Subject Index

ablation 173, 176
Aborigines 231
abrupt change 163, 164, 211, 260, 318–325, 413
  definition 319
Achilles' heels 318–324
acid rain 238, 265, 270–272
adaptive management 7, 18, 19, 356, 367, 381–384, 412–414
aeolian dust 194–197, 201
aerobic metabolism 86, 121, 216
aerosols 253, 265, 268, 274, 275, 282, 283, 299, 315, 390
  future estimates 316
  production of 256, 274
  role in climate sensitivity 314
Agenda 21 groups 358
agriculture 12, 230, 238, 268, 285, 297, 323, 400
  abandonment 232
  cropping strategies 233
  fertilizer use 4, 270
  intensive 245–247
  late arrival in Australia 229
  mono-cropping 389
  organic 402
  rice cultivation 213, 248, 269, 390
AIDS 261, 390
air pollution 272, 275, 279
  impact on human health 283
Aldo Leopold Leadership Program 393
algae 44, 86, 259
  eukaryotic 41, 122, 124
  Grypania 38–41, 122
  Allerød event 165, 199
alternative energy sources 265, 281, 298
altruism 222–224
Amazon rainforest 202, 255, 372
Amerindian "horse culture" 94, 233
Amsterdam Declaration 7, 8
anaerobic processes 85, 121, 216, 258, 269
Antarctic bottom water (AABW) 159, 163
Antarctica 279, 390
  ice sheets 171, 198, 199
  ozone hole 4, 261, 286, 324, 332
  total ozone 267, 287
Anthropocene 6, 239, 265, 266, 286, 293, 313, 314, 342
  climate dynamics 142, 265
  emergence of 297
  models of future evolution 310
  history of 1, 2
anthroposphere 10, 25, 106, 295, 388, 390, 397
  –ecosphere interactions 368, 372, 373, 377, 425
  monitoring 330
aquaculture 402
Aral Sea 235, 236, 240, 334
Archaean environment 60, 73, 77, 78, 83, 88
archaebacteria 41, 124
asteroid impact 44, 64, 65
astrobiology 31, 91, 92, 111, 125–127, 135
astronomical forcing 145, 146, 191
astronomical theory of climate change 143
atmospheric circulation 150, 157, 168, 195, 203, 272
  structure of 158
atmospheric oxygen 38, 134, 268
  history of 38, 39
  rise of 40–43, 122, 123
autocatalytic recycling 132, 133
Avança Brazil 251

bacterium 41, 79, 124
banded iron formations 65, 84, 121
Barberton 57–60, 117, 119
Beggiatoa 39, 42
bifurcation 320, 321
  Hopf 147
biodiversity 15, 20, 132, 323, 345
  conservation 350, 397, 418
  loss in 238, 310, 391, 397

biodiversity *(continued)*
models of 330
of prokaryotes 86
biogeochemical oscillators 144
biogeochemical processes 40, 74, 75, 81, 141, 150, 205, 211, 215, 317
biomarkers 41, 55, 113, 120–123, 148
biomass burning 213, 256, 265, 268, 269, 272, 275
biotechnology 249, 335, 369
biotic enhancement 81, 83, 87
bipolar seesaw 164, 166
black carbon 268, 274, 277, 283, 401
Bølling event 165, 199
Bond cycles 180
box models 295, 296
British Petroleum 403
Brundtland Commission 3, 410

C3 plants 190, 194, 217
C4 photosynthesis 216, 217
calcareous plankton 46, 47
calcification 122, 215
Cambrian 37, 65, 86
explosion 87
fauna 39, 44, 122
capacity building 26, 310, 428, 429
capitalism 228, 234, 235, 239, 355
carbon 73
black 268, 274, 277, 283, 401
cycle 37, 73, 78– 82, 202, 254
Global Carbon Project 392
organic 83, 277
sequestration 206, 237, 281, 420
sink 255
carbon dioxide 48, 78, 121, 122, 190, 216, 266, 268, 281, 283, 368, 390
atmospheric 73, 83, 260, 265, 299, 333
depletion in Cenozoic 217
global emissions from industry 303
in prebiotic atmosphere 117
regulation of 127
sequestration 206
carbonate formation 81, 117
carrying capacity 11, 13, 18, 389
cattle holding 224, 233, 248, 250, 269, 284, 285, 390
Cenozoic 217
chaotic behavior 134, 344, 376, 413
chemical spills 390, 391
chemoton model 111–114
China 224, 238, 302, 360
transportation system 390
chlorine 223, 279, 281, 287
chlorofluorocarbons (CFCs) 4, 238, 265, 279, 281, 286, 287, 299, 332, 390
chloroplasts 41, 43, 122
clathrates 203, 204
climate 143, 314
glacial 150, 151
human impact on 390
models 253, 254, 280, 327
projections 300, 316, 325, 326
uncertainty in 327, 328
role of silicate weathering 43, 123, 127
sensitivity 314, 315
variability 48, 141, 144, 146, 167, 180
Quaternary 171, 172, 182, 189
warming 4, 5, 198, 265, 266, 270, 283, 299, 370
climate change 152, 171, 177, 238, 254, 260, 307, 308, 315, 368
critical points 307
rates in high latitudes 318
scenarios 299
theory of 143, 161
CLIMBER 296
CLIMBER-2 150–153
clouds 253–256, 265, 268, 274, 275, 282, 283, 315, 316
acidity in 269
condensation nuclei (CCN) 253, 274
properties of 201, 280, 315, 401
coal 47, 298, 299, 301, 302, 303
burning 4, 272, 284
emissions 269
production 86, 285
coastal systems 245, 257, 259, 322, 323
eutrophication in 256, 257
coevolution 9, 24, 94, 112, 131, 217, 342, 352
geosphere–biosphere 73, 87, 111, 116–119, 135
model of 132
coherence resonance 321
cold trap 127, 132

Committee of Space Research 98
communication 356, 379, 422–425, 430
  of science 384, 392, 393, 396, 403
  skills 218
competition 34, 86, 129, 212, 220, 221
complexity 35, 388, 391, 392, 401, 403
  evolution of 221
  modeling 149
conscience 225, 342
  evolution of 219, 220
consumerism 216, 235, 331, 347, 355, 389, 391, 400, 402, 417
continental crust 78, 81, 82
continental growth 76, 117, 126
contract between science and society 7, 23, 24, 49, 369, 421, 422
convective feedback 165, 197
cooperation 86, 379, 392
Copernican Revolution 6, 7
coral reefs 45, 163, 167, 256
  loss 261
coupled models 329, 373
  atmosphere–ocean (AOGCMs) 149, 150, 167
  ecosphere–anthroposphere 372
  socioecological system 372
creep instability 181
cryosphere dynamics 62, 171, 295
culture 102, 230, 346, 353, 389
  Amerindian 94, 233
  Bronze period 221
  Chinese 361
  drivers of 96, 97
  equity across 343
  homogenization of 390
  Maya 105, 232
  Natufian 221
  of science 429
  Western 233, 389
cyanobacteria 84, 86, 120–124, 216, 259

Daisyworld 134, 296
Dansgaard/Oeschger (D/O) event 162–166, 180, 196, 319, 321, 324
Darwin (ESA) mission 126
Deccan Traps 45
Deevey's logarithmic–logistic function 227, 229
deforestation 4, 231, 249–251, 255, 285, 294, 368
  Amazonia 224, 251
  logging 251
  New England 232–234
  tropical 245, 254, 256, 260
democratization 228, 235
demographic transition 234, 250, 296, 317
denitrification 197, 258
desertification 201, 260
Devonian 87
diatoms 217
digital-mimicry principle 384
dissipotrophs 85
DNA 35, 58, 78, 123
domestication of animals 221, 228, 231, 266
Drake Equation 77
Dust Bowl 105, 235
dust feedback 200, 201, 277

early Earth 60–63, 78, 104
early warning systems 261, 347, 418
Earth system models of intermediate complexity (EMICs) 51–154, 205, 296
ecology, integrative streams in 374, 375
economy 387
  creation of 219
  free trade 402
  global 368, 372
  growth 23, 134, 304, 398, 402
  markets 389, 394, 399
  models of 296, 329
  transformation of 329
ecopoiesis 127
ecosphere–anthroposphere interactions 368, 372, 373, 377, 425
education 224, 374
  of scientists 384, 428, 429
Eemian interglacial 5, 153, 167, 172, 177, 180
El Niño Southern Oscillation (ENSO) 157, 159, 167, 194, 203, 317, 395
energy 132, 134, 298, 301
  –balance models 145, 174, 176, 296, 299
  global demand 222

energy *(continued)*
production 224
primary 301, 302
renewables 2, 225, 281, 298–302, 420
requirements 298, 300
savings 265
sources
alternative 265, 281, 298
blackouts 222
transition in 298
entropy 220
environmental degradation 231–233, 237, 249, 331–336, 398, 409, 418, 429
impact on migration 91, 105–107
social consequences 232
environmental recovery 133, 232, 234, 240, 429
epiphytic macroalgae 259
Equidae 94
equity 9, 10, 343, 354, 355, 428
erosion 231, 400
eukaryotes 41, 63, 64, 73, 81, 85–87, 114, 115, 121, 123, 128
Europa 57, 125
geological history 60, 62
Europeanization 232, 233
eusociality 124
eutrophication 4, 248, 257–260, 322, 323
evolution 64, 103, 112, 113, 134, 345
ape-to-human transition 130
human 94, 211, 212, 218, 221
language 130
major transitions in 29, 30, 34, 35, 111, 115, 116, 135
causes 87
of C4 plants 217
of complex life 85
of functional groups 215
of human behavior 211
of our Sun 86
societal 223
evolutionary "cheats" 133
exit option 91, 107, 108
extinction 48, 132, 133, 224, 391
Cretaceous 44, 45
current rate of 236
impact on human health 252
mass 44, 45, 211, 236, 260
of biota 231
of Holocene megafauna 231
of large reptiles 64
of megafauna 231
role of deforestation 252
Permian 44, 125

faint young Sun 40, 60, 74, 78, 120
Ferrel cell 158
fertilizer use 4, 201, 247, 257, 399
nitrogen 247, 248, 270, 285
fire 133, 134, 251, 266, 274
human use of 228, 230
role in extinction 231
fish 45, 48, 236, 248, 249, 258–260, 271, 284, 285, 322, 389, 390, 394–396
food production 10, 221, 246
demand for 5, 246
fertilizer use in 4, 201, 247, 257, 399
impact of S on 304
fossil fuels 4, 223, 228, 269, 281, 299, 389, 390
burning 238, 268, 272, 275, 285, 368
emissions 48
technologies 234
fungi 86, 124

Gaia 29, 30, 34, 112, 131–136, 431
autocatalytic 112, 133
emergence of 37
hypothesis 77
probable 33
theory 73, 75, 80
GAIM 8, 372
game theory 133
gas hydrates 203
general circulation models (GCMs) 294–296, 316, 326
atmospheric 150, 151
GeoAction 348, 354, 356
GeoGraphy 348, 351–353
GeoMind 348, 353, 354
geoscope 330, 348–351, 363, 364
geosphere–biosphere coevolution 73, 86, 111, 116, 119, 135
glaciation 42, 47, 64
extreme 42, 43
global 64, 66

glaciation *(continued)*
Huronian 40, 121
Makganyene 40
Marinoan 42
Neoproterozoic 124
Sturtian 42
Varangerian 42
Global Carbon Project 392
Global Climate Observing System 328
global management (*see also* adaptive management) 343–347, 354, 355
global warming 7, 9, 12, 48, 266, 283
acceleration of 202
past periods of 204
potential (GWP) 269
globalization 96, 134, 229, 238, 239, 334, 367, 370, 372, 387–391, 398
global subject 343, 356, 372, 381
governance 341, 391, 392, 397
designing 400, 401
effective 388
incentive policies 20–22, 223, 224, 399
grassroots organizations 402
Great Depression 235
Great Oxidation 37–41, 121, 122, 135
Great Plains 233, 235
Great Tropical Reactor 255
Green Ocean models 329
Green Revolution 17, 331, 333, 399, 401
technologies 246, 248
Green Sahara 199, 200
greenhouse gas 248, 258, 265, 268, 283, 286, 304, 314–316
forcing 154, 203, 275, 282
in Quaternary 192, 193
warming scenario 142
Greenland
ice cores 172, 178, 180
ice cover 324
ice sheet 107, 171, 177, 184, 198, 320
grounding line 172, 182, 183
Grypania 38–41, 122
guidance systems 19

habitability 75–77, 104, 111, 131, 215
minimal requirements 89
habitable zone 75, 102, 126
definition of 74
Hadean environment 77, 78
Hadley cell 158
health 234, 261, 283, 324, 378, 389, 390
agencies 400
AIDs 261, 390
disease vectors 372
malnutrition 261, 324
pandemics 261, 324
problems 238, 283, 390
Heinrich event 162–166, 179, 180, 196
Heinrich layers 172, 178
Hilbertian program 8, 9, 13
holistic approach 11, 125, 297, 357, 373, 384, 392
Holocene 142, 160, 172, 180, 199–202
hominids 94, 95
evolutionary tree 212
Homo erectus 130
Homo sapiens 48, 95, 130, 211, 213, 218, 221, 266
Hopf bifurcation 147
horse 94, 217, 233
hot spots 154, 317, 321
human exploration (*see also* migration) 96, 97, 102–104
space 98–104, 108
human impacts 48, 211, 213, 245, 246, 260, 265, 268, 284–286, 293–297, 313–316, 319, 332, 342, 345, 367, 387–392
list of of 285
human–environment condition 227, 313, 331, 409
hunting 95, 212, 230, 231
Huronian glaciation 40, 121
hydrological cycle 80, 87, 127, 174, 193, 194, 265, 274, 280, 282
hydroxyl radical 255, 269–271, 322
hypoxia 259, 260, 323

ice 155, 198
albedo 149, 193
deformation 173
volume 141, 144, 145, 149, 172
ice ages 141, 148, 163
characteristics of 171
theories of 143, 174, 184
triggering of 161

ice sheets 141, 151, 164, 171, 173, 191
100-ka relaxation oscillations 145
Antarctic 171, 198, 199
continental 42, 155, 161, 164, 168, 172, 176
Eurasian 179
Laurentide 172, 178, 179, 184
modeling 176
North American 161
rapid climate change 177, 181
thermomechanical instability 181, 182
impact models 297, 325, 326
incentives 20–22, 223, 224, 399
tradeable permits 420
India
coal resources of 302
Honey-Bee network 22
transportation system 390
Industrial Revolution 234, 257, 297
industrialization 228, 246, 298
advanced 229
information 20, 36, 234, 369, 376, 380, 400, 430
processing 238, 374
technology 49, 429
insolation 161, 162, 174
institutions 20, 229, 356, 388, 395–404, 418, 421, 430
alternative 387, 396
defined 21
economic 399
GATT 398
global-level 425
local 420
NGOs 348, 368, 402
WTO 398
integrated assessment (IA) 14, 297, 411
models 300, 308, 310, 327, 330
intelligence 83, 127–130
evolution of 125, 128
Inter-Academy Council 426
interglacial
climate 150–153
Eemian 5, 153, 167, 172, 177, 180
–glacial cycles 142
Intergovernmental Panel on Climate Change (IPCC) 4, 270, 300–302, 316, 344, 356, 357, 381, 392, 427
climate projection 325, 326
International Council for Science 426
International Council for the Exploration of the Sea (ICES) 392
International Geosphere–Biosphere Programme (IGBP) 8, 372, 392
International Human Dimensions Programme on Global Environmental Change 392
International Human Dimensions Programme on Global Environmental Change (IHDP) 372, 392
International Institute for Applied Systems Analysis (IIASA) 22, 395
International Institute for Sustainable Development 426
International Maize and Wheat Research Center (CIMMYT) 399
International Monetary Fund (IMF) 398
International Organization for Standardization (ISO) 402
International Research Institute for Climate Prediction 395
International Social Science Council (ISSC) 426
International Space Station (ISS) 104, 105
International Union for the Conservation of Nature (IUCN) 2
intertropical convergence zone (ITCZ) 159, 162, 163
invasive species 236, 390
invisible hand argument 133
IPAT 229
iron fertilization 201, 206
irreversibility 36, 198, 297, 381, 383, 413, 414
irrigation 201, 224, 232, 235, 246, 249
canal construction 236
in Mesopotamia 331

Japanese Earth Simulator Centre 307, 327
Johannesburg Summit 3, 15, 21, 24, 343, 364–368, 402, 411
Jupiter 63, 117

K/T extinction 132, 133, 217

Keeling curve 266, 267
kerogen 81–83, 121
knowledge 7, 17, 18, 266, 377, 384, 391, 392, 427
  coproduction 393, 395, 403
  ethical 220, 224
  gaps in 382
  individual 222
  integrating 21, 22
  lay 377, 423, 430
  other forms of 367, 378
  policy-relevant 387, 388
  technological 224
  transfer 219, 266, 393
Kramer's rule 321
Kyoto Protocol 18, 107, 239, 396, 403

Labrador Sea 178
land use 236, 266, 268
  change 20, 48, 253, 256, 272, 294
landscape 361, 362
  fragmentation of 236
  human imprint on 211, 230–233, 245
language 49, 111, 125, 129, 130,218, 220
  emergence 115, 218
  origin 130, 131
  syntax 125, 131
Large-scale Biosphere-Atmosphere Experiment, Amazonia 317
last common ancestor 37, 98, 115
Last Glacial Maximum (LGM) 150, 159, 160, 171
Late Cretaceous 63–66
Late Paleocene Thermal Maximum (LPTM) 142
Laurentide ice sheet 172, 178, 179, 184
lay knowledge 377, 423, 430
League of Nations 410
life
  complex 64, 73
  conditions for 54, 55, 78
  defined 53, 74, 78, 112
  emergence of 36, 37, 119
  evolution of 29, 63, 64, 112, 113
  on Earth 59, 93, 125
  origin of 54, 73, 75, 77, 79, 112, 134
  open questions 88
  role in carbon cycle 37
life expectancy 5, 220, 234, 295, 297
lifestyle 96, 106, 130, 329, 331, 346, 364, 389, 390
  expectations 234, 235, 391
  protecting 418
  suburbia 223, 224
lightning 253, 256, 271
lignin 133, 216
Lilliput principle 384
litho-panspermia 98–101, 127
logarithmic–logistic function 227, 228

macroscopes 9, 341, 350, 351, 425
major transitions in evolution 34–37, 111
Makganyene glaciation 40
malnutrition 261, 324
management
  adaptive 7, 18, 19, 356, 367, 381–384, 410–414
  goals 341–344, 358
  global 343–347, 354, 355
  tools 417
marine ice-sheet instability hypothesis 182, 183
Marine Isotope Stages 11 (MIS11) 142
Marinoan glaciation 42
Mars 61, 100–104, 125–127
  origin of water 56
  terraforming 98
mass extinction 44, 45, 211, 236, 260
Maya culture 105, 232, 234
megafauna 48, 231
mental component 341–349, 362
Mesopotamia 232, 331
metazoans 42, 88, 122, 124, 128, 221
meteorites 55–57, 60, 61, 98, 100, 116
  Martian 101, 103
methane 85, 120, 126, 132, 192, 248, 255, 269, 283, 390
  anthropogenic sources 200, 248, 270
  concentrations 270, 294, 299
  in prebiotic atmosphere 117
microaerobes 85
microbial mats 38, 46, 119
mid-Holocene 167, 320
  greening 142, 199, 200
mid-Pleistocene transition 145, 148, 191, 192

migration 91, 93, 98, 266
forced 105–107, 235
human 94–96, 135, 296
impact on coastal systems 257
interplanetary 91, 97
role of exploration 96, 97
Milankovitch cycles 47, 166–168, 191
Milankovitch–Croll theory 174, 184
Millennium Report 3, 12, 2, 343
mitochondria 122, 124
models
of the Anthropocene 310
atmosphere–ocean (AOGCMs) 149–151, 167
biodiversity 330
box 295, 296
chemoton 111–114
climate 253, 254, 280, 327
coupled 329, 372, 373
development 419
Earth system models of intermediate complexity (EMICs) 151–154, 205, 296
economic 296, 329
energy–balance 145, 174, 176, 296, 299
general circulation (GCMs) 294–296, 316, 326
Green Ocean models 329
impact 297, 325, 326
integrated assessment 300, 308, 310, 327, 330
socioeconomic 227, 296, 300, 308, 317, 326, 328
socioecological system 372
monsoon 9, 125, 161, 162, 168, 195, 200–204
Montreal Protocol 239, 271, 333
Moon 102, 116, 117

Natufian culture 221
natural selection 80, 115, 217
role in planetary regulation 30, 31, 49
Neanderthals 95, 130
neoliberal paradigm 398
Neolithic revolution 221
Neoproterozoic 37, 42, 43, 87, 122, 135
glaciations 124
networking 396, 397, 429
neural networks 131
N-GRIP 180
nitrogen 4, 73, 197, 332, 333
fertilizer 247, 248, 270, 285
fixation 32, 84, 197, 216
in prebiotic atmosphere 117
transformation pathways 259
nitrogen oxides (NO_x) 238, 248, 255
nitrous oxide (N_2O) 248, 270
no-analogue state 227, 230, 234, 313, 334, 367, 372, 390, 391
nomadic groups 212, 225
non-decomposability 373, 413
noösphere 2, 6, 15, 20, 21, 24
North Atlantic 161, 172, 177–180, 196, 198, 317
deep water (NADW) 159
Oscillation (NAO) 157, 159, 167, 194, 203
nuclear energy 222, 299–302, 347, 391

observation network 349–351, 362, 411, 425, 430
Geoscope Project 330
Global Climate Observing System 328
macroscopes 9, 341, 350, 351, 425
Occam's Razor 374
ocean
circulation 151, 157, 159, 163, 166, 168, 173
formation 78
timescales 295
oil 299–302, 325
burning 4, 284
spills 390
Organization for Economic Co-operation and Development (OECD) 304–306, 398, 420
overfishing 258–260, 322, 323
oxidation 38, 40, 124
oxygen 93, 120–122, 125, 126, 132–134
depletion 259
early Earth conditions 60
ozone 93, 124, 248, 256, 265–267, 270–272, 274, 280, 390
hole 4, 261, 279, 286–288, 319, 324, 332, 333

ozone *(continued)*
layer 127, 237, 279, 286
photochemical 4, 93, 238, 272, 285
stratospheric 286

paleo-analogues 141, 142
Paleocene–Eocene Thermal Maximum (PETM) 204
Paleoclimatic Modeling Intercomparison Project (PMIP) 150
pandemics 106, 261, 324
panspermia 97, 98
parasol effect 282
participatory decision making 26, 368, 402, 412, 415, 416
passive adaptive strategies 383, 414
Permo-Carboniferous 122
perturbations 245, 254, 259, 390–392, 401
pesticides 391, 399, 400
Phanerozoic 44, 46, 48
phosphorus 73, 122, 197, 248
photochemical smog 39, 238, 256, 265
photosynthesis 64, 73, 77, 93, 268
anoxygenic 119
oxygenic 37, 116, 119, 122
phytoplankton bloom 259
Pilbara greenstone belts 59, 117, 119
plants 86, 124, 132
C3 190, 194, 217
domestication of 221, 228, 231, 266
plate tectonics 59, 117, 126, 132, 135
Pleistocene 47, 144–147, 231
policy making 379–382, 387, 388, 393, 395, 402, 430
population 214, 266, 297, 388, 389
capacity 228
explosion 246
growth 213, 214, 227–230, 234, 235, 245, 257, 296, 329, 334, 400
pressures 230
poverty 250, 324, 343, 344, 398, 399, 411
Precambrian geological record 84
precautionary principle 396
precipitation (*see* rain)
primary energy structure 301, 302
probability distribution function 307, 327
projections 303
anthropogenic climate change 307
climate change 296, 300, 329
prokaryote 64, 73, 79–87, 93, 113, 115, 119, 123, 128
Proterozoic 38, 40, 44, 121
public awareness 393, 396

Quaternary 125, 141, 142, 154, 189, 192
atmospheric circulation 157
climate change 160
critical processes 195
major features of climate 190
oceanic circulation 157
phase-space topology 171
unified theory of system dynamics 154

radiative forcing 107, 145, 157, 265, 270, 274, 281, 304, 306, 315
rain 163, 235, 246, 253, 255, 275, 283, 320
acid 238, 265, 270–272
Red Queen 129, 132, 133, 211, 217–220
Redfield ratio 197
redox coupling 135, 214
regional forums 427
regional synthesis centers 429
renewables 2, 225, 281, 298–302, 420
research
agenda 31, 132–134, 377, 381, 417
challenges 335, 419, 420
cooperation 373, 375, 384, 393, 428
gaps 270, 271
needs 317, 370, 376, 377, 411, 420, 427, 428
rice cultivation 213, 248, 269, 390
Rio de Janeiro summit 3, 15, 358, 368, 402, 411
risk 327, 377, 380, 384, 401
RNA 35, 58, 78, 113, 123
rubber production 372
RuBisCO (ribulose bisphosphate carboxylase/oxygenase) 134

saccharolytic pathway 84
safe domains 418, 430
salinization 231, 232, 249, 331

scenario
building 419
climate change 299–302, 306
climate warming 142
coevolutionary 117
interplanetary transfer of life 100
SRES emissions 303–305
science
and technology 223, 225, 387, 393, 416
changes needed in 367–370
culture of 429
interface with policy 367, 379, 380, 394–397, 412, 421
limitations to 353, 354
training 384, 428, 429
Science and Policy Partnership for Sustainability 380
Science for the 21st Century 369
Scientific Committee on Problems of the Environment 392
sea ice 155, 161, 173, 195, 202
sea level 5, 161, 191, 192
change 162, 164
decrease 203
search for extraterrestrial intelligence (SETI) 67, 111, 127, 128
Seaweb 393
Second European Sulphur Protocol 304, 305
self-awareness 2, 345, 376, 409, 410
self-regulation 31, 32, 49, 73, 77, 89
sequestration 265, 417
silicate weathering 43, 123, 127
smog 4, 39, 120, 238, 248, 256, 265
smoke 253, 254, 274, 275
snow 42, 152, 173–177, 198, 199, 295, 361
albedo feedback 155
snowball Earth 33, 42, 65, 74, 87, 121
social contract for science 7, 23, 24, 49, 369
social systems 376, 377, 388
sociocatalytic theory 133
socioeconomic models 227, 296, 300, 308, 317, 326, 328
soda ocean 78
soil salinization 231, 232, 249, 331
Southern Ocean 317
Soviet Union 102, 235
space travel 98–104, 108
Spanish Flu pandemic 261
SRES scenario 300–306
stakeholders 11, 355, 380–384, 397
disenfranchised actors 402
involvement 367, 380, 381, 393, 402, 403, 412
participatory decision making 26, 368, 378, 402, 412, 415, 416
state variables 418
sterols 121–124
stewardship 367, 370, 384, 409
stochastic resonance 321
Stockholm Conference on the Human Environment 260
stromatolites 81, 119, 120
Sturtian glaciation 42
sulfur 73, 299, 304–306
surface albedo 42, 152, 174
sustainability 133, 214, 370, 384, 388, 392, 395, 403, 404, 409
defined 2, 214, 343
guidance systems for 19–21
option 107
prerequisites for 314
prognosis for the future 5, 6
science 14–18, 370
strategies for 367, 373
transition to 1, 6, 239, 371, 387, 391, 394, 403, 411
sustainable development 3, 15–17, 91, 224, 367, 368, 378, 397, 410
synthesis centers 429

technological fix and substitution 235, 237, 331–334
technological intelligence 64
technology 266, 333, 389
capacity 228, 368
evolution of 329
innovations 49
pressures 230
terraforming 98, 104, 127, 133
terrestrial life, origin of 54, 58
terrestrial mismanagement 91
exit option 91, 107, 108

Terrestrial Planet Finder (NASA) 126
thermodynamic constraints 126, 220, 221
thermohaline circulation (THC) 153, 159, 163, 181, 195–197, 317, 320
thermohaline circulation riddle 151
thermomechanical instability 181, 182
Third World Academy of Science 426
tool use 129, 218, 220, 228
tourism industry 96
tragedy of the commons 409
transition toward sustainability 1, 6, 239, 371, 387, 391, 394, 403, 411
tropical forest 251, 252, 255, 294
  deforestation 245, 254, 256, 260
  extinction of species 236, 252
tundra–taiga feedback 199

ultraviolet radiation 56, 62, 93, 116, 120, 132, 255, 271
  extraterrestrial solar 97
  shields 119
uncertainty 327, 344, 347, 367, 376, 381, 384, 391–395, 403, 413
United Nations 343, 354, 364, 410, 426
  Conference on Environment and Development 3, 15, 358, 368, 402, 411
  Environment Programme (UNEP) 356
  Food and Agriculture Organization 400
  Framework Convention on Climate Change 18, 357, 396
  Johannesburg Summit 3, 15, 21, 24, 343, 364–368, 402, 411
  Millennium Report 3, 12, 343
  World Summit on Sustainable Development 3, 15, 21, 24, 343, 364–368, 402, 411
universal common ancestor 79, 120
unpredictability 368, 345
urbanization 222

values 16, 17, 229, 230, 344, 355, 365, 380, 411, 424
  belief structures 219
  criteria of truth 367
Varangerian glaciation 42
vascular plants 46, 87, 122
Venus 56–61, 66, 76, 99
Viking expedition 104
virtual biospheres 75, 87
volatile organic compounds (VOC) 255, 256, 309
Vostok 1 spacecraft 102
Vostok ice core 148, 182, 192–194
vulnerability analysis 18, 19

warning signals
  detection 261
  early warning systems 261, 347, 418
waste disposal 257, 258, 322, 323
water 248, 343, 365
  conservation 249
  cycle 256
  drinking 343
  for irrigation 249
  importance for life 54, 55
  in prebiotic atmosphere 117
  on Europa 62
  on Mars 62
  origin of in solar system 56
  redistribution of 224
  role in astrobiology 125
  treatment facilities 237
  use 232
waterlogging 232
watershed protection 237
wealth 234, 257, 355, 364, 389
  accumulation 219
  disparity 344, 400
  distribution 224
  redistribution 223
weathering 43, 80, 81, 86, 87, 217
WEHAB agenda 417
Weichselian glacial 172, 177–180
well-being 3, 5, 231, 248, 258, 321, 378, 412, 414, 417
Western culture 233, 389
Western Hemisphere
  Columbian Encounter 233
Western Pacific Warm Pool 150
wetlands 193, 231
Wilson cycle 190
Wissenschaft 17, 20, 24

World Bank 398
World Climate Research Programme (WCRP) 372
World Conference on Science 369
World Conservation Strategy 2
World Environment Organization 426
World Health Organization 400
World Meteorological Organization 356
World Summit on Sustainable Development 343, 364, 365, 402
World Trade Organization (WTO) 398, 399, 426, 427
World War II 8, 223, 322, 369, 398

Younger Dryas event 164, 165, 178, 179, 200