
lymphocryptovirus 33	human orthopneumovirus A 289
lymphoeryptovirus 33	humans, conflict with 89
	humans, interaction with 60, 98
	lymphocryptovirus 33
M	numbers xv
macroparasites 6, 322	parasites 88, 90, 133, 135
malabsorption 94, 96	population growth 60, 86
malaria 12, 30–31, 114, 283	
Malaysia 34, 36, 84, 114, 247, 265, 266; see also Borneo	renal disease 39
malnutrition 36–38, 56, 94, 96, 124, 166, 286	reproduction xxxiii
management systems, disaster 187–190	respiratory diseases 90, 151–152
mange mites/scabies 16–17, 59, 60, 89, 94, 283	sarcoptic mange (scabies) 16, 59
measles 13, 64, 89, 94, 99, 117, 126, 151–152	social organization xxii–xxiii, xxiv
meliodosis (a.k.a. Whitemore's disease) 36, 280	tourism 83, 84–85, 85–86, 87, 95, 98, 116
meningitis 94	vaccinations 126, 151–152
metabarcoding 29, 33, 322	Moyen-Bafing National Park, Guinea 210
metabolic bone disease 37, 40	Müller's gibbon (<i>Hylobates muelleri</i>) xviii, xxii,
metabolic syndrome 39, 322	xxvi-xxvii; see also gibbons (Hylobatidae);
	Hylobates gibbons
metazoan parasites 135, 322; see also helminths	Myanmar 68, 265, 299
Mgahinga Gorilla National Park, Uganda 85, 87	Mycobacterium leprae 18, 280
minimization step of mitigation strategy 209-210,	Mycobacterium lepromatosis 18
212, 302	Mycobacterium tuberculosis complex 13, 28, 34-35, 114,
mining 28, 30, 66, 67, 206, 210, 218, 224, 227–230,	137–138, 282, 323
287, 298–300, 301–302; <i>see also</i> infrastructure	
development; resource extraction	
mitigation hierarchy 208–210, 211–212, 214, 218,	N
224–225, 230, 301–302, 322	
moloch gibbon (<i>Hylobates moloch</i>) xviii, xxii,	nasal flora 26, 323
xxvi-xxvii; see also gibbons (Hylobatidae);	national parks see specific park
Hylobates gibbons	natural disasters see disaster impacts; disaster
Mondika field station, Central African Republic	management
221–224	necropsies 17, 18, 28, 29, 323; see also post-mortem
monkeypox virus (MPXV) 6, 10–11, 13, 15–16, 36, 280	examinations
moral agency 147, 158–159	necrotizing dermatitis 17, 323
moral courage 145, 158–159, 159–160, 322	necrotizing inflammation 32, 323
moral distress 159, 160, 322	nematodes 32–33, 135, 282, 283, 323
moral resilience 145, 159-160, 322	nephritis 39, 277, 323
moral standing/status 144, 146, 323	nesting xxxi
mosquitoes 30, 31, 170, 283	neurological diseases/conditions 30, 278, 287
Mountain Gorilla Veterinary Project/Gorilla Doctors	next-generation sequencing (NGS) 6, 135, 323
see Gorilla Doctors	Ngamba Island Chimpanzee Sanctuary, Uganda
mountain gorilla (Gorilla beringei beringei); see also	104–105, 168–170, 294–297
eastern gorillas (Gorilla beringei); gorillas	Niger 262
(Gorilla spp.)	Nigeria 262, 263, 264
behavioral studies, landmark 115	Nigeria-Cameroon chimpanzee (Pan troglodytes
cardiovascular disease 37	ellioti) xv, xxi, xxiv–xxv, 209; see also
CITES and IUCN listing xxi	chimpanzees (Pan troglodytes)
COVID-19 87, 176, 178, 181, 186	Nigerian Cross River superhighway 209
diet xvi, xxiii	Niokolo-Koba National Park, Senegal 301-302

nodules 18, 280, 323	integrated risk management 159–160, 174
Nomascus gibbons; see also gibbons (Hylobatidae);	intersections and convergences of related
specific species	disciplines 48-49, 49-50, 75, 236
CITES and IUCN listing xxiii	and land use changes 66-68
distribution xviii, xxiii, xxvi-xxvii	Manhattan Principles 46
home and day range xxxi	translational medicine 70, 71
numbers xviii	translocation applications 133, 134
offset legislation 214	One Welfare framework 52, 236, 305, 309, 323
overview xviii–xix	operant conditioning 29, 157, 245, 323
parasites 32	Orangutan Veterinary Advisory Group (OVAG)
physiology xix	65–66, 69–70, 114, 128–129, 130, 185
social organization xix	orangutans (Pongo spp.); see also specific species;
species xxiii	specific subspecies
northeast Bornean orangutan (Pongo pygmaeus	age-related diseases 37
morio) xxi; see also Bornean orangutans	air sacculitis 35, 281
(Pongo pygmaeus)	arboreal nature of xxx-xxxi
northern white-cheeked crested gibbon (Nomascus	behavioral and ecological characteristics 205
leucogenys) xxiii, xxvi-xxvii, 32; see also	behavioral studies, landmark 116
gibbons (Hylobatidae); Nomascus gibbons	cardiovascular disease 38
northern yellow-cheeked crested gibbon (Nomascus	CITES and IUCN listing xvi, xxi
annamensis) xxiii, xxvi-xxvii, 210; see also	conflict with humans 120
gibbons (Hylobatidae); Nomascus gibbons	dental disease 40
northwest Bornean orangutan (Pongo pygmaeus	diagnostics 138
0 270	diet xvi, xxviii, xxix, 205
pygmaeus) xxi; see also Bornean orangutans (Pongo pygmaeus)	Dirofilaria immitis 282
	disease transmission from humans 94, 95, 114
Nouabalé-Ndoki National Park (NNNP), Republic of	distribution xvi, xx, xxi, xxvi–xxvii
Congo 221–224	Ebola virus 21–22, 24
nucleic acids 29, 135, 323; see also DNA	flanged/unflanged 320
(deoxyribonucleic acid); RNA (ribonucleic acid)	forest fire impacts 28, 164, 167
nutrition 56-58; see also malnutrition	gastrointestinal illnesses 32, 33, 69
	gut microbiome 69–70
0	habitat tunes yawiii aas
obesity 36, 37, 69, 286	habitat types xxviii, 205 habituation 81
ocular conditions 38, 277	health interventions 112–114
	•
Odzala-Kokoua National Park, Republic of Congo	hepadnavirus 114
22–23	hepatitis B 279
Oesophagostomum spp. 32, 283	herpes viruses 33, 279
offsetting step of mitigation hierarchy 210, 212–213, 302	home and day range xxx-xxxi
One Health strategy	illegal captivity 241
aims 50	industrial impacts 299
and animal welfare 236	interbirth interval xvii, xxxii
Berlin Principles 48	life expectancy xvi
case studies 58, 59–60, 61–65, 65–66, 67–68,	locomotion 205
69-70, 71, 72-73	malaria 30–31, 114
community health initiatives 53, 55–56, 137	meliodosis 36
defining 44, 49, 50, 323	monkeypox virus (MPXV) 36
globalization of principles 49–51	nesting xxxi
health interventions 150, 151, 154	numbers xvi
history and evolution of 43-44, 46-47	numbers in captive settings 262, 265, 266-267
human behaviors and spillover risks 52–53	268, 269
and the Human–Ape Interface 51–58	obesity 37
improving human health to improve wildlife health	overview xvi–xvii
53, 55–56, 59–60, 86	physiology xvi

Pseudomonas spp. infections 281	xxvi-xxvii; see also gibbons (Hylobatidae);
release programs 246, 250, 253, 254	Hylobates gibbons
renal disease 39	planetary health paradigm 45, 48, 58, 110, 324;
reproduction xxxii, xxxiii	see also One Health strategy
respiratory diseases 27, 28, 34, 35	Plasmodium spp. 12, 13, 30-31, 114, 283, 324
smoke inhalation 28, 164	pneumococcus (Streptococcus pneumoniae) 26-27, 35,
social organization xvii, xx, xxiv-xxv, 205	126, 281–282, 288
socioecology xx-xxxiii	pneumonia 26-27, 35, 277-278, 280, 281-282
solitary lifestyle 12	pneumoviruses (Pneumoviridae) 25, 26, 27, 35, 279,
species xxi	288, 289, 324
stress impacts 83, 87, 88, 92	poaching/hunting; see also snares/traps; wild meat
threats to xvi	consumption/trade
ticks 102	and ape numbers in sanctuaries 262, 263, 264
tourism 84, 85, 88, 92	COVID-19 impacts 60, 87, 99, 174
translocations 112, 113, 120, 129, 133, 134	deforestation impacts 88, 164
tuberculosis (TB) 34, 114	and disease transmission 4, 14, 24, 100, 137
vaccinations 126	roads, impact of 28, 206, 208
vocalizations 103	sustainable hunting 58
weaning ages xxxii	and tourism 85, 86
worms 114	poisoning 30, 166, 287
Orthopoxvirus see monkeypox virus (MPXV)	polio 117, 151
osteoarthritis 37, 38, 39, 277, 324	poliomyelitis 281
osteopenia 37	pollution 30, 67, 88, 100, 167, 287
oscopema 3/	polymerase chain reaction (PCR) tests 135-136, 137,
	138, 324
B	positive reinforcement training 83, 157, 258, 324
P	post-mortem examinations 29, 30, 64, 115, 131, 324
Paramyxoviridae 25, 279, 288	see also necropsies
parasitemia 30–31, 324	post-traumatic stress disorder (PTSD) 40, 158, 159, 284
parasites	prediabetes 37, 324
defining 324	preparedness, disaster; see also risk assessments
filariasis 282	capacity and capability 184-185, 296
gastrointestinal 7, 31–33, 64, 69, 90, 108–109, 282	case study 168–170, 294–297
health interventions 133, 135	documentation 185-186, 296
helminths 31, 32–33, 114, 124–125, 133, 135, 283,	evacuation plans 190
321, 326	exercises and drills 190, 297
host–parasite ecoevolutionary dynamics 140, 276	governance structures 186–187
in illegally-trafficked apes 124–125	health interventions 117–118
mange mites/scabies 16–17, 59, 60, 89, 94, 283	management systems 187-190, 297
Plasmodium spp. 12, 13, 30–31, 114, 283, 324	monitoring/reviewing 193, 194-195
protozoa 6, 31, 32, 282, 283, 324	non-human resources 185, 191
Pasteurella multocida 27–28, 281	overview 181–184
pathogenicity 102, 135, 324	reputational risk assessment 293
PEESTOLM risk management approach 164, 172, 174,	primary prevention 144, 150, 324
290–292	Primate Microbiome Project 69–70
personal protective equipment (PPE) 6, 26, 27, 100,	Project ChimpCARE Chimpanzee Assessment 311–312
171, 176	pro-poor tourism 85–86, 324
personhood 146, 236, 324	proteomics 136, 324
pesticides 30, 287	protozoa 6, 31, 32, 282, 283, 324
pets, apes as 33, 94, 96, 118, 267	Pseudomonas spp. 281
pets, non-ape <i>see</i> domestic animals/livestock	psychological disorders 40, 284
phages 41, 324	
Pic de Fon Classified Forest, Guinea 227–230	
Picornaviridae 278, 288	Q
pileated gibbon (<i>Hylobates pileatus</i>) xviii, xxiii,	quarantine 26, 28, 34, 87, 91, 99, 131, 181, 325
pricated 5100011 (11)100mics pricatios) Aviii, AAIII,	quartaritatic 20, 20, 34, 0/, 91, 99, 131, 101, 323

R	S
radio telemetry 139, 253, 325	Sabah, Malaysian Borneo 70, 85, 87, 88, 94, 95
railways 227, 287	Salmonella spp. 32, 281, 282
recovery from disasters 168-170, 171-172, 179, 183,	sampling/testing 20, 29, 64, 91, 102-103, 117, 135-136
191–192	137-138, 140
regulations see legislation and regulations	sanctuaries; see also captive ape welfare; captive/
rehabilitation/restoration step of mitigation 210, 302	semi-captive settings
reintroductions 36, 62, 113-114, 134, 138, 139, 171, 239,	accreditation 244
246-247, 250, 325	animal welfare 238, 244, 245, 246, 248, 255-257
renal disease 30, 37, 38, 39, 277, 287	ape numbers/status in Africa 262–264
Republic of Congo 17, 21, 22-23, 137, 221-224, 263, 264	ape numbers/status in Asia 266–267
reservoirs, disease 15, 17, 21, 24, 31, 36, 52, 126, 325	ape numbers/status in Europe 267
resource extraction 60, 66, 67, 68, 75, 223; see also	ape numbers/status in the USA 270
industrial development projects; logging; mining	collaboration 257–259
respiratory diseases 15, 25-28, 34-36, 41, 90, 94, 95-96,	disaster management 168–170, 294–297
102, 116, 151–152, 167; see also specific disease	disease transmission risk to/from humans 80
responses, disaster 168-170, 184, 186, 190-191, 193,	diseases/conditions in 21, 36, 38
194–195	Enclosure Design Tool 255–257
retroviruses 24-25, 281, 325	health care provision 156–158
rickets 37	operating at or over capacity 270
risk assessments; see also disaster management	reputational risk assessment 293
compounding risks 174-177, 318	Sangha Trinational (TNS) region, Congo Basin 221–22.
of Congo Basin forestry 221–224	Sarcoptes scabiei 16–17, 59, 60, 89, 94, 283, 317
in contingency plans 186	sarcoptic mange (scabies) 16–17, 59, 60, 89, 94, 283, 31
for diseases 26, 53, 62, 100-101, 136, 172, 174,	screening 32, 62, 64, 82, 94, 100, 113, 114, 131, 137–138
290-292	
guidance 174	scurvy 37 Sebangau National Park, Borneo 72, 73, 167
for habituation 101, 103	-
for health interventions 29, 110, 112, 119, 126, 127,	secondary prevention 144, 150, 161, 325 semi-terrestriality xxx
131–132, 149, 152, 153–154, 156, 158	•
of Ngamba Island flooding 168–170, 294–295	Senegal 164, 301–302
PEESTOLM approach 164, 172, 174, 290-292	sentience 211, 212, 233, 234, 236, 237, 259, 261, 325
for reintroductions/relocations 36, 120, 133, 134,	septicemia 124, 277, 280, 325
190–191, 212	seroconversion 114, 124, 325
reputational risk assessment 293	serology 29, 114, 325
reviewing 193	severe acute respiratory syndrome coronavirus 2
risk mapping 180, 195	(SARS-CoV-2) xi, 7, 13, 35–36, 45, 60, 66, 171, 174
as start of preparedness 181, 185	176, 181, 278; see also COVID-19
risk management 119, 133, 170, 172–178, 195, 215	shared situational awareness 187, 196, 325
risk mapping 165, 180, 294	siamang (Symphlangus syndactylus) xix, xxiii,
RNA (ribonucleic acid) 27, 135, 325	xxvi–xxvii, xxix, 214, 310; see also gibbons
roads 3, 28, 30, 200-201, 202, 206, 208, 209, 222, 223, 228,	(Hylobatidae)
287, 298–299; see also infrastructure development	Sibual-Buali Nature Reserve, Sumatra xvi
Roundtable on Sustainable Palm Oil (RSPO) 216	Sierra Leone 192–193, 263, 264, 278
roundworms (nematodes) 32-33, 135, 282, 283, 323	Simandou Mine, Guinea 227–230
Rungan River Landscape, Borneo 72-73	simian acquired immunodeficiency syndrome (SAIDS
Rwanda	24, 281
COVID-19 impacts 174-177, 181	simian immunodeficiency viruses (SIVs) 13, 24-25, 28
Ebola virus disease (EVD) 185	smallpox 15
Gorilla Doctors 62, 63, 64, 114–115	smoke inhalation 28, 164, 167, 287
habitat loss/fragmentation/degradation 101	snares/traps 6, 87, 115, 116, 117, 118, 121, 153–156, 174, 28
habituation, rise in 89	social media 97, 103, 105, 187–188, 267, 270
interventions, ape health 114-115, 117	sociality/social organization xx, xxii-xxv, xxvii, 4,
respiratory diseases 25, 289	11-12,15,21,22-23,25,90,205,211,325
tourism 84-85, 85-86, 174-177, 192	socioecology, of apes xx-xxxiii

southern white-cheeked crested gibbon (Nomascus	Sustainable Development Goals (SDGs), UN 45-46,
siki) xviii, xxiii, xxvi–xxvii, 210; see also gibbons	48-49, 75
(Hylobatidae); Nomascus gibbons	syndromic surveillance 28, 326
southern yellow-cheeked crested gibbon (Nomascus	
gabriellae) xviii, xxiii, xxvi–xxvii, 210; see also	
gibbons (Hylobatidae); Nomascus gibbons	Т
southwest Bornean orangutan (Pongo pygmaeus	1
wurmbii) xxi; see also Bornean orangutans	Taï National Park, Ivory Coast 16, 18, 19, 21, 24, 288
(Pongo pygmaeus)	Taiwan 266
spillback 45, 137, 325	Tanjung Puting rehabilitation site, Kalimantan, Borneo
spillover events	87, 88
bi-directionality 7, 13, 14, 15	Tanzania 16, 24-25, 90, 91, 115, 116, 117, 262, 288
in captive situations 4, 6	Tapanuli orangutan (Pongo tapanuliensis); see also
defining 12, 325	orangutans (Pongo spp.)
examples 13, 18, 21, 26, 91, 137	Batang Toru Ecosystem 62
risk factors 45, 53, 55, 79, 80, 92, 113, 134, 230	CITES and IUCN listing xxi
risk management 95, 97, 106–107, 137, 151	diet xxix
transmission settings 14	distribution xvi, xxi, xxvi-xxvii
standard operating procedures (SOPs) 87, 94, 95, 97,	habitat types xxviii
98, 245, 246, 326	inbreeding concerns xvi
strategic environmental assessments (SEAs) 220–221,	industrial impacts and mitigations 230, 299
230	numbers xvi
Streptococcus pneumoniae (pneumococcus) 26–27, 35,	resilience xxix
126, 281–282, 288	threats to xvi
stress	translocation risk matrix 134
to apes	tapeworms (cestodes) 32, 33, 283
impact on gut microbiome 70	terrestrial locomotion 205, 208, 326
impact on gat interostonic 76	"territories of life" 68
impact on physical health 6, 30, 83, 87–88,	tertiary prevention 144, 326
90, 106, 124	testing see sampling/testing; screening
physiology metrics 136	ticks 102
in rehabilitation/release programs 212, 239	tourism and research 59–60, 62–64, 77–107, 248–250;
to humans working with apes 159–160	see also habituation
Strongyloides 32–33, 114, 124–125, 135, 283, 326	aiding conservation 60, 83–84, 86–87, 105–106
Sumatra 61–62, 87, 112–114, 120, 230, 254, 299	and animal welfare 248, 250, 303
Sumatran orangutan (<i>Pongo abelii</i>); see also	benefits/costs to local communities 78, 85–86
orangutans (Pongo spp.)	best management practices (BMPs) 91, 97–100, 105
CITES and IUCN listing xvi, xxi	COVID-19 impacts 87, 98, 174–176, 181, 264, 270
diet xvi, xxix	disease prevention strategies 28, 91, 97–103,
distribution xxi, xxvi–xxvii	106–107, 176, 181
habitat types xxviii	as disease risk factor 78, 89, 90, 91, 94, 95–97, 116
home and day ranges xxx	evidence-based assessments 100–101
industrial impacts 299	GDP from 78, 84–85
1 22	human fascination with apes 78
life expectancy xvi numbers xvi	1 '
	impact on health interventions 121
release programs 62, 254	improving for ape health 103–107
reproduction xxxii	key findings on impacts of 80
social organization xvii, xxv	negative impacts on apes 40, 78, 81, 87, 88, 284
threats to xvi	photographs 97
translocations 120	post-COVID recovery 192
weaning age xxxii	trafficking, wild animal 123–125, 238, 259, 263, 264–265,
superinfections 124, 326	266, 267, 268, 270, 303
surge capacity 184, 326	translational medicine 50-51, 70, 71, 326
Sustainability Policy Transparency Toolkit (SPOTT)	translocations
(ZSL) 226	anesthesia use 120, 122

COVID-19 impacts 171	vectors, disease 65, 326; see also reservoirs, disease
decision-making 120	Versteria mustelae 33
and disease risk 69, 94–95, 118, 120	vicarious resilience 160, 326
and human-ape conflict 118, 120	vicarious traumatization 159–160, 326
Indonesia's plan for 129	Vietnam 210, 265, 266
IUCN guidelines 128–129 as part of disaster management 182, 189, 190–191	viral infections 15, 25–28, 33, 35–36, 277–281, 288–289 Virunga Massif, Rwanda and DRC xxviii, 60, 87, 89
rights approach to 212	98, 115, 188
risk management 36, 133, 134, 139	Virunga National Park 63, 64, 77–78, 85, 135, 174, 198
stress 40, 284	viruses see specific virus
traps/snares see snares/traps	vitamins 37
trematodes 32, 283	Volcanoes National Park, Rwanda 64, 85, 101, 289
Treponema pallidum pertenue (TPE) 17–18, 282	
Trichuris spp. 32, 125, 283	
tuberculosis (TB) 28, 34–35, 94, 99, 114, 137–138, 282 typhoid fever 94, 282	W
7,1	weaning ages xxxii
	welfare see captive ape welfare
11	western black crested gibbon (Nomascus concolor)
U	xviii, xxiii, xxvi-xxvii; see also gibbons
Uganda	(Hylobatidae); Nomascus gibbons
ape diseases/conditions found in 16, 25, 30, 59,	western chimpanzee (Pan troglodytes versus); see also
287, 288	chimpanzees (Pan troglodytes)
community engagement 59-60, 68, 85-86	CITES and IUCN listing xxi
COVID-19 impacts 87, 174–177, 178, 181	disease transmission from humans 25, 26, 288
COVID-19 safe practices 60, 176, 181	distribution xxi, xxiv-xxv
disaster management 168–170, 181, 294–297	habitat type xxvii
Greater Virunga Transboundary	human metapneumovirus (HMPV) 25, 26
Collaboration 176, 178, 185, 186–187, 188	human respiratory syncytial virus (HRSV) 25
habitat loss/fragmentation/degradation 3	increased sanctuary intake of 264
health interventions 108–109, 153–156	industrial impacts and mitigations 210, 227, 298
human-ape conflict 89	301–302
Ngamba Island Chimpanzee Sanctuary 168–170,	leprosy 18 numbers xiv
294–297	population declines xv
numbers of apes in sanctuaries 263, 264	western gorillas (Gorilla gorilla); see also Cross River
pesticide poisoning 287	gorilla (Gorilla gorilla diehli); gorillas (Gorilla spp.)
strategic environmental assessments (SEAs) 220 tourism 60, 84–85, 85–86, 86–87, 89, 99, 104–105,	western lowland gorilla (Gorilla gorilla gorilla)
174, 181	diet xxix
ultrasound 29, 71, 115, 326	distribution xv
United Arab Emirates (UAE) 118, 123–125, 265, 267	habitat types xxviii
Universal Declaration on Animal Welfare (UDAW)	home and day range xxx, xxxi
243-244	physiology xv-xvi
utilitarianism 146, 326	reproduction xxxii, xxxiii
-4-, 3	social organization xvi, xxiii
	threats to xv
W	western hoolock (Hoolock hoolock) xvii, xxii,
V	xxvi-xxvii; see also gibbons (Hylobatidae);
vaccination	Hoolock gibbons
of apes 24, 25, 26, 117-118, 124, 126-127, 151-152	western lowland gorilla (Gorilla gorilla gorilla);
of dogs/cats 65	see also gorillas (Gorilla spp.); western gorillas
ethical complexities 123, 126-127, 151-152	(Gorilla gorilla)
of humans 26, 27, 28, 55–56, 64, 176	cardiovascular disease 38
of non-ape wildlife 126	CITES and IUCN listing xxi
varicella-zoster virus 33	Congo Basin studies 222

```
distribution xxiv-xxv
    Ebola virus 22-23
    gastrointestinal parasites 32
    habituation 81, 89-90, 92
    home and day range xxxi
    human orthopneumovirus A 289
    human respiratory syncytial virus (HRSV) 25
    individual's importance 145
    industrial impacts 299
    population estimate xv
    simian immunodeficiency virus (SIVgor) 24
    sociality/social organization 22-23
wild meat consumption/trade 14, 56, 60, 137, 262, 263
Wildlife Wood Project (WWP), Cameroon 199, 224,
    225-226
World Health Organization (WHO) 2, 18, 48, 50, 87,
    171, 174, 187, 190, 193, 194
World Organisation for Animal Health (OIE) 48, 50,
    66, 243
worms 32-33, 114, 124, 133, 135, 283
```

ape numbers/status in the USA 269 collaboration 257, 259 disaster management 178, 182, 190, 195 diseases/conditions in 32, 34, 35–36, 37, 38, 39, 71, 278, 279, 286 plastics ban 100 spillover risks 4–5, 6, 14, 33, 94 vaccinations 126

Y

yaws (TPE) 12, 17–18, 89, 282 yeast infections 125

7

Zaire ebolavirus (ZEBOV) 21, 278 zoonoses; see also specific disease defining 4, 327 disease transmission apes-to-humans 21, 24, 89, 127, 137 domestic animals/livestock-to-apes 90, 92 humans-to-apes 12, 15, 16-17, 26-27, 32, 33, 34, 35-36, 64, 78-79, 89, 90, 91, 94, 288-289 other wildlife-to-apes 34, 278 other wildlife-to-humans 34, 36 One Health strategy see One Health strategy PEESTOLM Risk Register 172, 174, 290-292 spillback 45, 137, 325 spillover events see spillover events zoos; see also captive ape welfare; captive/semicaptive settings accreditation 244 animal transfer between 238 and animal welfare 237, 244, 247-248, 251-252, 310, 311-312 ape numbers/status in Africa 262 ape numbers/status in Asia 265-266 ape numbers/status in Europe 267, 268 ape numbers/status in Latin America 268 ape numbers/status in Oceania 269-270