

INDEX

A

Abbott's gray gibbon (*Hylobates abbotti*) xviii, xxii, xxvi–xxvii; *see also* gibbons (Hylobatidae); *Hylobates* gibbons

abscesses 32, 36, 280, 282, 317

accreditation of captive facilities 235, 238, 244, 245, 247–248, 250, 259, 268, 304, 307

Africa, number and status of captive apes in 261–264

African apes *see* bonobos (*Pan paniscus*); chimpanzees (*Pan troglodytes*); gorillas (*Gorilla* spp.)

age-related diseases 4, 6, 37, 38–40, 277

agile gibbon (*Hylobates agilis*) xxii, xxvi–xxvii; *see also* gibbons (Hylobatidae); *Hylobates* gibbons

agriculture; *see also* domestic animals/livestock; industrial development projects; One Health strategy

and disease risk to apes 53, 54–55, 66

expected prevalence 2020–2025 and risks to apes 298–300

and habitat loss/fragmentation/degradation 28, 52, 54–55, 66, 67, 163–164, 165

human–ape conflict 30

poisoning from 287

pollution from 30

sustainable farming 56–58, 60

air sacculitis 27, 35, 277–278, 281

amplifying hosts 12, 317

anemia 30–31, 125, 317

anesthesia use 29, 115, 116, 117–118, 120, 122, 128, 139, 155, 156–158

animal reservoir *see* reservoirs, disease

animal welfare; *see also* captive ape welfare and animal trade 238

barriers and challenges 247–250

health care provision 156

indicators 250–252

legislation and regulations 100, 240–241

and release programs 239

standards of practice 235, 240–247, 259–260

tools, technology and context 252–253

understanding 234, 235–237, 259

Ankylostoma spp. 283

Anopheles mosquitoes 30, 31, 283; *see also* malaria

anthelmintic treatments 32, 124–125

anthrax 19–20, 89, 277

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

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

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

 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

Ascaris spp. 283

Asian apes *see* gibbons (Hylobatidae); orangutans (*Pongo* spp.)

B

Bacillus anthracis 19–20, 277

Bacillus cereus biovar *anthracis* (Bcbva) 19–20

bacterial diseases 16, 26–28, 277–282; *see also specific diseases*

Balantidium coli 282

Batang Toru, Sumatra xvi, 62, 299

bats 21, 22, 278

Berlin Principles of One Health 48, 49, 58, 74

best management practices (BMPs) 64, 80, 81, 91, 95, 97–100, 105; *see also* standard operating procedures (SOPs)

best practice guidelines 26, 36, 97, 98, 99, 112, 128, 181, 210, 219–220, 225

Best Practice Guidelines for Great Ape Tourism (Macfie and Williamson) 98

Best Practice Guidelines for Health Monitoring and Disease Control in Great Ape Populations (Gilardi *et al.*) 26, 98, 112

Best Practice Guidelines for Responsible Images (Waters *et al.*) 97

biopsies 29, 136, 317

biosafety practices 32, 107, 124, 133, 317–318

biosecurity practices 68, 131, 181, 189, 318

bloating 32, 282, 318

bonobos (*Pan paniscus*)

 anthrax 19

 cardiovascular disease 38, 71

 CITES and IUCN listing xiv, xxi

 climate change impacts 171, 172–173

 diet xiv, xxviii, 205

 distribution xiv, xx, xxi, xxiv–xxv

 Ebola virus 21

 habitat types xxvii, xxviii, 205

 home and day ranges xxx, xxxi

 human orthopneumoviruses 288

 life expectancy xiv

 locomotion 205

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

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

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

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

E

- eastern chimpanzee (*Pan troglodytes schweinfurthii*) xiv–xv, xxi, xxiv–xxv, xxvii, xxviii, 24–25, 288; *see also* chimpanzees (*Pan troglodytes*)
- eastern gorillas (*Gorilla beringei*); *see also* gorillas (*Gorilla spp.*); Grauer's gorilla (*Gorilla beringei graueri*); mountain gorilla (*Gorilla beringei beringei*)
- distribution xv
- habitat types xxviii
- home and day ranges xxx, xxxi

physiology xv–xvi
 reproduction xxxi
 social organization xvi
 threats to xv

eastern hoolock (*Hoolock leuconedys*) xvii, xxii, xxvi–xxvii; *see also* Hoolock gibbons

Ebola virus disease (EVD) 12, 13, 14, 21–24, 126, 127, 137, 150, 151–152, 185, 192–193, 278

Echinococcus multilocularis (fox tapeworm) 33

echocardiographers 71, 319

ecoimmunology 139–140

ecosystem health 44, 45, 46, 48, 55, 58, 61–65, 70, 72–73, 150, 319

ectoparasites 11, 29, 283, 319; *see also* sarcoptic mange (scabies)

ectopy 39, 320

electrocution 285

employee health programs 28, 62, 64–65, 131

encephalomyocarditis 126, 279, 320

Enclosure Design Tool (EDT) 52, 199, 246, 254, 255–257

enclosure designs 26, 30, 52, 94, 237, 240, 255–257

endoparasites 69, 320

Entamoeba spp. 32, 282

Enterobius spp. 32, 33, 283

epizootic neurologic and gastroenteric syndrome (ENGS) 278

Epstein–Barr virus 33

Equator Principles 215

ethics of ape care 142–144, 159–160

- case studies 151–152, 153–155, 156–158
- compassionate conservation 147–150
- ethical importance of apes 211–212
- “first, do no harm” approach 110, 140, 149, 152
- general considerations 145–147
- inclusivity 149
- individual and collective importance 121, 145–147, 148–149, 159, 211–212
- moral agency and moral courage 158–159, 159–160
- peaceful coexistence 149–150
- in sanctuary settings 156–158
- secondary prevention 150, 153–156
- tertiary prevention 156–158
- vaccination 123, 126–127, 151–152
- in wild settings 29, 116–117, 121, 153–155

F

facial dysplasia 30, 287, 320

feral animals 64, 180

field laboratories 28

fighting, inter- and intragroup 121, 286

filariasis 282

“first, do no harm” approach 110, 140, 149, 152

fission–fusion dynamics 171, 205, 320

Five Domains Model 199, 235–236, 250

flooding 168–170, 192, 294–297

flukes (trematodes) 283

fomites 89, 100, 320

food security 56–58, 126, 320

forest fires

- impacts on apes 28, 164, 165, 166, 171, 266, 284, 287
- prevention and response strategies 73, 180, 183, 188–189, 190

Forest Stewardship Council (FSC) 216–218, 219, 223, 226

formulation, diet 36, 320

fungi 3, 6, 321

G

Gabon 21, 85, 96, 263, 264

Gaoligong hoolock (*Hoolock tianxing*) xvii, xxii, xxvi–xxvii; *see also* gibbons (Hylobatidae); Hoolock gibbons

gastrointestinal diseases

- bacterial 34, 69, 278, 280, 281, 282
- parasitic 6, 7, 31–33, 64, 108–109, 282, 283
- Primate Microbiome Project 69–70
- viral 278, 279

gene sequencing 135–136, 137–138

genetic sampling 102–103

geriatric disorders 4, 6, 37, 38–40, 277

Giardia spp. 32, 60, 125, 282

gibbons (Hylobatidae); *see also specific genus; specific species*

- abundance estimates xii
- behavioral and ecological characteristics 205
- in captive/semi-captive settings 238, 240, 262, 265–266, 267, 268, 269–270, 279
- CITES and IUCN listing xxii
- cytomegalovirus 124
- dental disease 40
- dependency, alcohol/drug/tobacco 40, 284
- diet xxix, 205
- distribution xxii, xxvi–xxvii
- emergency response plan 176, 178, 185, 190–191
- forest fire impacts 167
- gastrointestinal parasites 32–33
- habitat types xxviii, 205
- habituation 81, 90
- health interventions 123–125
- hepatitis A 279
- hepatitis B 123, 124, 279
- herpes viruses 33, 279
- home and day range xxxi
- illegal trafficking of 123–125
- industrial impacts and mitigations 221, 299
- locomotion 205
- meliodosis 36

- overview xvii
 - parasites 124–125
 - privately-held 123–125, 238
 - rehabilitation/release 238, 240
 - reproduction xxxii
 - social organization xx, xxv, xxvii, 205
 - socioecology xx–xxxiii
 - species xxii–xxiii
 - territoriality 205, 240
 - tourism 84
 - tuberculosis (TB) 34
 - vaccinations 126
 - vocalizations 103, 167
 - glucocorticoids (GCs) 92, 136, 321
 - Gombe National Park, Tanzania 16, 24–25, 90, 91, 115, 116, 117, 281
 - Gorilla Doctors 60, 62–65, 68, 108–109, 114–115, 118, 121, 135, 151–152, 186
 - Gorilla Rehabilitation and Conservation Education Center (GRACE), DRC 199, 257–258
 - gorillas (*Gorilla* spp.); *see also specific species; specific subspecies*
 - age-related diseases 37
 - anthrax 19
 - in captive situations 257–258, 262–263, 265, 266, 267, 268, 269, 270, 279, 310
 - cardiovascular disease 37, 38, 71
 - CITES and IUCN listing xv, xxi
 - COVID-19 60, 87, 174, 176, 181, 185, 186, 278
 - dental disease 40
 - diet xvi, xxviii–xxix, 205
 - distribution xv, xx, xxi, xxiv–xxv
 - Ebola virus 12, 21, 22–23, 137
 - gastrointestinal parasites 32, 33, 108–109
 - Giardia* diseases 60
 - habitat types 205
 - habituation 81, 86, 88, 89–90, 92, 98
 - health interventions 117, 118, 119, 121, 133, 135, 151–152; *see also* Gorilla Doctors
 - hepatitis B 279
 - herpes viruses 33, 94, 279
 - home and day ranges xxx
 - human conflict with 68, 89
 - human metapneumovirus (HMPV) 25, 289
 - human orthopneumoviruses 289
 - human respiratory syncytial virus (HRSV) 25
 - industrial impacts and mitigations 209, 223–224, 226, 299
 - inter- and intragroup fighting 121
 - leprosy 12
 - life expectancy xv–xvi
 - locomotion 205
 - malaria 12
 - measles 117
 - meliodosis 36
 - monkeypox virus (MPXV) 36
 - nesting xxxi
 - numbers xv
 - obesity 37
 - overview xv–xvi
 - parasites 133, 135
 - as pets 96
 - physiology xv–xvi
 - renal disease 39
 - reproduction xxxi–xxxii, xxxiii
 - respiratory diseases 25, 90, 289
 - sarcoptic mange (scabies) 16, 59, 60
 - severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) 35–36, 60, 181
 - simian immunodeficiency viruses (SIVs) 24
 - snare injuries 121
 - social organization xvi, xx, xxii–xxiv, 22, 205
 - socioecology xx–xxxiii
 - threats to xv
 - and tourism 81, 84–85, 85–86, 86–87, 92, 95, 98, 99, 116, 176, 177–178, 181, 192
 - vaccinations 126, 151–152
 - yaws (TPE) 12, 17–18
 - Goulougo Triangle Ape Project 221–224
 - governance, disaster 186–187, 188, 190, 195, 196
 - Grauer's gorilla (*Gorilla beringei graueri*) xv, xxi, xxiv–xxv, 62–65, 94, 115; *see also* eastern gorillas (*Gorilla beringei*); gorillas (*Gorilla* spp.)
 - Greater Virunga Transboundary Collaboration 176, 178, 185, 186–187, 188
 - Guinea 17, 68, 192–193, 199, 210, 214, 227–230, 263, 264, 298
 - Guinea-Bissau 18
 - Gunung Palung National Park, Indonesia 67–68, 74, 75, 165
 - gut microbiome 6–7, 31, 32, 41, 69–70, 124
- ## H
- habitat loss/fragmentation/degradation; *see also* agriculture; deforestation; industrial development projects; logging; mining; resource extraction; roads and disease ecology 101, 102
 - due to tourism 88
 - and genetic degradation 120
 - and health risks 4, 28, 30, 52, 58, 66–67, 92, 101, 102
 - leading to human–ape conflict 14, 58
 - leading to human–wildlife interactions 3, 4, 52, 58
 - and vulnerability to natural hazards 162–164
 - habituation
 - benefits versus costs 83, 84
 - best management practices (BMPs) 81
 - captive apes
 - behavioral impacts 83

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

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

locomotion
 arboreal 89, 205, 209, 255, 257, 317
 terrestrial 205, 208, 326
 logging 62, 66, 67–68, 133, 164, 206, 221–224, 225–226,
 298–300; *see also* deforestation; habitat loss/
 fragmentation/degradation; resource extraction
 lymphocryptovirus 33

M

macroparasites 6, 322
 malabsorption 94, 96
 malaria 12, 30–31, 114, 283
 Malaysia 34, 36, 84, 114, 247, 265, 266; *see also* Borneo
 malnutrition 36–38, 56, 94, 96, 124, 166, 286
 management systems, disaster 187–190
 mange mites/scabies 16–17, 59, 60, 89, 94, 283
 measles 13, 64, 89, 94, 99, 117, 126, 151–152
 melioidosis (a.k.a. Whitmore's disease) 36, 280
 meningitis 94
 metabarcoding 29, 33, 322
 metabolic bone disease 37, 40
 metabolic syndrome 39, 322
 metazoan parasites 135, 322; *see also* helminths
 Mgahinga Gorilla National Park, Uganda 85, 87
 minimization step of mitigation strategy 209–210,
 212, 302
 mining 28, 30, 66, 67, 206, 210, 218, 224, 227–230,
 287, 298–300, 301–302; *see also* infrastructure
 development; resource extraction
 mitigation hierarchy 208–210, 211–212, 214, 218,
 224–225, 230, 301–302, 322
 moloch gibbon (*Hylobates moloch*) xviii, xxii,
 xxvi–xxvii; *see also* gibbons (Hylobatidae);
Hylobates gibbons
 Mondika field station, Central African Republic
 221–224
 monkeypox virus (MPXV) 6, 10–11, 13, 15–16, 36, 280
 moral agency 147, 158–159
 moral courage 145, 158–159, 159–160, 322
 moral distress 159, 160, 322
 moral resilience 145, 159–160, 322
 moral standing/status 144, 146, 323
 mosquitoes 30, 31, 170, 283
 Mountain Gorilla Veterinary Project/Gorilla Doctors
see Gorilla Doctors
 mountain gorilla (*Gorilla beringei beringei*); *see also*
 eastern gorillas (*Gorilla beringei*); gorillas
 (*Gorilla* spp.)
 behavioral studies, landmark 115
 cardiovascular disease 37
 CITES and IUCN listing xxi
 COVID-19 87, 176, 178, 181, 186
 diet xvi, xxiii

distribution xxi, xxiv–xxv
 gastrointestinal parasites 33
 habituation 81, 88, 89, 90, 98
 health interventions 114–115, 119, 121, 133, 135
 home and day range xxxi
 human metapneumovirus (HMPV) 25, 289
 human orthopneumovirus A 289
 humans, conflict with 89
 humans, interaction with 60, 98
 lymphocryptovirus 33
 numbers xv
 parasites 88, 90, 133, 135
 population growth 60, 86
 renal disease 39
 reproduction xxxiii
 respiratory diseases 90, 151–152
 sarcoptic mange (scabies) 16, 59
 social organization xxii–xxiii, xxiv
 tourism 83, 84–85, 85–86, 87, 95, 98, 116
 vaccinations 126, 151–152

Moyen-Bafing National Park, Guinea 210
 Müller's gibbon (*Hylobates muelleri*) xviii, xxii,
 xxvi–xxvii; *see also* gibbons (Hylobatidae);
Hylobates gibbons
 Myanmar 68, 265, 299
Mycobacterium leprae 18, 280
Mycobacterium lepromatosis 18
Mycobacterium tuberculosis complex 13, 28, 34–35, 114,
 137–138, 282, 323

N

nasal flora 26, 323
 national parks *see specific park*
 natural disasters *see* disaster impacts; disaster
 management
 necropsies 17, 18, 28, 29, 323; *see also* post-mortem
 examinations
 necrotizing dermatitis 17, 323
 necrotizing inflammation 32, 323
 nematodes 32–33, 135, 282, 283, 323
 nephritis 39, 277, 323
 nesting xxxi
 neurological diseases/conditions 30, 278, 287
 next-generation sequencing (NGS) 6, 135, 323
 Ngamba Island Chimpanzee Sanctuary, Uganda
 104–105, 168–170, 294–297
 Niger 262
 Nigeria 262, 263, 264
 Nigeria–Cameroon chimpanzee (*Pan troglodytes*
elliotti) xv, xxi, xxiv–xxv, 209; *see also*
 chimpanzees (*Pan troglodytes*)
 Nigerian Cross River superhighway 209
 Niokolo-Koba National Park, Senegal 301–302

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

Pseudomonas spp. infections 281
 release programs 246, 250, 253, 254
 renal disease 39
 reproduction xxxii, xxxiii
 respiratory diseases 27, 28, 34, 35
 smoke inhalation 28, 164
 social organization xvii, xx, xxiv–xxv, 205
 socioecology xx–xxxiii
 solitary lifestyle 12
 species xxi
 stress impacts 83, 87, 88, 92
 threats to xvi
 ticks 102
 tourism 84, 85, 88, 92
 translocations 112, 113, 120, 129, 133, 134
 tuberculosis (TB) 34, 114
 vaccinations 126
 vocalizations 103
 weaning ages xxxii
 worms 114

Orthopoxvirus see monkeypox virus (MPXV)
 osteoarthritis 37, 38, 39, 277, 324
 osteopenia 37

P

Paramyxoviridae 25, 279, 288
 parasitemia 30–31, 324
 parasites
 defining 324
 filariasis 282
 gastrointestinal 7, 31–33, 64, 69, 90, 108–109, 282
 health interventions 133, 135
 helminths 31, 32–33, 114, 124–125, 133, 135, 283, 321, 326
 host–parasite coevolutionary dynamics 140, 276
 in illegally-trafficked apes 124–125
 mange mites/scabies 16–17, 59, 60, 89, 94, 283
 Plasmodium spp. 12, 13, 30–31, 114, 283, 324
 protozoa 6, 31, 32, 282, 283, 324

Pasteurella multocida 27–28, 281
 pathogenicity 102, 135, 324
 PEESTOLM risk management approach 164, 172, 174, 290–292
 personal protective equipment (PPE) 6, 26, 27, 100, 171, 176
 personhood 146, 236, 324
 pesticides 30, 287
 pets, apes as 33, 94, 96, 118, 267
 pets, non-ape see domestic animals/livestock
 phages 41, 324
 Pic de Fon Classified Forest, Guinea 227–230
Picornaviridae 278, 288
 pileated gibbon (*Hylobates pileatus*) xviii, xxiii, xxvi–xxvii; see also gibbons (Hylobatidae); *Hylobates* gibbons
 planetary health paradigm 45, 48, 58, 110, 324; see also One Health strategy
Plasmodium spp. 12, 13, 30–31, 114, 283, 324
 pneumococcus (*Streptococcus pneumoniae*) 26–27, 35, 126, 281–282, 288
 pneumonia 26–27, 35, 277–278, 280, 281–282
 pneumoviruses (*Pneumoviridae*) 25, 26, 27, 35, 279, 288, 289, 324
 poaching/hunting; see also snares/traps; wild meat consumption/trade
 and ape numbers in sanctuaries 262, 263, 264
 COVID-19 impacts 60, 87, 99, 174
 deforestation impacts 88, 164
 and disease transmission 4, 14, 24, 100, 137
 roads, impact of 28, 206, 208
 sustainable hunting 58
 and tourism 85, 86
 poisoning 30, 166, 287
 polio 117, 151
 poliomyelitis 281
 pollution 30, 67, 88, 100, 167, 287
 polymerase chain reaction (PCR) tests 135–136, 137, 138, 324
 positive reinforcement training 83, 157, 258, 324
 post-mortem examinations 29, 30, 64, 115, 131, 324
 see also necropsies
 post-traumatic stress disorder (PTSD) 40, 158, 159, 284
 prediabetes 37, 324
 preparedness, disaster; see also risk assessments
 capacity and capability 184–185, 296
 case study 168–170, 294–297
 documentation 185–186, 296
 evacuation plans 190
 exercises and drills 190, 297
 governance structures 186–187
 health interventions 117–118
 management systems 187–190, 297
 monitoring/reviewing 193, 194–195
 non-human resources 185, 191
 overview 181–184
 reputational risk assessment 293
 primary prevention 144, 150, 324
 Primate Microbiome Project 69–70
 Project ChimpCARE Chimpanzee Assessment 311–312
 pro-poor tourism 85–86, 324
 proteomics 136, 324
 protozoa 6, 31, 32, 282, 283, 324
Pseudomonas spp. 281
 psychological disorders 40, 284

Q

quarantine 26, 28, 34, 87, 91, 99, 131, 181, 325

R

radio telemetry 139, 253, 325
 railways 227, 287
 recovery from disasters 168–170, 171–172, 179, 183, 191–192
 regulations *see* legislation and regulations
 rehabilitation/restoration step of mitigation 210, 302
 reintroductions 36, 62, 113–114, 134, 138, 139, 171, 239, 246–247, 250, 325
 renal disease 30, 37, 38, 39, 277, 287
 Republic of Congo 17, 21, 22–23, 137, 221–224, 263, 264
 reservoirs, disease 15, 17, 21, 24, 31, 36, 52, 126, 325
 resource extraction 60, 66, 67, 68, 75, 223; *see also* industrial development projects; logging; mining
 respiratory diseases 15, 25–28, 34–36, 41, 90, 94, 95–96, 102, 116, 151–152, 167; *see also specific disease*
 responses, disaster 168–170, 184, 186, 190–191, 193, 194–195
 retroviruses 24–25, 281, 325
 ricketts 37
 risk assessments; *see also* disaster management
 compounding risks 174–177, 318
 of Congo Basin forestry 221–224
 in contingency plans 186
 for diseases 26, 53, 62, 100–101, 136, 172, 174, 290–292
 guidance 174
 for habituation 101, 103
 for health interventions 29, 110, 112, 119, 126, 127, 131–132, 149, 152, 153–154, 156, 158
 of Ngamba Island flooding 168–170, 294–295
 PEESTOLM approach 164, 172, 174, 290–292
 for reintroductions/relocations 36, 120, 133, 134, 190–191, 212
 reputational risk assessment 293
 reviewing 193
 risk mapping 180, 195
 as start of preparedness 181, 185
 risk management 119, 133, 170, 172–178, 195, 215
 risk mapping 165, 180, 294
 RNA (ribonucleic acid) 27, 135, 325
 roads 3, 28, 30, 200–201, 202, 206, 208, 209, 222, 223, 228, 287, 298–299; *see also* infrastructure development
 Roundtable on Sustainable Palm Oil (RSPO) 216
 roundworms (nematodes) 32–33, 135, 282, 283, 323
 Rungan River Landscape, Borneo 72–73
 Rwanda
 COVID-19 impacts 174–177, 181
 Ebola virus disease (EVD) 185
 Gorilla Doctors 62, 63, 64, 114–115
 habitat loss/fragmentation/degradation 101
 habituation, rise in 89
 interventions, ape health 114–115, 117
 respiratory diseases 25, 289
 tourism 84–85, 85–86, 174–177, 192

S

Sabah, Malaysian Borneo 70, 85, 87, 88, 94, 95
Salmonella spp. 32, 281, 282
 sampling/testing 20, 29, 64, 91, 102–103, 117, 135–136, 137–138, 140
 sanctuaries; *see also* captive ape welfare; captive/semi-captive settings
 accreditation 244
 animal welfare 238, 244, 245, 246, 248, 255–257
 ape numbers/status in Africa 262–264
 ape numbers/status in Asia 266–267
 ape numbers/status in Europe 267
 ape numbers/status in the USA 270
 collaboration 257–259
 disaster management 168–170, 294–297
 disease transmission risk to/from humans 80
 diseases/conditions in 21, 36, 38
 Enclosure Design Tool 255–257
 health care provision 156–158
 operating at or over capacity 270
 reputational risk assessment 293
 Sangha Trinational (TNS) region, Congo Basin 221–224
Sarcoptes scabiei 16–17, 59, 60, 89, 94, 283, 317
 sarcoptic mange (scabies) 16–17, 59, 60, 89, 94, 283, 317
 screening 32, 62, 64, 82, 94, 100, 113, 114, 131, 137–138
 scurvy 37
 Sebangau National Park, Borneo 72, 73, 167
 secondary prevention 144, 150, 161, 325
 semi-terrestriality xxx
 Senegal 164, 301–302
 sentience 211, 212, 233, 234, 236, 237, 259, 261, 325
 septicemia 124, 277, 280, 325
 seroconversion 114, 124, 325
 serology 29, 114, 325
 severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) xi, 7, 13, 35–36, 45, 60, 66, 171, 174, 176, 181, 278; *see also* COVID-19
 shared situational awareness 187, 196, 325
 siamang (*Symphalangus syndactylus*) xix, xxiii, xxvi–xxvii, xxix, 214, 310; *see also* gibbons (Hylobatidae)
 Sibual-Buali Nature Reserve, Sumatra xvi
 Sierra Leone 192–193, 263, 264, 278
 Simandou Mine, Guinea 227–230
 simian acquired immunodeficiency syndrome (SAIDS) 24, 281
 simian immunodeficiency viruses (SIVs) 13, 24–25, 281
 smallpox 15
 smoke inhalation 28, 164, 167, 287
 snares/traps 6, 87, 115, 116, 117, 118, 121, 153–156, 174, 286
 social media 97, 103, 105, 187–188, 267, 270
 sociality/social organization xx, xxii–xxv, xxvii, 4, 11–12, 15, 21, 22–23, 25, 90, 205, 211, 325
 socioecology, of apes xx–xxxiii

- southern white-cheeked crested gibbon (*Nomascus siki*) xviii, xxiii, xxvi–xxvii, 210; *see also* gibbons (Hylobatidae); *Nomascus* gibbons
- southern yellow-cheeked crested gibbon (*Nomascus gabriellae*) xviii, xxiii, xxvi–xxvii, 210; *see also* gibbons (Hylobatidae); *Nomascus* gibbons
- southwest Bornean orangutan (*Pongo pygmaeus wurmbii*) xxi; *see also* Bornean orangutans (*Pongo pygmaeus*)
- spillback 45, 137, 325
- spillover events
 - bi-directionality 7, 13, 14, 15
 - in captive situations 4, 6
 - defining 12, 325
 - examples 13, 18, 21, 26, 91, 137
 - risk factors 45, 53, 55, 79, 80, 92, 113, 134, 230
 - risk management 95, 97, 106–107, 137, 151
 - transmission settings 14
- standard operating procedures (SOPs) 87, 94, 95, 97, 98, 245, 246, 326
- strategic environmental assessments (SEAs) 220–221, 230
- Streptococcus pneumoniae* (pneumococcus) 26–27, 35, 126, 281–282, 288
- stress
 - to apes
 - impact on gut microbiome 70
 - impact on mental health 30, 40, 158, 284
 - impact on physical health 6, 30, 83, 87–88, 90, 106, 124
 - physiology metrics 136
 - in rehabilitation/release programs 212, 239
 - to humans working with apes 159–160
- Strongyloides* 32–33, 114, 124–125, 135, 283, 326
- Sumatra 61–62, 87, 112–114, 120, 230, 254, 299
- Sumatran orangutan (*Pongo abelii*); *see also* orangutans (*Pongo* spp.)
- CITES and IUCN listing xvi, xxi
- diet xvi, xxix
- distribution xxi, xxvi–xxvii
- habitat types xxviii
- home and day ranges xxx
- industrial impacts 299
- life expectancy xvi
- numbers xvi
- release programs 62, 254
- reproduction xxxii
- social organization xvii, xxv
- threats to xvi
- translocations 120
- weaning age xxxii
- superinfections 124, 326
- surge capacity 184, 326
- Sustainability Policy Transparency Toolkit (SPOTT) (ZSL) 226
- Sustainable Development Goals (SDGs), UN 45–46, 48–49, 75
- syndromic surveillance 28, 326
- ## T
- Tai National Park, Ivory Coast 16, 18, 19, 21, 24, 288
- Taiwan 266
- Tanjung Puting rehabilitation site, Kalimantan, Borneo 87, 88
- Tanzania 16, 24–25, 90, 91, 115, 116, 117, 262, 288
- Tapanuli orangutan (*Pongo tapanuliensis*); *see also* orangutans (*Pongo* spp.)
- Batang Toru Ecosystem 62
- CITES and IUCN listing xxi
- diet xxix
- distribution xvi, xxi, xxvi–xxvii
- habitat types xxviii
- inbreeding concerns xvi
- industrial impacts and mitigations 230, 299
- numbers xvi
- resilience xxix
- threats to xvi
- translocation risk matrix 134
- tapeworms (cestodes) 32, 33, 283
- terrestrial locomotion 205, 208, 326
- “territories of life” 68
- tertiary prevention 144, 326
- testing *see* sampling/testing; screening
- ticks 102
- tourism and research 59–60, 62–64, 77–107, 248–250; *see also* habituation
- aiding conservation 60, 83–84, 86–87, 105–106
- and animal welfare 248, 250, 303
- benefits/costs to local communities 78, 85–86
- best management practices (BMPs) 91, 97–100, 105
- COVID-19 impacts 87, 98, 174–176, 181, 264, 270
- disease prevention strategies 28, 91, 97–103, 106–107, 176, 181
- as disease risk factor 78, 89, 90, 91, 94, 95–97, 116
- evidence-based assessments 100–101
- GDP from 78, 84–85
- human fascination with apes 78
- impact on health interventions 121
- improving for ape health 103–107
- key findings on impacts of 80
- negative impacts on apes 40, 78, 81, 87, 88, 284
- photographs 97
- post-COVID recovery 192
- trafficking, wild animal 123–125, 238, 259, 263, 264–265, 266, 267, 268, 270, 303
- translational medicine 50–51, 70, 71, 326
- translocations
 - anesthesia use 120, 122

COVID-19 impacts 171
 decision-making 120
 and disease risk 69, 94–95, 118, 120
 and human–ape conflict 118, 120
 Indonesia's plan for 129
 IUCN guidelines 128–129
 as part of disaster management 182, 189, 190–191
 rights approach to 212
 risk management 36, 133, 134, 139
 stress 40, 284
 traps/snares *see* snares/traps
 trematodes 32, 283
Treponema pallidum pertenuis (TPE) 17–18, 282
Trichuris spp. 32, 125, 283
 tuberculosis (TB) 28, 34–35, 94, 99, 114, 137–138, 282
 typhoid fever 94, 282

U

Uganda
 ape diseases/conditions found in 16, 25, 30, 59, 287, 288
 community engagement 59–60, 68, 85–86
 COVID-19 impacts 87, 174–177, 178, 181
 COVID-19 safe practices 60, 176, 181
 disaster management 168–170, 181, 294–297
 Greater Virunga Transboundary
 Collaboration 176, 178, 185, 186–187, 188
 habitat loss/fragmentation/degradation 3
 health interventions 108–109, 153–156
 human–ape conflict 89
 Ngamba Island Chimpanzee Sanctuary 168–170, 294–297
 numbers of apes in sanctuaries 263, 264
 pesticide poisoning 287
 strategic environmental assessments (SEAs) 220
 tourism 60, 84–85, 85–86, 86–87, 89, 99, 104–105, 174, 181
 ultrasound 29, 71, 115, 326
 United Arab Emirates (UAE) 118, 123–125, 265, 267
 Universal Declaration on Animal Welfare (UDAW) 243–244
 utilitarianism 146, 326

V

vaccination
 of apes 24, 25, 26, 117–118, 124, 126–127, 151–152
 of dogs/cats 65
 ethical complexities 123, 126–127, 151–152
 of humans 26, 27, 28, 55–56, 64, 176
 of non-ape wildlife 126
 varicella-zoster virus 33

vectors, disease 65, 326; *see also* reservoirs, disease
Versteria mustelae 33
 vicarious resilience 160, 326
 vicarious traumatization 159–160, 326
 Vietnam 210, 265, 266
 viral infections 15, 25–28, 33, 35–36, 277–281, 288–289
 Virunga Massif, Rwanda and DRC xxviii, 60, 87, 89, 98, 115, 188
 Virunga National Park 63, 64, 77–78, 85, 135, 174, 198
 viruses *see specific virus*
 vitamins 37
 Volcanoes National Park, Rwanda 64, 85, 101, 289

W

weaning ages xxxii
 welfare *see* captive ape welfare
 western black crested gibbon (*Nomascus concolor*)
 xviii, xxiii, xxvi–xxvii; *see also* gibbons
 (Hylobatidae); *Nomascus* gibbons
 western chimpanzee (*Pan troglodytes versus*); *see also*
 chimpanzees (*Pan troglodytes*)
 CITES and IUCN listing xxi
 disease transmission from humans 25, 26, 288
 distribution xxi, xxiv–xxv
 habitat type xxvii
 human metapneumovirus (HMPV) 25, 26
 human respiratory syncytial virus (HRSV) 25
 increased sanctuary intake of 264
 industrial impacts and mitigations 210, 227, 298, 301–302
 leprosy 18
 numbers xiv
 population declines xv
 western gorillas (*Gorilla gorilla*); *see also* Cross River
 gorilla (*Gorilla gorilla diehli*); gorillas (*Gorilla* spp.);
 western lowland gorilla (*Gorilla gorilla gorilla*)
 diet xxix
 distribution xv
 habitat types xxviii
 home and day range xxx, xxxi
 physiology xv–xvi
 reproduction xxxii, xxxiii
 social organization xvi, xxiii
 threats to xv
 western hoolock (*Hoolock hoolock*) xvii, xxii,
 xxvi–xxvii; *see also* gibbons (Hylobatidae);
Hoolock gibbons
 western lowland gorilla (*Gorilla gorilla gorilla*);
see also gorillas (*Gorilla* spp.); western gorillas
 (*Gorilla gorilla*)
 cardiovascular disease 38
 CITES and IUCN listing xxi
 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

Y

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

Z

- 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/semi-captive 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

