577.3 WAR

INDEX

A
Aber, J.D., 3, 97, 168, 210, 213
Abies balsamea, 165, 188
Abies grandis, 188
Abies lasiocarpa, 217
Abiotic disturbance agents, 203–218
  atmospheric factors, 207–214
    gases, 207–209
    wet- and dry-fall, 209–214
  fire, 203–207
  forest harvesting, 214–216
  mechanical forces, 216–218
  overview, 203
Abiotic site variables, 231–236
Abiotic weathering, 116
Absorbed PAR (APAR), 64, 77, 93, 94, 309
Absorbing surface area, 41
Acacia aneura, 29
Accumulation, snow, 46–48
Acer saccharum, 187, 218
Acid-neutralizing capacity, 142
Adams, J.M., 311
Adelges piceae, 187
Adsorption, 136
Advanced Very High Resolution Radiometer (AVHRR), 245, 249, 256, 273, 296, 312
Advection, 26
Aerodynamic transfer equation, 26
Aerosols, 118
Agee, J.K., 204
Aggregation errors, 234
Ahies balsamea, 187
Airborne canopy lidar sensors, 335
Air saturation deficit, 26
Air temperatures, 237, 241
Albedo, 22, 250
Allocation, carbon, 82–96
  annual assessment of, 86–94
  indices of, 94–96
  overview, 82–83
  seasonal dynamics in, 83–86
Allometric equations, 93
Allometric relations, 87, 109
Alnus, 113, 328
Alnus incana, 218
Alnus rubra, 218
Alpha species diversity, 310
Altitude, 293
Aluminum hydroxides, 121
Aluminum ions, 142
Ambient partial pressure, 63
Ambrose, S.H., 270
Ammonia, 136, 207
Ammonium, 113, 130
Ammonium nitrogen, 205
Angiosperms, 34
Animals
  browsing, 198–203
  wildlife habitat analysis, 269–272, 337
Anion
  adsorption, 142
  exchange, 133–135
Annual global atmospheric loading, 309
Annual net primary product allocation assessment, 86–94
Annual snowpack map, 284
APAR (absorbed PAR), 64, 77, 93, 94, 309
Arctic timberline, 293
Aridity, 13
Armillaria mellea, 198
Arrhenius-type relationships, 63
Asner, G.P., 335
Atmosphere-forest interactions, 272–274
Atmospheric carbon dioxide, 61
Atmospheric carbon pool, 304
Atmospheric circulation patterns, 45
Atmospheric deposition, 111–112, 138, 141, 210, 214
Atmospheric disturbance factors, 207–214
  gases, 207–209
  wet- and dry-fall, 209–214
Atmospheric humidity, 52
Atmospheric inputs, 100, 112
Atmospheric transmittance, 239
Attiwill, P.M., 203
Autotrophic respiration, 59, 67–71, 82, 91, 332
Avalanches, 218
AVHRR (Advanced Very High Resolution Radiometer), 245, 249, 256, 273, 296, 312

B
B (Bowen ratio), 22–23, 252, 327
Bacteriostatic compounds, 185
Balanities, 153
Balanities willsoniana, 153
Ball, J.T., 63
Band, L.E., 231, 233, 275, 279, 281
Bark beetles, 193–195
Bark sloughing, 187
Bartlein, P.J., 176
Base cations, 214
Beaufils, E.R., 104
Beer–Lambert law, 30, 48
Beer's law, 254
Beets, P.N., 91
Before present (BP), 293
Beta diversity, 310
Beven, K.J., 232
Bhupinderpal-Singh, 320
Bigfoot project, 329
"Big-leaf" Penman–Monteith equation, 53
Biochemical plant defenses, 185–188

Biochemical reactions, 11
Biodiversity, 310–313, 336–338
Biogeochemistry, 3, 16. *See also* Regional ecological analysis
  biogeochemical cycling, 335
  biogeochemical models, 170
  ecosystem models, 168–170
  and eddy-flux measurements, 327–328
  and potential forest distribution, 294–296
Biological fixation, 100
Biological nitrogen xation, 113
Biomass, 87, 159, 254–257, 335–336
BIOMASS model, 97, 170
Biome, 126
Biophysical model analysis, 283
Biospheric process models, 306–307
Biotic agents of disturbance, 184–203
  bark beetles, 193–195
  biochemical defenses in plants, 185–188
  browsing animals, 198–203
  defoliating insects, 188–193
  overview, 184–185
  pathogens, 195–198
Biotic analysis of forest patterns, 262–272
  disturbance propagation, 267–269
  overview, 262–263
  spatial heterogeneity, 266–267
  temporal changes in forest cover, 263–266
  wildlife habitat analysis, 269–272
Biotic variables, 234
Biotic weathering, 116
Bonan, G.B., 96, 175, 303
Bond-Lamberty, B., 336
Boreal forests, 291
Boreal zones, 84
Bossel, H., 180
Botkin, D., 173
Boundary-layer conductance, 26, 30, 31–32
Bowen ratio (β), 22–23, 252, 328
BP (before present), 293
Bridgham, S.D., 109
Bristow, K.L., 238
Browsing animals, 198–203
Bryant, J.P., 198
Buchmann, N., 139
Bulk canopy conductance, 31
Bulk density, 50

C
Calcium, 101, 108
Calvaria major, 153
Cambium, 35
Campbell, G.S., 238
Candau, J.-N., 343
Cannell, M.G.R., 84
Canopies
  chemistry, 142
  and eddy-covariance fluxes, 328–333
  evapotranspiration, 52
  gas, 7, 9
  leaf mass, 64
  leaf nitrogen, 64
  level, 3
  photosynthesis, 77
  radiation models, 254
  remote sensing light absorbed by, 253–254
  stomatal conductance, 32
  transpiration from plant, 31–32
Carbohydrates, 84
Carbon. *See also* Carbon cycle; Gross primary production; Net primary production
  acquisition, 82
  allocation, 84, 89, 168
Carbonate rock, 40
Carbonation, 116
Carbon balance, 6
Carbon cycle, 59–98
  autotrophic respiration, 67–71
  carbon balances
    landscape, 281–283
    net ecosystem, 341–342
  comparison of ecosystem models, 96–98
  forests in global, 303–310
    elements of carbon cycle, 303–305
    global net primary production, 306–309
    other gas emissions from forests, 309–310
    source/sink dynamics, 305–306
  heterotrophic respiration, 71–75
  modeling photosynthesis and respiration, 76–82
    assessment of heterotrophic respiration, 80–82
    carbon balance of vegetation, 78–80
    gross and net photosynthesis, 76–78
  net primary production and allocation, 82–96
    allocation indices, 94–96
    annual assessment of, 86–94
    overview, 82–83
    seasonal dynamics in allocation, 83–86
  overview, 59–62
  photosynthesis, 62–67
Carbon dioxide, 40
Carbon isotope discrimination, 40
Carboxylation capacity, 76
Carboxylation enzymes, 298
Carboxylation rate, 63
Castanea dentata, 195
Casuarina, 113
Cation components, 115
Cation exchange, 133–135, 210
Cation-exchange capacity (CEC), 133
Cattelino, P.J., 176, 178
Ceanothus velutinus, 113
CEC (cation-exchange capacity), 133
Cellulose, 125, 195
CENTURY model, 97, 167
Ceulemans, R., 298
C fixation, 76
Chemical weathering, 115
Chemistry, canopy, 333–335
Chen, J.M., 254
Chlorophyll, 101, 333
  levels, 64
  pigments, 65, 298

Chloroplasts, 62
Choristoneura fumiferana, 188
Choristoneura occidentalis, 188
Ciais, P., 305
Cihlar, J., 254
Clay minerals, 116
Clements, F.E., 150
Cleugh, H.A., 332
Climate
  changes in, 339–344
    climatic trends, 339
    impact on forests, 339–344
    response of forests, 298–299
  and forest interactions, 300–303
  and potential forest distribution, 294–296
  stabilization and forest planting, 315
Climatological extrapolations, 228
Climatology, 237–240
Climax vegetation, 150
C : N ratio, 73
Cobalt, 102
Cohen, W.B., 256, 266
Columbia River basin, 285–287
Composition, forest, 344
Computer simulation models, 7
Condensation, 45
Conductivity, hydraulic, 37–39
CONIFER model, 228
Conifers, 38, 39
Core area, 257
Coughlan, J.C., 48, 236
Cowles, H.C., 150
Coyea, M.R., 165, 188
Creed, I.F., 279
Crop Moisture Index, 273
Cropper, W. P., Jr., 170
Crow, T.R., 267
C-sequestration rates, 341
Cyanocitta cristata, 153

D

Daily time step model (DAYTRANS), 236
Dale, V.H., 297
Dalton's equation, 31
Daly, C., 241
Darcy's law, 52
Data layer inconsistencies, 259
Daviesia mimosoides, 205
DAYMET model, 286
DAYTRANS (daily time step model), 236
Dead soil animals, 122
Decomposition, 14, 73, 121, 124–128, 132, 133, 151, 160, 184, 193, 198
Defensive compounds, 185
Defoliating insects, 87, 188–193
Delbart, N., 332
DEM (digital elevation model), 231–232
Dendrochronology, 162–166, 341
Dendroctonus ponderosae, 194
DeNiro, M.J., 270
Denitrification, 137
Density, stand, 254–257
Desjardins, Ray, 288
DeSteven, D., 218
Detrital pool, 87
Detritus, 71, 124
Dewar, R.C., 63, 84
Dew point, 25
Diameter xylem elements, 37
Digital elevation model (DEM), 231–232
Dinitrogen, 113, 114, 137
Directional options, remote sensing, 249
Discrimination, carbon isotope, 40
Dissolved organic carbon (DOC), 138
Distribution, global forest. *See* Global forest assessment
Disturbance, 13, 183–219. *See also* Atmospheric disturbance factors
  abiotic factors, 203–218
    fire, 203–207
    forest harvesting, 214–216
    mechanical forces, 216–218
    overview, 203
  biotic factors, 184–203
    bark beetles, 193–195
    biochemical defenses in plants, 185–188
    browsing animals, 198–203
    defoliating insects, 188–193
    overview, 184–185
    pathogens, 195–198
  and climate change, 342–344
  and landcover, 336
  overview, 183–184
  propagation of, 267–269
Diurnal variation, 23
Diversity, 257
Dixon, R.K., 305, 314
DOC (dissolved organic carbon), 138
Dormancy, 70
Dothistroma, 197, 343
Douglas-fir, 104
Driving variables. *See* Spatial scaling
Drought analysis, regional, 272–273
Dryfall, 112, 209–214

E

Earth Observing System (EOS), 249
Earthworms, 121, 124
Ecological process models, 15
Ecophysiology, 3
Ecosystem analysis. *See* Forests, ecosystem analysis
Ecosystem carbon balances, net, 341–342
Ecosystem models, 168–180
  biogeochemistry models, 168–170
  comparison of, 96–98
  coupled water balance, 52–57
  evaporation, 30–31
  gap models, 170–179
    growth submodel, 173–175
    mortality, 175–179
    overview, 170–173
    recruitment, 173
  hybrid models, 179–180
  overview, 4–10, 168
  photosynthesis and respiration, 76–82
    assessment of heterotrophic respiration, 80–82
    carbon balance of vegetation, 78–80
    gross and net photosynthesis, 76–78

Ecosystem models (*continued*)
simplifications for spatial scaling, 228–231
snow in hydrologic balance, 48–50
Ecosystem respiration, 319–321
Ecotone, 295
Ectotrophic mycorrhizae, 103
Eddy-covariance fluxes, 317–344
biogeochemistry, 327–328
climate change, 339–344
climatic trends, 339
impact on forests, 339–344
ecosystem respiration, 319–321
gross primary production, 318–319
hydrologic and energy partitioning, 325–327
net ecosystem production, 321
net primary production, 321–324
overview, 317–318
remote sensing, 328–338
canopy fluxes, 329–335
forest structure, 335–338
overview, 328–329
trace gas emissions, 324–325
Electron transport, 63
Electron transport rate, 76
Elemental balance, 6
Elements, essential, 100–102
Eluvial processes, 119
Emissions, trace gas, 324–325
Empirical models, 33–34
Endotrophic mycorrhizae, 103
Energetic optimization, 198
Energy balance, 6, 21–24
Energy exchange, 46–48
Energy partitioning, 325–327
Enhanced vegetation index (EVI), 331, 336
Entry, J.A., 198
Enzymatic activity, 67
Enzymatic reactions, 101
Enzyme nitrogenase, 113
EOS (Earth Observing System), 249
Epiphytes, 28
Epsilon, 94
Equilibrium evaporation rate, 32
Equivalent water thickness (EWT), 335
Erosion, 115, 215
E. sieheri, 106
ET (evapotranspiration), 207, 237, 275, 325, 332
Eucalyptus, 106, 110, 205, 313
Evaporation, 25–27
Evapotranspiration (ET), 207, 237, 275, 325, 332
EVI (enhanced vegetation index), 331, 336
EWT (equivalent water thickness), 335
Extrapolations, topographic, 240–243
Exudation, 106

F

Fagus grandifolia, 218
Farquhar, G.D., 62, 164, 298
Farquhar model, 76
Fecal materials, 122
Federer, A., 97, 168
Fertilization, 200, 214
Fire, 158, 203–207, 273–274
FIRE-BGC model, 285
Fisher, J.I., 332
Fixation, ion, 136
Flannigan, L.B., 299
F layer, of forest floor, 119
Fleming, R.A., 343
Flow, water. *See* Water cycle
Fluvic acids, 121
Foley, J.A., 293
Foliage
elongation, 187
respiration, 80
temperature, 31
Foliar biomass, 211
FORDYN model, 180
FOREST-Bio-Geo-Chemical simulation model (FOREST-BGC), 7–9, 164, 168, 170, 179, 228, 236, 281, 287
Forests. *See also* Biotic analysis of forest patterns; Global forest assessment
biodiversity, 336
and climate change, 339–344
and climate interactions, 300–303
composition, 344
ecosystem analysis, 1–16
management applications of, 14–16
overview, 1–2, 317–318
scientific process for, 2–3
spatial scaling, 13–14
stand/seasonal level of, 4–10
temporal scaling, 10–13
forest-atmosphere interactions, 272–274
forest cover, 263–266
harvesting, 214–216
structure, 335–338
Forest Stand Dynamics, 16
FORGRO model, 96
Forman, R.T.T., 266
Fossil fuel emissions, 303
Fossilized wood, 292
FPAR, 309
Fragmentation, litter, 122–124
FRAGSTATS software package, 258, 259
Franklin, J.F., 266
Fraxinus pennsylvanica, 43
Frelich, L.E., 266, 274
Fritz, S., 162
Fuel, 314–315
Functional biodiversity, 310–313
Functional stand responses, 159–162
Fung, I., 309
Fungistatic compounds, 185
Fuzzy systems theory, 178

G

Gamma species diversity, 310
Gap ecosystem models, 170–179
growth submodel, 173–175
mortality, 175–179
overview, 170–173
recruitment, 173
Gap-phase vegetation, 150
Garnier, B.J., 238, 241
Garten, C.T., Jr., 131
Gas analyzers, 288
Gases, 207–209, 309–310, 324–325
Gash, J.H.C., 31
Gauged watersheds, 21
GCM (Global Circulation Model), 293, 299, 300

G'DAY (Generic Decomposition and Yield model), 97
Gear, A.J., 293
GEM, 97
Gemmell, F.M., 256
Generic Decomposition and Yield model (G'DAY), 97
Genetic diversity, 310
Geographic information system (GIS), 13, 229
Geographic range, 344
Geographic representation, 231–234
Geologic weathering, 100
Geostationary Operational Environmental Satellites (GOES), 248
GEP (gross ecosystem production), 61
Gholz, H.L., 170
Gillett, N.P., 342
GIS (geographic information system), 13, 229
Glacier National Park, 284–285
Global carbon balance, 215, 291
Global carbon cycle, 303
Global Circulation Model (GCM), 293, 299, 300
Global climate database, 301
Global forest assessment, 291–316
  biodiversity, 310–313
  forest-climate interactions, 300–303
  global carbon cycle, 303–310
    elements of carbon cycle, 303–305
    global net primary production, 306–309
    other forest gas emissions, 309–310
    source/sink dynamics, 305–306
  global forest distribution, 292–300
    bioclimatic definition of potential, 294–296
    future response to climate change, 298–299
    monitoring future changes in, 299–300
    paleoecological evidence of past, 292–294
    satellite estimates of current, 296–297
  overview, 291–292
  sustainability, 314–315
Global precipitation trends, 339
Global Production Efficiency Model (GLO-PEM), 254
Global scale monitoring, 300
Global vegetation modeling analysis, 336
Global warming, 300–302
GLO-PEM (Global Production Efficiency Model), 254
GOES (Geostationary Operational Environmental Satellites), 248
Goodale, C.L., 341
Gosz, J.R., 108
Goulden, M.L., 82
Goward, S.N., 250, 252, 254
Gower, S.T., 159
GPP (gross primary production), 318–329, 320, 329–331
Grace, J.C., 159
Graham, R.L., 315
Graumlich, L.J., 164
Graustein, W.C., 136
Gravimetric water content, 73
Gravitational component, 35
Gravitational potential, 50
Green, D.S., 333
Greenhouse gas-induced warming, 300
Grier, C.C., 54
Groisman, P.Y., 301
Gross ecosystem production (GEP), 61
Gross primary production (GPP), 318, 318–319, 329–331
Growth, 69–71, 340–341
Growth ecosystem submodel, 173–175
Gustafson, E.J., 267
Gymnosperms, 34

H

Habitat analysis, wildlife, 269–272, 338
Hall, F.G., 266
Hansen, A.J., 269, 338
Hardwoods, 39
Harvest index, 96
Harvesting, forest, 214–216
Haxeltine, A., 294, 296
Heartwood, 34
Heat transfer from vegetation, 21–34
  energy balance, 21–24
  evaporation from wet surfaces, 25–27
  interception, 27–30
  modeling evaporation, 30–31
  seasonal estimation of leaf area index, 30
  stomatal conductance, 32–34
  transpiration from plant canopies, 31–32
Heavy metals, 209
Hemicellulose, 125
Henderson-Sellers, 303
Herbicides, 214
Herbivores, 87
Heterogeneity, spatial, 266–267
Heterotrophic fungi, 211
Heterotrophic metabolism, 59
Heterotrophic microbial activity, 138
Heterotrophic organisms, 111
Heterotrophic respiration, 61, 71–75, 80–82
Historical "natural" sequence, 184
H layer, of forest floor, 119
Högberg, P., 320
Hogg, E.H., 343
Houghton, R.A., 314
Huff, M.H., 204
Humidity, 237
Humus, 119, 128–129
Hunsaker, C.T., 281
Hunt, E.R., 164
Huntley, B., 293
Hybrid ecosystem models, 179–180
Hydraulics, plant, 34–40
  carbon isotope discrimination of limitations on, 40
  restrictions on water flow, 34–37
  seasonal variation in conductivity, 37–39
Hydrogen, 11, 142
Hydrogen ions, 135
Hydrogen sulfide, 137
Hydrologic analyses, 227

Hydrologic and energy partitioning, 325–327
Hydrologic balance, watershed, 275–279
Hydrologic cycle, 19
Hydrologic equilibrium theory, 14
Hydrologic gas, 7, 9
Hydrologic recovery, 56, 278
Hydrologic routing, 232–233
Hydrologic system, 52
Hydrology, snow, 48–50
Hydrophobic soil, 50
Hydrostatic pressure, 35
Hydroxide radicals, 133
Hyperspectral sensors, 333

I
IBP (International Biological Program), 141, 228
Ice, 217–218
Illuvial horizon, of mineral soil, 120
Immobilization, nutrient, 129–133
Inconsistencies, data layer, 259
Indices, allocation, 94–96
Infiltration, 50–52
Initiation stage of stand development, 152–153
Insects, defoliating, 87, 188–193
Interception, 27–30, 46–48
Intermediate regeneration, 179
Internal recycling, 103–106
Internal tree physiology, 9
International Biological Program (IBP), 141, 228
Invertebrates, 184
Ion exchange, 133–135
Ips typographus, 194
Isoprene, 209
Isotopes, stable, 11–12
Isotope-tracer study, 138
Isotopic analyses, 75, 168, 305
Isotopic composition, 298
Isotopic forms, 39
Isotopic fractionation, 45, 73, 75
Iverson, L.R., 256

J
JABOWA model, 173
Jarrah leaf litter, 73
Jarvis, P.G., 64, 77
Johnston, C.A., 267
Jolly, W.M., 319
Joules (J), 22
Juniperus, 38, 80

K
Karl, T.R., 301, 303
Karri substrate, 73
Kaufmann, M.R., 206
Keane, R.E., 285
Keeling, C.D., 75, 309
Kelliher, F.M., 25, 32, 311
Kelvin temperature, 22
Kern, J.S., 233
Kicklighter, D.W., 229
Kimball, J.S., 237, 332
Kinetic reactions, 11
Kirkby, M.J., 232
Koerper, G., 297
Körner, C., 32, 311
Korol, R.L., 168, 179
Kull, O., 64
Kuusisto, E., 302

L
Lagarostrobus franklinii, 163
LAI. *See* Leaf area index
Lamberson, R.H., 269
Laminated root rot, 197
Land cover, 250, 336
Landsat Thematic Mapper (TM), 231, 254, 284, 312
Landsberg, J.J., 77, 90, 93, 94, 170
Landscapes. *See also* Regional ecological analysis
  carbon balances, 281–283
  efficient representation with abiotic variable, 234–236
  patterns and processes, 226–228
  spatially explicit pattern analysis, 257–259
Land surface temperature (LST), 336
Lapse rates, 241
Larix, 332
Latent heat transfer, 46
Law, B.E., 327
Leachate, 106–109
Leaching, 137–138, 140, 210, 213
Leaf abscission process, 108
Leaf area index (LAI), 9, 54, 151, 156, 159, 193, 229, 321
  and remote sensing, 253–254
  seasonal estimation of, 30
Leaf–gas exchange measurements, 32
Leaf litter, 87, 109
Leaf photosynthesis, 75
Leaf-specific conductivity (LSC), 36, 40
Leaf stomatal conductance, 32
Lefsky, M.A., 336
Leith, H., 306
Lemon, P.C., 218
Lepers, E., 336
Leverenz, 77
Levine, E.R., 281
Li, H., 267
Lichens, 113
Lidar measures, 335, 335–336
Light absorbed by canopy, 253–254
Light compensation point, 64
Light Use Efficiency (LUE), 9, 94, 226, 254, 283, 306
Lignin, 73, 127, 136, 195
Lipid-soluble compounds, 185
Litter
  and mineral cycles, 106–109
  and soil processes, 119–138
    adsorption and fixation, 136
    cation and anion exchange, 133–135
    fragmentation and mixing, 122–124
    humus formation, 128–129
    microbial decomposition, 124–128
    mineralization and immobilization, 129–133
    overview, 119
    soil profile development, 119–122
    volatilization and leaching, 137–138
Liu, 141
L layer, of forest floor, 119
Lloyd, J., 32, 298
Long-wave radiation, 21–22
Lonicera japonica, 339

LSC (leaf-specific conductivity), 36, 40
LST (land surface temperature), 336
Luan, J., 180
LUE (Light Use Efficiency), 9, 94, 226, 254, 283, 306
LUE models, 13
Luxury consumption, 104
Lysimeters, 100

M
Macrozamia riedlei, 205
MAESTRO model, 96, 97
Magnesium, 101
Maintenance respiration, 61, 67–69
Management applications of ecosystem analysis, 14–16
Marks, P.L., 259, 298
Mass balance, 138–143
Mass movement, 218
Mather, A.S., 78, 314
Matric potential, 35, 50
Maximum leaf conductance, 311
McGarigal, K., 259
McGuire, A.D., 97, 298
McKay, D.S., 279
McMurtrie, R.E., 77, 97, 170
McNulty, S.G., 343
Mean residence time (MRT), 125, 215
Mechanical disturbance forces, 216–218
Mechanical weathering, 115
Mechanistic approach, 3
Melillo, J.M., 3, 306, 314
Mencuccini, M., 159
Metamorphic rocks, 115
Meteorological satellites, 250–252
Methane, 137, 207
Microbial biomass, 72
Microbial decomposition, 100, 124–128
Micrometeorology, 3
Milne, B.T., 236
Milner, K.S., 283
Mineral cycles, 99–144
  and mass balance, 138–143
  overview, 99–100
  plant processes affecting, 100–111
    essential elements, 100–102
    nutrient use efficiency, 109–111
    plant uptake, 102–103
    return in litter and leachate, 106–109
    storage and internal recycling, 103–106
  soil and litter processes, 119–138
    adsorption and fixation, 136
    cation and anion exchange, 133–135
    fragmentation and mixing, 122–124
    humus formation, 128–129
    microbial decomposition, 124–128
    mineralization and immobilization, 129–133
    overview, 119
    soil profile development, 119–122
    volatilization and leaching, 137–138
  sources of nutrients, 111–119
    atmospheric deposition, 111–112
    nitrogen fixation, 113–114
    weathering, 114–119
Mineralization, 124, 129–133, 193, 198
Mineral weathering, 143
Mixing, litter, 122–124
Models, ecosystem. *See* Ecosystem models
MODIS (Moderate Resolution Imaging Spectroradiometer), 249, 329–331
Moisture and heterotrophic respiration, 73
Molybdenum, 102, 204
Monoterpenes, 209
Monteith, John, 31, 94
Morphological responses, 187
Mortality, 175–179
Mousseau, 298
MRT (mean residence time), 125, 215
MT-CLIM, 236, 240, 272, 285
Mu, Q., 332
Mull forest floors, 121
Multifactor growth multipliers, 175
Mycorrhizae, 91, 102, 103, 324
Mycorrhizal fungi, 103
Myers, N., 297
Myneni, R.B., 309

N
Nadelhoffer, K.J., 71
NASA Earth Observing System program, 249, 273
National Fire Danger Rating System, 274
National Oceanic and Atmospheric Administration (NOAA), 245
National Soil Geographic Date Base (NATSGO), 233
National Weather Service, 273
NATSGO (National Soil Geographic Date Base), 233
NDSI (Normalized Difference Snow Index), 332
NDVI (Normalized Difference Vegetation Index), 246, 254, 272, 329, 332
NDWI (Normalized Difference Water Index), 332
Near-infrared radiation (NIR), 21–22, 246, 331
Near-term forecasting, 275
NEE (net ecosystem exchange), 61, 127, 318, 341
Needle-leaf trees, 30
Neilson, R.P., 294, 296, 298
Nemani, R.R., 56, 231, 252, 254, 273, 274, 279, 296
Nematodes, 122
NEP (net ecosystem production), 59, 318, 321
Net carbon exchange, 318
Net ecosystem exchange (NEE), 61, 127, 318, 341–342
Net ecosystem production (NEP), 59, 321
Net forest carbon balances, 341
Net nitrification, 211, 213
Net photosynthesis, 62, 64, 286
Net photosynthetic rates, 64
Net primary production (NPP), 3, 59, 159, 168, 286, 299, 309, 321, 336
  allocation indices, 94–96
  annual assessment of, 86–94

Net primary production (NPP) (*continued*)
contribution of forests to global, 306–309
and eddy-covariance fluxes, 321–324
NPP/gross photosynthesis (GPP) ratio, 80
overview, 82–83
remote sensing of, 331–332
seasonal dynamics in allocation, 83–86
Net radiation, 27, 31
Net sinks, 305
N fixation, 102, 114
N-fixing lichens, 114
Nicholas, N.S., 218
NIR (near-infrared radiation), 21–22, 246, 331
Nitrate nitrogen, 201
Nitrification, 130
Nitrobacter, 131
Nitrogen, 73, 93, 100–101, 111–112, 137, 193, 209
compounds containing, 186
deposition, 211
ecosystems saturated with, 210
fixation, 113–114
Nitrogenase, 113
Nitrogen oxides, 207
Nitrosomonas, 130–131
Nitrous oxide, 137, 213, 310
NOAA (National Oceanic and Atmospheric Administration), 245
Norby, R. J., 165
Normalized Difference Snow Index (NDSI), 332
Normalized Difference Vegetation Index (NDVI), 246, 254, 272, 331, 332
Normalized Difference Water Index (NDWI), 332
Normalized ratios, 39
Norman, J.M., 252
Nothofagus, 80, 218, 313
NPP. *See* Net primary production
Nutrients
accumulation of soil organic matter and, 159–162
cycling models, 141
efficiency of use, 109–111
immobilization, 129
reabsorption, 142
sources of, 111–119
atmospheric deposition, 111–112
nitrogen fixation, 113–114
weathering, 114–119
Nyssa aquatica, 43

O

Odocoileus hemionus, 201
Oerlemans, 301
O'Hara, K.L., 158
Ohm's law, 36, 37
Old-growth stage of stand development, 158
Ollinger, S.V., 238, 241, 279
Olsson, H., 256
Optimum nutrient balance, 104
Oregon transect, 15
Organic matter, 159–162
Overpeck, J.T., 299
Overstory canopy, 162
Oxygen, 11
Ozone, 207

P

Paleoecology, 162, 292–294
Pan, Y., 331
PAR (photosynthetically active component of radiation), 21, 77, 309, 330
Parton, W.J., 138
Patch, 257
Pathogens, 186, 195–198
Pearson, S.M., 270
Peat bog, 109, 292
Pedology, 166–168
Pee Dee Belemnite formation, 40
Penman equation, 26, 31
Penman–Monteith equation, 31, 34, 53, 76, 332
Penman's equation, 31
Percolation, 50–52, 142
PGEN, 96
Phellinus weirii, 197
Phenolic acids, 116
Phenology, 84, 332–333, 339
Phloem, 35
Photorespiration, 61, 66, 67
Photosynthate, 82, 84, 86, 96, 179
Photosynthesis, 3, 39, 40, 73, 111, 168, 184, 207
and carbon cycle, 62–67
discrimination of, 298
modeling respiration and, 76–82
assessment of heterotrophic respiration, 80–82
carbon balance of vegetation, 78–80
gross and net photosynthesis, 76–78
Photosynthetically active component of radiation (PAR), 21, 77, 309, 330
Photosynthetic capacity, 7, 69
Photosynthetic gas exchange, 75
Photosynthetic pathways, 167
Photosynthetic rates, 298
Phytoalexins, 185
Picea, 216
Picea mariana, 321
Picea rubens, 86, 218
Picea sitchensis, 217
Pielke, R.A., 272
Pierce, L.L., 236, 254, 276, 283
Pinus, 110, 216
Pinus banksiana, 333
Pinus contorta, 43, 194, 344
Pinus jeffreyi, 217
Pinus monticola, 198
Pinus radiata, 43, 90, 93, 165, 170, 197
Pinus sylvestris, 66
Pinus taeda, 328
Plant biochemical defenses, 185–188
Plant canopies, transpiration from, 31–32
Planting forests, 315
Plant phenology, 84
Plant processes. *See* Mineral cycles
PnET model, 168, 331
Podzolization, 120
Pollution-producing aerosols, 300
Population modeling, spatially explicit, 269–272
Populus, 332
Populus tremuloides, 321, 339, 344

Pore size distribution, 50
Potassium, 101
Potential global forest distribution, 294–296
Precipitation, 45–46, 241
Predawn plant water potential, 46
Prentice, I.C., 293, 294, 296
Pressure component, 35
Price, C., 299
Primary succession, 150
Protein, 185
Pteridium aquilinum, 159

Q
Quantitative descriptors, 257
Quantum efficiency, 64
Quartz, 115

R
Radiances, 244
Radiant energy, 62
Radiata pine, 313
Radiation, solar, 237–241
Radiation balance, 21
Radiative gases, 216
Radiometric surface temperatures, 247
Raich, 71
Rainfall, 112
Raphus cucullatus, 153
Raster (square) cells, 283
Raster format, 231
Rastetter, E.B., 283
Rayleigh distillation kinetics, 114
Ray parenchyma cells, 105
Recruitment, seedling, 173
Recycling, internal, 103–106
Reflectances, 244
Reflectivities, 22
Regional carbon balances, 215
Regional drought analysis, 272–273
Regional ecological analysis, 261–289
  biogeochemistry analysis, 274–288
    landscape carbon balances, 281–283
    overview, 274
    regional applications, 284–287
    validating models, 287–288
    watershed biogeochemistry, 279–281
    watershed hydrologic balance, 275–279
  biotic analysis of forest patterns, 262–272
    disturbance propagation, 267–269
    overview, 262–263
    spatial heterogeneity, 266–267
    temporal changes in forest cover, 263–266
    wildlife habitat analysis, 269–272
  forest-atmosphere interactions, 272–274
  overview, 261–262
Regional Ecosystem Simulation System (RESS), 13–14
Regional forest-atmosphere interactions, 272
Regional Hydroecological Simulation System (RHESSys), 232, 254, 275, 279, 281, 284
Regional scale monitoring, 300
Reich, P.B., 266
Relative equivalent mass, 133
Relative humidity, 25
Relative water content (RWC), 38
Remote sensing, 243–257
  and eddy-covariance fluxes, 328–338
    canopy fluxes, 328–333
    forest structure, 335–338
    overview, 328–329
  of landscape attributes, 250–257
    albedo, land cover, and snow, 250
    biomass, structure, and density, 254–257
    LAI and fraction of light absorbed by canopy, 253–254
    satellite-derived surface meteorology, 250–252
    surface resistance, 252–253
  principles of, 243–249
    directional options, 249
    overview, 243–245
    spatial resolution, 245–246
    spectral resolution, 246–248
    temporal resolution, 248–249
Representation, geographic, 231–234
Resistant soil materials, 121
Resolution
  spatial, 245–246
  spectral, 246–248
  temporal, 248–249
Resource management decisions, 262
Respiration
  of carbon dioxide, 73–75
  ecosystem, 319–321
  modeling photosynthesis and, 76–82
    assessment of heterotrophic respiration, 80–82
    carbon balance of vegetation, 78–80
    gross and net photosynthesis, 76–78
Respiration quotient, 68
RESS (Regional Ecosystem Simulation System), 13–14
RHESSys (Regional Hydroecological Simulation System), 232, 254, 275, 279, 281, 284
Ribulose bisphosphate (RuBP), 62
Ring chronologies, 162
Riparian zone, 117
River flow dynamics, 275
Robinson, J.S., 232
Romme, W.H., 274
Roots, 102, 324
  depth, 42–43
  growth, 71
  respiration, 135
  rooting zone, 20, 41
  temperatures, 43
  water available to, 43–46
Rose, C.L., 48, 201
Roughness length, 30
Rubidium/strontium ratios, 118
Rubisco enzyme, 67, 96
RuBP (ribulose bisphosphate), 62
Ruel, J.C., 216
Running, S.W., 48, 54, 56, 170, 234, 236, 241, 252, 274, 275, 279, 281, 283, 296, 314

Runoff, surface, 50
Runyon, J., 78, 80, 94
Rutter, A.J., 28, 31
RWC (relative water content), 38
Ryan, M.G., 80, 159
Rykiel, E.J., Jr., 9

S
Sakai, A., 294
Salinization, 276
Sapwood, 67–68
Sarr, D.A., 336
Satellites
  estimates of current global forest distribution, 296–297
  satellite-borne laser altimeters, 257
  surface meteorology derived from, 250–252
Saturated hydraulic conductivity, 51
Schlesinger, W.H., 128
Schwartz, M.D., 303
Scientific process for ecosystem analysis, 2–3
Scots pine, 28
Scotter, 25
Sea of nitrogen, 113
Seasonal carbon allocation, 83–86
Seasonal leaf area index, 30
Seasonal level of analysis, 4–10
Seasonal patterns, in soil water depletion, 52
Seasonal water flow and plant hydraulics, 37–39
Sedjo, R.A., 315
Seedling recruitment, 173
Self-thinning rule, 154
Sellers, P.J., 303, 306
Sensitivity analyses, 76
Sequoiadendron, 205
Sequoia sempervirens, 158, 218
Sesquioxides, 121
Sharma, N.P., 314
Short-wave radiation, 21–22, 250
Shugart, H., 173
Silvicultutal handbooks, 218
Simaba cedron trees, 153
Simple Ratio (SR), 246, 254, 284
Simulation models, mineral cycling, 141–143
Sinks, carbon, 305–306
Sisk, T.D., 312
Site descriptors, 52
Site indices (SI), 170, 341
Site quality, 170
Skole, D.L., 303
SLM (specific leaf mass), 64–65
Snow
  as factor of disturbance, 217–218
  hydrology, 48
  and remote sensing, 250
  snowpack dynamics, 52
  snow pillows, 48
  water storage and losses from, 46–50
Soil, 19
  accumulation of organic matter and nutrients, 159–162
  bulk densities, 41, 43
  fertility multipliers, 175
  and geographic representation, 233–234
  hydraulic properties, 52
  limitations on flow of water, 40–43
  and litter processes, 119–138
    adsorption and fixation, 136
    cation and anion exchange, 133–135
    fragmentation and mixing, 122–124
    humus formation, 128–129
    microbial decomposition, 124–128
    mineralization and immobilization, 129–133
    overview, 119
    soil profile development, 119–122
    volatilization and leaching, 137–138
  organic matter, 87
  temperatures, 46, 237
  temperatures of, 237
  texture, 42
  water available in rooting zone, 43–46
  water flow across and through, 50–52
Soil–Vegetation–Atmosphere–Transfer (SVAT) models, 226, 272
Solar radiation, 77, 237–241, 300
Solar zenith angles, 48
Sollins, P., 130
Solomon, A.M., 176
Solute potential, 35
SOM, 128
Sources, carbon, 305–306
Spanner, M.A., 254
Spatial heterogeneity, 266–267
Spatial isolation, 184–185
Spatially explicit population modeling, 269–272
Spatial resolution, 245–246
Spatial scaling, 225–259. *See also* Eddy-covariance fluxes; Global forest assessment; Regional ecological analysis; Remote sensing
  abiotic site variables, 231–236
  data layer inconsistencies, 259
  environmental driving variables, 236–243
    climatology, 237–240
    overview, 236
    topographic extrapolations, 240–243
  landscape patterns and processes, 226–228
  model simplifications, 228–231
  overview, 13–14, 221–226
  spatially explicit landscape pattern analysis, 257–259
  stand/seasonal level of analysis, 4–10
Specht, R.L., 56
Species diversity, 310
Specific leaf mass (SLM), 64–65
Spectral resolution, 246–248
Spies, T.A., 256, 267
Split-window approach, 252
SPM model, 96
SPOT sensor, 249
SPOT-VGT satellite, 332
Square (raster) cells, 283

Square picture element, 245
SR (Simple Ratio), 246, 254, 284
Stable isotopes, 11–12, 73–75
Stands
  functional responses of during development, 159–162
  and seasonal level of analysis, 4–10
  structural stages in development of, 151–158
    initiation, 152–153
    old-growth, 158
    overview, 151–152
    stem exclusion, 154–156
    understory reinitiation, 156–157
State Soil Geographic Data Base (STATSGO), 233
State–space diagram, 263
State variables, 3
STATSGO (State Soil Geographic Data Base), 233
Steady-state climax vegetation, 150
Stefan–Boltzmann constant, 22
Stem
  elongation, 70
  mortality, 156
  stem exclusion developmental stage, 154–156
Stenberg, P., 75
Stochastic models, 13
Stomata, 34, 62, 298
Stomatal closure, 37
Stomatal conductance, 31–32, 63, 209
  and carbon isotope discrimination, 40
  empirical model of, 32–34
  soil limitations on, 40–43
Storage, 103–106
Stream discharge, 227
Streamflow, 19, 275, 279
Stress indices, 13
Strontium, 117
Structure
  remote sensing of forest, 335–338
  remote sensing of stand, 254–257
  stand development stages, 151–158
    initiation, 152–153
    old-growth, 158
    overview, 151–152
    stem exclusion, 154–156
    understory reinitiation, 156–157
Subalpine, 84, 175
Sublimation, 46
Substrate quality, 72–73
Sulfur, 101, 111–112, 209
Sulfur dioxide, 137, 207
Supervised spectral reflectance data, 244
Surface meteorology, 250–252
Surface resistance, 252–253
Surface runoff, 50
Surface wetness, 252
Sustainability, global forest, 314–315
SVAT (Soil–Vegetation–Atmosphere–Transfer) models, 226, 272
Swartzman, G.L., 4
Swedish National Forest Inventory, 341
Swenson, J.J., 338
Swift, L.W., 238, 241
Symbiotic N fixation, 113
Synthesis respiration, 61, 69–71
Syringa vulgaris, 339
System states, 3

T
Tannins, 185, 201
Tans, P.P., 305
Target cell, 226
Taxodium distichum, 43
TEM model, 97
Temperate forests, 291
Temperature
  air, and topographic extrapolations, 241
  and climatology, 237
  and heterotrophic respiration, 73
Temporal biodiversity, 310
Temporal changes in forest cover, 263–266
Temporal resolution, 248–249
Temporal scaling, 149–182. *See also* Disturbance; Gap ecosystem models
  dendrochronology, 162–166
  ecosystem models, 168–180
    biogeochemistry models, 168–170
    hybrid models, 179–180
    overview, 168
  functional responses during stand development, 159–162
  overview, 10–13, 145–151
  paleoecology, 162
  pedology, 166–168
  of standlevel, 10
  structural stages in stand development, 151–158
    initiation, 152–153
    old-growth, 158
    overview, 151–152
    stem exclusion, 154–156
    understory reinitiation, 156–157
Termites, 124
Terrestrial Ecosystems, 16
Terrestrial vegetation, 303
Thornton, P.E., 241
Tiessen, H., 215
Tiktak, A., 141
Tilia americana, 218
Tilman, D., 311
Tissue composition, 12
Tissue turnover, 168
TM (Landsat Thematic Mapper), 231, 254, 284, 312
TOMS (Total Ozone Mapping Spectrometer), 250
TOPMODEL logic, 232–233, 234, 284
Topographic climatic extrapolation, 13
Topographic partitioning, 277
Topographic Saturation Index (TSI), 233
Topographic variables, 48
Topography, 231–232, 240–243
Total Ozone Mapping Spectrometer (TOMS), 250
Townsend, A. R., 167
Townshend, J., 296
Trace gas emissions, 137, 215, 324–325
Tracheids, 34

$2,063.70

Transition zone, 295
Transmittance, 239
Transpiration, 31–32, 184
TREE-BGC, 179
TREEDYN3, 96, 180
Tree pollen, 292
Tree-ring data, 162–163
Tree seedlings, 172
TREGRO, 96
Trumbore, S.E., 128, 166, 215
TSI (Topographic Saturation Index), 233
Tsuga heterophylla, 204, 217
Tsuga mertensiana, 197, 217
Tuomisto, H., 312
Turbulence, 26
Turbulent transfer, 31
Turner, D.P., 234, 263, 274, 297
Turner, M.G., 263, 270, 296

U

UAVs (unmanned aerial vehicles), 338
Understory regeneration, 179
Understory reinitiation stage of stand development, 156–157
Unmanned aerial vehicles (UAVs), 338
Unsaturated hydraulic conductivity, 51
Unsupervised spectral reflectance data, 244
Uptake, 102–103
Urea, 136
U.S. National Atmospheric Deposition Program, 279
U.S. National Weather Service and World Meteorological Organization, 236

V

Vaccinium ovalifolium, 201
Validation, ecosystem analysis model, 9–10, 287–288
Vapor pressure deficit, 237
Vapor transfer. *See* Water cycle
Variable disturbance sensitivities, 175
Variable-plot surveys, 87
Variables, driving. *See* Spatial scaling
Vascular tissue, 34
Vector format, 231
Vegetation carbon balance, 78–80. *See also* Water cycle
Vegetation dynamics, 150
VEMAP (Vegetation/Ecosystem Modeling and Analysis Program), 7, 299
Vertebrate animals, 198
Vessels, 34
Vetter, M., 341
Vidal, A., 274
Visible radiation, 156
Vitousek, P.M., 314, 335
Volatilization, 137–138
Volcanic eruptions, 112
Volumetric water content, 41

W

Walcroft, A.S., 165
Wallin, D.O., 267
Walsh, J.E., 302
Waring, R.H., 93, 94, 338
Warming, climate, 300–302
Water cycle, 19–57
  coupled water balance models, 52–57
  flow across and through soil, 50–52
  flow through trees, 34–46
    carbon isotope discrimination, 40
    hydraulic restrictions on, 34–37
    seasonal variations, 37–39
    soil limitations on, 40–43
    water available in soil rooting zone, 43–46
  heat and water vapor transfer from vegetation, 21–34
    energy balance, 21–24
    evaporation from wet surfaces, 25–27
    interception, 27–30
    modeling evaporation, 30–31
    seasonal estimation of leaf area index, 30
    stomatal conductance, 32–34
    transpiration from plant canopies, 31–32
  overview, 19–21
  storage and losses from snow, 46–50
Waterlogging, 276
Watershed biogeochemistry, 279–281
Watershed hydrologic balance, 275–279
Weathering, 114–119
Weinstein, D.A., 84
Western spruce budworm, 190
Wetfall, 112, 209–214
Wetness, 252–253
Whitehead, D., 91
Wigmosta, M.S., 232, 275
Wildfires, 173
Wildlife habitat analysis, 269–272, 338
Wind, 216–217, 242
Wood cellulose, 46
Wood fiber, 315
Wood permeability, 36
Wood relative water, 46
Woods, A.S., 343
Wood supply, global, 314–315
Woodward, F.I., 294, 311

X

Xylem, 34, 38, 46, 76

Y

Yellowstone National Park, 263

Z

Zarco-Tejada, P.J., 333
Zero point charge (ZPC), 134
Zheng, D., 234, 237
Zhu, A.-X., 234
ZPC (zero point charge), 134