INDEX

Note: entries followed by a lower-case f or t refer to figures or tables.

accumulation, of pollutants, 189f adaptive control, and two-parameter harvest policy, 119 adjacent harvests, 118 adult biomass, 79 advection: and individual motion, 124; and pollution, 190-1, 192, 193f aeration, and pollution, 197, 199–202 age: biomass as function of, 96-7; recruitment to fishable, 111 agriculture: and scarce resources, 132; and sequential harvesting, 103, 108 Allman, E. S., 89 alternative constraints, and water management, 152 annual yield, 103 anoxia, and pollution, 200, 208 assimilative capacity, and pollution, 188, 190 augmented form, and canonical forms, 139 autocorrelated series, and random numbers, 217 autocorrelation, and dynamics of water management, 170-1 Bau, D., 218 binary-integer programming, 151 bioaccumulation, 195-7 bioeconomic interaction, of growth and harvesting, 42 biology. See individual-based modeling

biology. *See* individual-based modeling biomass: and cohort, 95; and computer programs, 63–4; concept of, 42; and decision rules, 48–51; and effort dynamics, 51–3; growth and

harvesting of, 42-48; intertemporal decisions and influence of interest rate on harvesting, 53-60; and sample problems, 64-70; and sustainability, 42; technology and harvesting of, 60-3; and uncontrolled recruitment, 110-11 biomass vector, and stage-structured populations, 71, 75 Bogardi, J. J., 176 bonanza cohort, 103 boom-or-bust cycles: in biomass harvesting, 52; in exploration for sterile resources, 31 Boudreau, B., 210 Bower, B. T., 209 Box-Muller transformation, 217 Bradlow, D. B., 176 Britton, N. F., 89

canonical linear-programming problem, 137–9 capital cost, and water management, 151–2 carbon, and case study of pollution, 197–202, 211 carrying capacity: and biomass, 47; and stage-structured populations, 82, 86 Carson, Rachel, 211 Caswell, H., 89 Chapra, S. C., 210 Clark, C. W., 32, 63, 126 climatology, and periodic hydrology, 162–3, 171

225

226 Inde

Index

cohort: and computer programs, 126: concept of, 95; and economic harvesting, 103-10; example of, 100-103; and individuals, 120-6; and sample problems, 126-30; and single cohort development, 95-100; and uncontrolled recruitment, 95, 110-20 cohort mining, 103, 104-106 common-pool resources, 63, 209 competition, in exploration for sterile resources, 29 competitive production, of sterile resources, 19-23 complementary slackness principle, 136 composite metric, 154-5 computer programs: and biomass, 63-4; and cohort, 126; and pollution, 211; and stage-structured populations, 89; and sterile resources, 32-3; and water management, 176-7 Conrad, J. M., 32, 63 constitutive relations, and consumptive use of water, 141 consumers' surplus (CS), and costless production of sterile resource, 7-9 consumption tax, 17 consumptive use, and demand for water, 131, 141, 142 contamination, of natural resources, 188 contraction, of demand, 12-13 controlled access: and discovery of sterile resources, 29; and equilibrium of biomass, 50-1 controlled recruitment, 95 convolution sum, and uncontrolled recruitment, 114-17 Cornes, R., 32 cost: of exploration for sterile resources, 29; of harvesting biomass, 48. See also capital cost; costless harvesting; costless production; costly case; costly production costless harvesting, of biomass, 54-5 costless production, of sterile resource, 1 - 16costly case, and harvesting of biomass, 55 - 60costly production, and decision rules for sterile resources, 17-19 Cressie, N. A. C., 218 Cushing, J. M., 89

Deangelis, D., 126 decision rules: and biomass, 48-51; and sterile resources, 16-23 decision variables: and canonical forms, 139; and human rights, 156-7 "degradability," and pollution, 188 demand, for sterile resource, 4-16. See also consumptive use; expanding demand; finite demand; linear demand Demmel, J. W., 218 dependable annual recruitment, 103 depensatory growth, 53 depletion histories, for sterile resource, 3f Deriso, R. B., 89 dilution, of pollutants, 190-1 discovery, of sterile resources, 23-31 discrete mortality events, 121-2 discrete-time description, 72 Dorfman, R., 209 dynamics: of effort in biomass, 51-3; ocean and atmospheric carbon, 211; of recruitment in stage-structure populations, 81-2; and water management, 159-74 economic exhaustion, 42 economic extinction, 48, 55 economic harvesting, 103-10 economic lifetime, and cohort mining, 104-105 ecosystems, and sustainability, 63 education, and human rights, 156, 157 Eecke, W. Ver, 159 efficiency, and discovery rate for sterile resources, 25-7, 28f effort: and discovery rate of sterile resources, 25-31; and harvesting of biomass, 45-6, 51-3 elasticity, of demand for sterile resources, 20 Ellison, A. M., 218 employment, and human rights, 156, 157 endogenous demand growth, for sterile

resource, 16 energy. *See* carbon; ethanol production;

hydropower; petroleum equilibrium, and harvesting of biomass, 49–51

escape, and residence time, 122-3

estimation, and two-parameter harvest policy, 119 ethanol production, 149

Eumetric harvest, 99, 101f, 102, 103 exhaustion: forms of, 42; sterile resources and history of, 4 exogenous discovery, of sterile resources, 23-5 expanding demand, and costless production of sterile resource, 11-16 exploration profit, and discovery of sterile resources, 28-9 exponential demand growth, 12 exponential form, and saturation of pollutants, 191, 193f export, of pollutants, 195, 208 extended harvest, 106 extinction, and harvesting of biomass, 45.47 extraction history, of sterile resource, 5–6, 26f Faustman criterion, 95, 103, 108-10 Fennel, W., 89 fertilizer, as scarce resource, 132, 136-8 Fiering, M. B., 174, 176 finite demand, and production of sterile resources, 4-9 first-order discovery rate, 23 first-order transformation, 191 Fisher criterion, 105, 108 fishery management, 42, 63, 71, 95 fish farm, and stage-structured population, 82-7 fish ladders, 145 Fitzpatrick, J., 210 flow rates: and hydropower, 144; and navigation, 145; and networked hydrology, 139-41; and reservoirs, 162 flushing, of pollutants, 191 Forester criterion, 95, 99, 100f, 110 forestry, 95, 103, 108, 110 free-access equilibrium, 49-50 free entry: in discovery of sterile resources, 29; and equilibrium of biomass, 49

Gaussian deviate, 217 Getz, W. M., 89 Gladwell, J. S., 176 Gleick, P. H., 176 Gordon-Scott fishery, 63 Gotelli, N. J., 218 Grafton, R. Q., 63 Griffin, R. C., 32, 176

Grimm, V., 126 Gross, L., 126 growth: and biomass, 43-5 growth rate distribution, and cohort of individuals, 120-1

habitat, and water quality, 204-205 Haight, R. G., 89 half-saturation constant, 63, 191 Hammer, M., 210 harvest control, 51 harvesting: of biomass, 45-63; cohorts and economic, 103-10; and pollution, 195, 197, 198f; and single cohort development, 97–9; size and timing of closures, 118-19; and stage-structured populations, 77, 79-81; and uncontrolled recruitment, 112-13, 117-18, 119 harvest per recruit, 99 HDR Engineering, 210 Heron, M., 126 Hilborn, R., 63 Hillier, F., 218 Hoppensteadt, F. C., 89 Hotelling's rule, 2 Houghton, J., 211 Hufschmidt, M. N., 176 human rights: and access to water, 176; and decision variables, 156-7 hydroeconomy, 142-3, 160 hydrology, climatological view of, 163. See also networked hydrology hydropower, 144-5, 165-7 hyperbolic form, and saturation of pollutants, 191-2, 193f

impoundments, and water pollution, 201 income, and human rights, 156, 157 individual-based modeling (IBM), of cohorts, 120-6 influence coefficients, 202 innovation rate, and technology, 60-1 instantaneous harvest, and cohorts, 99-100, 105-106, 116-17 instantaneous surge, in harvesting effort, 55 - 6integers, and water management, 150-3 interbasin transfer, of water, 153 interest rate, and biomass harvesting, 53-60 Intergovernmental Panel on Climate Change, 211

228

Index

international development, and water management, 176 intertemporal decisions, and influence of interest rate on biomass harvesting, 53 - 60invasive species, 44

Kaul, I., 32 Kneese, A. V., 209 Kundzewicz, Z. W., 176

lakes, and water pollution, 202-209 land, as scarce resource, 132, 133-6 learning curve, and discovery rate for sterile resources, 25-7 Leslie matrix, 72-4, 88 Levin, S., 126 life stages, 71 linear demand, and production of sterile resources, 9-11, 12-13, 20-22, 23f loading, of pollutants, 189f logarithmic transformation, 173-4 logistic growth, 43-4, 57-9 Loucks, D. P., 174, 176 Lough, R. G., 126 Lynch, D. R., 209

Major, D. C., 176 Mangel, M., 63, 103, 118, 126, 218 Marglin, S. A., 176 market control, and harvesting of biomass, 51 Martell, S. J. D., 63 maximum sustainable yield (MSY), and biomass harvesting, 45, 47, 54 McGillicuddy, D. J., 126 merit, and goals of resource management, 158 - 9metrics, and water management, 154-6 Miller, C., 126 mixed cohorts, and economic harvesting, 107-108 mixed-integer programming (MIP), 151 modeling, and individual-based processes, 125-6 monopoly production, and sterile resources, 19-23 mortality: cohort of individuals and discrete events of, 121-2; and single cohort development, 97-9; and stage-structured populations, 72

motion, and individual-based cohort processes, 124 Mueller, J. A., 210 multiple loading, and pollution, 202-209 multiple objectives, and goals of water management, 153-4 municipal water supply, 143-4, 204-205 Murray, J. D., 89 Musgrave, P. B. & R. A., 32, 159 Nassauer, J. I., 210 navigation, and water management, 145 Neher, P. A., 32 network continuity equation, 140 networked hydrology, 139-41, 160 networked rivalry, 131 Neumann, T., 89 "New Scarcity," and pollution, 188 nonconsumptive use, of water, 131, 145 nonlinear recruitment, 86-7 nonrenewable resource, 103 N stages, and stage-structured populations, 87-8 numbers of individuals per stage, 71

ocean, and long-term carbon dynamics, 211 Okubo, A., 126 old growth, as economically nonrenewable resource, 110 open access: and discovery of sterile resources, 29; of equilibrium of biomass, 49 Ostrum, E., 63 oxygen deficit, 199

parks, and water quality, 204-205 peak harvest per recruit, 99 periodic hydrology, 162 perturbations, and production of sterile resources, 18 petroleum, as example of sterile resource, 1 physics, and site-specific simulations, 125 political control, of biomass harvesting, 51 political exhaustion, 42 pollution: and basic processes, 188-97; carbon as case study in, 197-202; common-pool nature of, 209; and computer programs, 211; and multiple loading, 202-209; as resource in reverse, 188; and sample problems, 211-15; and transport

Index

229

processes, 209-10; water management and control of, 148 population structure, and stage-structured populations, 71-5 Press, W. H., 216 producers' surplus (PS), and costless production of sterile resource, 8 production: and monopoly versus competition in sterile resources, 19-23; rate of relative to discovery of sterile resources, 25. See competitive production; costless production; costly production; monopoly production productive resource, water as, 132-45 Proehl, J., 126 program of activity, and canonical forms, 139 programs. See computer programs proportional rate of growth, 43 proportional tax, 17 pseudo-random generators, 216 public health, and water management, 147 - 8quadrants, and resource classification, 1 quasistatic case, 160-1 Quinn, T. J., 89 Railsback, S., 126 random numbers, generation of, 216-18 random recruitment, 114 random walk, and individual motion, 124

rate of growth, proportional, 43 rational economic actor, 54 Rawlsian metric, 155 reaeration rate, and pollution, 199-200 recruitment: and cohort, 95, 110-20; definition of, 71; and stage-structured populations, 75-82, 86-7, 88 recycling, of sequestered biomass, 195, 196 regret, and goals of resource management, 157-8 removal, of pollutants, 188, 189f renewable resources: and economic harvesting, 103; financial criterion for, 55; fundamental equation of, 60; water as, 131-2. See also sustainability Renshaw, E., 89

rent: and biomass, 47–8; and production of sterile resources, 3, 6, 10, 13; and

stage-structured populations, 77-9. See also total rent rent dissipation point, 49 reproduction: and individual-based cohort processes, 123-4; stage-structured populations and rate of, 72, 83 reservoirs, and water management, 161-8, 206-208 residence time, 122-3, 190-1 resource(s). See renewable resources; scarce resources; sterile resources; sustainability resource mining, 42. See also cohort mining restricted entry, and discovery of sterile resources, 29 Rhodes, J. A., 89 rivers, and water pollution, 201-202, 208. See also St. John River; Wheelock/Kemeny Basin system Rodda, J. C., 176 run-of-river installations, 144, 150

St. John River, as example of water dynamics, 171-3 sale, of rights to new discoveries of sterile resources, 28 Salman, S. A., 176 Sammarco, P., 126 Sandler, T., 32, 63, 211 saturation: and demand growth for sterile resources, 14-16; and transformation of pollutants, 191-3 scarce resources: land and fertilizer as, 132; simple concept of, 1; and water, 131 sequential harvesting, 103 sequencing, and water management, 152 sequestration, of pollutants, 188, 190f, 193 - 5shadow price, 135-6, 140-1 Shiklomanov, I. A., 176 Shroeder, E., 210 Simpson, R. D., 188 simulation: of individual-based cohort processes, 124-5; of synthetic streamflow, 168-74 single cohort development, 95-100 site specific management options, 126 slack variables, 138-9 software. See computer programs solidarity matrix, 159 spatially explicit populations, 125-6

230 index

stage duration, and individual processes, 122 stage-structured populations: and computer programs, 89; concept of, 71; and fish farm, 82-7; and N stages, 87-8; and population structure, 71-5; and recruitment, 75-82, 88; and sample problems, 89-94 stage transition, and residence time, 122 - 3statistically identical individuals, 120-1 steady harvest, and stage-structured populations, 79-81 steady recruitment, and convolution sum, 116 steady state, and biomass, 45 sterile resources: concept of, 1; costless production of, 1-16; and decision rules, 16-23; discovery of, 23-31; and sample problems, 33-41; and software programs, 32-3 Stern, N., 211 stochastic disturbances, 53 stock effect, 19, 48, 59 "storage-head relation," 145 storage, of water, 144-5, 160-1, 163-5. See also reservoirs Streeter-Phelps dissolved-oxygen analysis, 199, 200f, 201-202, 206 strict equality and strict inequality, 134 suboptimal harvesting, 102-103 subsidy policy, and stage-structured populations, 86 sustainability: and biomass, 42; and exhaustion of sterile resources, 32; and pollution, 188. See also renewable resources sustained recruitment, 107-108 synthetic streamflow, and simulation study, 168-74 targets, of water management, 156-7 taxation, and decision rules for sterile resources, 17 Tchobanoglous, G., 210 technology control, and harvesting, 51 Terminal Condition (TC), and production of sterile resources, 3, 9, 14, 21 Thomann, R. V., 210 time history: and discovery of sterile resources, 30f; and production of

sterile resource, 15f, 16f time series, and synthetic streamflow, 169 total rent, and resource exhaustion, 22 transformation, of pollutants, 188, 190f, 191-3 transit time, and water pollution, 206-208 transport processes, and pollution, 209-10 Trefethen, L. N., 218 Tremblay, J. M., 126 two-parameter harvesting policy, 96 two-reservoir system, 167-8, 169f two-stage system, and stage-structured populations, 71-5 uncontrolled recruitment, and cohort, 95, 110 - 20uniform annual increment, and instantaneous harvest, 99-100 uniform deviate, and random-number generator, 216

United Nations World Water Program, 176 unit profile, 202 Universal Declaration of Human Rights, 156–7

van den Bergh, J. C. J. M., 63 variable annual recruitment, 103 vital rates, and cohort, 96

waiting time, and random-number generators, 218 Walters, C. J., 63 water: and computer programs, 176-7; and dynamics, 159-74; goals of management, 153-9; and integers, 150-3; and pollution, 201-209; as productive resource, 132-45; and sample problems, 177–87; as sterile, renewable resource, 131-2; Wentworth Basin as example of management, 145–50; and Wheelock/Kemeny Basin as case study, 174-6. See also lakes; municipal water supply; rivers weight, at fishable age, 111, 113 Wentworth Basin, and water management, 145-50 Werner, F. E., 126 Wheelock/Kemeny Basin system: as case study of water management, 174-6; and water pollution, 205-209, 210t

withdrawal, and water consumption, 142

year class, and cohort, 95