Index

Page number entries in bold denote illustrations or tables.

A
ACCase herbicides, 376, 388
actinomycetes, 68, 75, 76
adaptation strategies, and climate change, 17, 35–36
aerial drones, 333, 473, 555
aerial photography, 333, 337, 338, 342, 346, 473, 555
AgBalance, 560
AgBiz Logic, 560–566, 561, 564, 567
AgClimate Atlas, 40–42
AgClimate (Agriculture Climate) Network, 4, 37
aggregate stability. See also soil aggregation
cropping system related to, 52, 52
crop residue harvesting and, 136
earthworms and, 82, 83
how to determine, 51
organic materials and crop residues for, 53–54, 53
soil health and, 50–54
water infiltration patterns in, 51, 52
agricultural policies. See farm policies
agroecological classes (AECs)
alternative crop sequences in, 169
crop diversity in, 167–170, 168
description of, 26–27, 26, 167–170
general water holding capacity and productivity by crop in, 234–235
geographic diversity in, 323
predominant crops in, 21, 22
production issues and adaptive strategies in, 169
agronomic zones, 25, 26, 167, 327
AgWeatherNet website, 39–40, 345, 554–555
air pollutants, from crop residue burning, 162
Alfisol soil order, 23, 24
ALS herbicides, 376, 384
aluminum
cation exchange and, 64
phosphorus availability and, 259
soil aggregates with, 51
soil pH and levels of, 59, 60
aluminum toxicity
soil acidity and, 59, 265
wheat grain yield and, 59, 60, 263
Andisol soil order, 23, 24
Annual Crop agroecological class (AEC)
alternative crop sequences in, 169
canola and, 187, 188, 190, 193, 196
conservation tillage in, 171
crop diversity in, 167–170, 168, 170–171, 180
crop residue for erosion protection in, 131
description of, 26, 26, 27, 102, 167
direct seeding in, 170
diversification strategies in, 169, 170–171
everthog populations in, 84, 85
economic analysis of net returns by crop in conventional tillage in, 211, 212
general water holding capacity and productivity by crop in, 234–235
Grain-Fallow AEC compared with, 102
grain legumes in, 174, 175, 176–178, 179, 180, 181
lime application for soil pH and, 62
nitrogen fertilizer application in, 330
over-winter soil water storage and infiltration in, 58–59
Advances in Dryland Farming in the Inland Pacific Northwest

predominant crops in, 21, 22
production issues and adaptive strategies in, 169
soil aggregate stability in, 52–53
soil organic carbon (SOC) dynamics in, 70, 78
typical rotation crops in, 102
variable rate nitrogen (VRN) applications used in, 341
water storage efficiency in, 132, 133, 133
wheel traffic soil compaction in, 54, 55

Annual Crop-Fallow Transition
agroecological class (AEC)
alternative crop sequences in, 169
canola and, 187, 191, 196
crop diversity in, 167–170, 168, 171–172
description of, 26, 26, 27, 102, 167
diversification strategies in, 169, 171–172
economic analysis of net returns by crop in, 213–215, 214
general water holding capacity and productivity by crop in, 234
Grain-Fallow AEC compared with, 102
grain legumes in, 175, 176, 178, 181
predominant crops in, 21, 22
soil organic carbon (SOC) dynamics in, 70, 71, 79–80, 82
soil pH in, 61, 62
antibiotics, in manures, 305
aphids, 475–483
climate change impacts on, 483
description of, 476–478, 476, 478
host plants and damage with, 479–481, 479, 480
identifying characteristics of, 477
integrated management of, 481–482
life cycle of, 478–479
status and distribution of, 475–476
Aridisol soil order, 23, 24, 472

armyworms. See wheat head armyworm auto-steer systems, 339

barley. See also grains
as predominant crop in dryland farming, 21
rotational use of, 205–206
soil pH and yield in, 59
spring planting of, 202–203
wheel traffic soil compaction and yield in, 54, 55
bicarbonate extract test, for potassium, 262
biochar

crop residue harvesting for, 146, 151
soil applications of, 306–308
soil health benefits of, 306–308, 308
soil pH and wheat yield and, 62, 63, 306, 308
sources and generation of, 306, 307
biofuel, legislation encouraging, 166
biofuel production, 4, 71, 146, 188, 218
biological controls, in disease management, 410
biomass

crop residue harvesting and, 151
crop residue production and, 131, 137–141, 139
crop-weed competition and, 363
particulate organic matter (POM) in, 72
soil organic matter (SOM) dynamics and, 69, 71, 72, 73, 74–77, 75, 78, 79–80, 81, 81, 82
bio-oil, from crop residue harvesting, 151
biosolids, 286, 290–297
application rates for, 292–283
composition and nutrients supplied by, 291–292, 292
contaminants in, 296–297
costs of, 291
grain quality considerations in, 293–294
heavy metals in, 296–297
most common crops receiving, 291
nutrient loss considerations with, 296
rate calculation worksheet for, 292
resources on, 291, 297
soil carbon accumulation using, 284, 285, 289, 289

B

banks grass mite, 509–511, 510. See also mites
soil health benefits of, 294, 295
sources of, 290
standards for pathogen-reduction
treatment of, 290–291
yield impacts of, 293
black cutworm, 493, 493, 494. See also
cutworms
black liquor
crop residue harvesting for, 146, 151,
308
possible soil amendment use of, 309
brown wheat mite, 509, 510. See also
mites
bulk density
biosolid applications and, 294, 295
cropping practices related to, 55, 55,
56
landscape-specific processes affecting,
325
as soil health indicator, 49, 54–56
soil compaction and, 54, 55
soil organic matter (SOM) and, 55–56,
56
C
calcium
pH range and availability of, 59
soil fertility and, 64, 263
soil flocculation and, 66
Calcium Carbonate Equivalent (CCE)
scoing method, 265, 266
camelina
diversification strategy using, 196–198
rotational use of, 197–198
canola
benefits of, 188
challenges to adopting, 187–188
crop residue nutrients in, 136,
143–144
diversification strategy using, 186–196
grazing of first season’s forage in,
191–192, 192
herbicide use and, 377
Italian ryegrass and, 388
nitrogen management for, 195–196
as predominant crop in dryland
farming, 21, 22
prices received by growers in, 215, 217
resource on, 272
rotational effect of, 188–190, 189
rotational fit of, 186–188
spring establishment of, 190–192
sulfur fertilizer for, 269
unit nitrogen requirements (UNRs)
for, 196
weed management for, 193–195
winter establishment of, 191–195
carbon (C). See also soil organic carbon
(SOC)
biosolids applications for, 284, 285,
294
mineralizable, in plant respiration, 78
permanganate oxidizable, 74, 79
soil health and loss of, 284
soil organic matter (SOM) with, 72,
73, 74
carbon dioxide (CO₂), atmospheric
agricultural policy for management of,
544
barley yellow dwarf virus (BYDV)
spread and, 483
cereal pathogens and disease and, 403
climate change impact and, 5, 16, 21,
257
plant growth and water usage related
to, 16, 21
plant respiration and mineralizable
carbon and, 77–78
rapid plant development and growth
(CO₂ fertilization) and, 31, 35, 42
soil organic matter (SOM) and, 9, 68,
285
CO₂ fertilization, 31, 35, 42
carbon sequestration
amendment type and, 289
barley and, 202
carbon planning tools for, 557, 558,
562
conservative versus conventional
tillage for, 117
crop residue production and, 142, 146
direct seed methods and, 115
diversification and, 165
flex cropping for, 172, 206
management strategies for, 10
reduced tillage practices for, 35
soil organic matter and, 112, 115
winter triticale and, 204
carbon-to-nitrogen (C:N) ratio
amendment use determination using, 287, 288
composting and, 298
legume decomposition and, 247
manure nutrient content and, 299, 300, 302
potentially mineralizable nitrogen (PMN) and, 78
residual soil nitrogen and, 248
residue structure components and, 80, 143, 144–146, 152
soil organic matter (SOM) and, 74, 78, 80
Cascade Mountains
climatically distinct areas divided by, 17
inland PNW area defined by, 2
rain shadow effect from, 2, 15, 17, 27
cation exchange capacity (CEC), 64–67
base saturation in, 64–66
description of process of, 64
factors affecting, 66, 67
flocculation and, 66
leaching and, 64
soil pH values and, 264
typical values in soil types, 64, 65
Cephalosporium stripe, 453–458
background on, 453
causes of, 454
characteristics and management options for, 454
disease cycle and conditions favoring, 456
diseases similar to, 449–450
distribution of, 438
key diagnostic features of, 454–455, 455
management strategies for, 457–458
potential climate change effects on, 456–457
cereal leaf beetle (CLB), 487
cclimate change impacts on, 492
description of, 487, 488, 490
host plants and damage with, 489
identifying characteristics of, integrated management of, 489–492, 491
life cycle of, 489
resource for, 528
status and distribution of, 487
cereal production
atmospheric carbon dioxide and, 21
crop residue estimates in, 138, 139
crop residue harvesting in, 143–144, 147–149, 150, 151
crop residue retention in, 136
pests affecting, 470
selected pathogens affecting, 410–462, 410
cereal rust nematodes, 442–448
background and causes of, 442–443
characteristics and management options for, 443
disease cycle and conditions favoring, 445
distribution of, 438
key diagnostic features of, 443–444, 444
management strategies for, 446–448
potential climate change effects on, 445
chisel tillage, 104, 105, 106, 111
chloride, and soil fertility, 261, 262
cclimate, 15–43
average annual maximum temperature (1981–2020) across PNW and, 17, 18
average annual precipitation (1981–2020) across PNW and, 17–18, 18
Cascade Mountains with distinct areas in, 17
diversity of dryland agricultural systems and, 21–27
key points for, 24
overview of, 17–21
primary drivers of variability in, 19–20
topography influences on, 17
weed adaptation to, 359
weed seed germination and plant development and, 359
year-to-year variability in annual temperature and precipitation in, 18, 19
climate change
alternate crop explorations due to, 165
annual temperature change as indicator of, 20
economic considerations of, 36
educational resources about, 37–38
future projections for, in inland PNW, 28–30, 29, 30
global impacts in, 20–21
greenhouse gas emissions and, 20
grower considerations about, 32–34
longer term projections on, 33–34
nitrogen fertilizer use and, 322
pest management and, 473, 483, 486–487, 492, 500, 504, 508–509, 515, 525
precision agriculture response to, 36, 321, 329
production practices for adaptation and mitigation of, 35–36
regulatory context and, 35
small grain production and, 30–31
soil amendments for mitigation of, 36, 285–286
tools and resources for, 37–42, 345
weather and climate data sources on, 38–40, 41
climate change modeling
alternate crop explorations and, 166
description of, 27–28
educational resources about, 37–38
future climate projections for inland PNW using, 28–30, 29, 30
growing degree day changes on, 29, 30
information gaps in, 34–35
limitations of, 27
longer term projections in, 33–34
mean annual temperature and precipitation changes on, 28–29, 29
regional studies’ use of, 27
selecting right model for, 34–35
weather and climate data sources for, 38–40
climate data
decision support tools using, 40–42
resources for, 38–40, 41
Climate Data Online website, 39–40
Climate Engine website, 38–39
climate forecasting, 32–34
longer term climate change projections in, 33–34
seasonal climate forecasts in, 33, 34
weather forecasts and, 32, 34
Climate Learning Network webinar, 37
climate modeling, 37–38. See also climate change modeling
Columbia Plateau Ecoregion, US
Environmental Protection Agency, 21
Columbia Plateau PM10 Project, 116
Columbia River Basin
rain shadow effect in, 17
warmest locations in, 17
compaction of soil
bulk density as measure of, 54, 55
deep-injected fertilizers and, 256
fallow period reduction and, 9
indicators of, 50
intensive tillage and, 51, 51, 54
precision agriculture for, 325, 343
root penetration and, 54, 54
results of, 49
soil health and, 49, 50
soil hydraulic properties related to, 57
soil organic matter (SOM) content and, 55–56, 56
wheel traffic causing, 54, 55
composted manures
contaminants in, 304
dairy solids and, 298
organic production of, 298
plant-available nitrogen in, 301, 302
safety regulation of production of, 305
soil health benefits of, 301–303
weed seeds in, 305
conservation tillage, 99–118
Annual Crop AEC and, 171
biosolid application in, 293, 294
conventional systems compared with, 101–102, 106–108, 116, 117
crop residue amounts produced in, 128, 129, 131
definitions of, 99
disease management and, 410
effects of different implements in, 105, 106–108
factors in adoption of, 116
grower considerations in, 116
inland PNW adoption of, 104–105, 108
key points for, 98–99
mulch tillage in, 103
no-till/chemical fallow tillage in, 103
reduced tillage in, 104
resources for, 116–118
ridge tillage in, 102–103
soil aggregation in, 111, 111
soil erosion and, 109–111
soil organic matter (SOM) in, 111–113, 114
soil pH and soil fertility in, 113–115
sustainability challenges in, 105–109
types of, 102–104
winter peas in, 175
yield and economics in, 115–116
conventional tillage systems. See also specific systems
biosolid application in, 294
conservative tillage compared with, 101–102, 106–108, 116, 117
crop residue amounts produced in, 128, 129
crop residue for erosion control in, 128, 130
description of, 101–102
earthworm populations in, 84, 85
economic analysis of net returns by crop in, 211, 212
ground cover, runoff, and soil erosion in, 58, 58, 111
snow depth in, 133–135, 134
soil erosion in, 110, 111
soil organic carbon (SOC) dynamics and, 69, 70, 71
copper toxicity, 305–306
Cornell soil health assessment, 88
cover crops
diversification strategy using, 208–209
farm policies on, 547
long-term productivity improvements with, 164
manure use with, 298
potential options for, 209
soil aggregation and, 56
soil compaction reversal using, 49
soil organic matter (SOM) and, 80
critical period thresholds, in weed management, 363, 364
cropping systems. See also specific systems
bulk density related to, 55, 55, 56
soil infiltration and saturated hydraulic conductivity related to, 57, 57
soil organic matter (SOM) related to, 56, 68, 69, 79–80
crop residue, 125–155
benefits of retaining, 127
crop varieties and differences in, 143–144
decomposition acceleration in, 141–142
factors influencing decomposition rates for, 143
ground cover estimates for, 137, 137, 138
inland PNW dry cropping use of, 141–142
key points for, 126
nitrogen mineralization or immobilization and, 144
overview of, 126–127
residue biomass estimates for, 137–141, 139
root composition and, 144–146
soil erosion protection using, 128–131, 130
soil health improvements using, 135–136
soil nutrients and crop comparisons in, 136
tillage systems and amount of, 128, 129
snow capture and, 133–135, 134, 135
stripper header in harvesting and, 142–143
water conservation and, 131–135, 133, 134, 135
wind erosion and, 128, 129, 131, 135
yield relationships in, 138–141, 139, 140
crop residue burning, 142, 151–154
cost factors in, 153, 154
economic tradeoffs for, 152–153
environmental impacts of, 152
fertilizer replacement costs in, 153, 153
reasons for using, 151
retaining enough residue for erosion protection during, 131
soil organic carbon (SOC) in, 71, 71
tradeoffs in, 152
windrow, 151, 365, 369
crop residue harvesting, 142, 146–151
biomass return after processing in, 151
calculating amount needed from, 146–147
cost factors in, 147–149, 150
economic tradeoffs for, 147–148, 149
partial budgeting approach in, 147, 149
site-specific issues in, 149–151
soil organic carbon (SOC) and, 146–147, 148
uses for harvested residue in, 146
crop rotation
acronyms used in, 165
alternative crop sequences in, 169
canola and, 186–190, 189
camelina and, 197–198
crop residue management using, 142
disease prevention using, 407
economic and environmental goals and, 166
economic impacts of, 209–215, 212, 214, 216, 217
grain legumes for, 173–179
herbicide use during, 377, 378–379
manure use in, 298
nitrogen use efficiency (NUE) and, 253–254
safflower and, 199–200
short-run costs of changing cropping systems in, 210
soil aggregation and, 56
soil pH and, 62, 64
spring grains in, 200
weeds management and, 377, 378–379
yellow mustard and, 199
CropSyst crop model, 31, 559
crop yield. See yield
cutworms, 493–500
climatic change impacts on, 500
descriptions of, 493–494, 493, 494, 495, 496
host plants and damage with, 498, 498
integration of management of, 499–500
life cycle of, 496–498, 497
resources for, 528–529
D
decision support tools, 550–567
agricultural management using, 40–42
climate forecasting and, 32–34
farm policies and use of, 550–551
information gaps in, 34–35
key points for, 538
REACCH tools for, 40
resources for, 567
selective list of, 552–567
selecting right model for, 34–35
delayed minimum tillage, 104
denitrification, 241, 256–257
Differential Global Positioning System (DGPS), 339
direct seeding
Annual Crop AEC using, 170
camelina and, 197
canola and, 188, 190, 194
erosion control using, 111, 170
high-disturbance, 103
increased acreage under, 105
low-disturbance, 103
nitrogen fertilizer use related to, 247
one-pass and two-pass systems in, 103–104
potential alternate crops for, 165, 233
runoff control using, 111
soil erosion control using, 111
tillage approaches in, 103–104, 106–108
variability in agricultural practices and, 322
yellow mustard and, 198
disc tillage, 104, 105, 106, 111
disease management, 399–463
cation exchange capacity (CEC) in, 66
climatic change adaptation strategies using, 35
cultural practices in, 411, 412
foliar and head diseases and, 401
future research in, 462
key points for, 399–400
microorganisms and, 76–77
monitoring in, 406–407
overview of pathogens in, 400–401
Prevent, Avoid, Monitor, and Suppress (PAMS) approach in, 404–410
prevention in, 405–406
resources for, 412, 462–463
root-infecting fungal pathogens and nematodes in, 402–403
selected inland PNW dryland cereal pathogens in, 410–462, 410
suppression in, 407–410
viral diseases and, 402
diseases. See also specific diseases
climate change impact on, 21, 29, 30, 403–404
foliar and head diseases, 401
viral diseases, 402
diversification, 163–218
agroecological classes and strategies in, 169
alternative crop sequences in, 169
Annual Crop AEC and, 169, 170–171
benefits of, 165
camelina and, 196–198
canola and, 186–196
climate change mitigation and, 166
cover crops and, 208–209
economic and environmental goals and, 166
economic impacts of, 209–215, 212, 214, 216, 217
facultative wheat or barley and, 205–206
flex cropping in, 206–207, 207
general water holding capacity and productivity by crop in, 234–235
Grain-Fallow AEC and, 169, 173
grain legumes and, 173–186
hard red winter wheat and, 204–205
hard spring wheat and, 200–201
key points for, 164
long-term productivity improvements with, 164
nitrogen requirements and water use by crop in, 236
potential alternate crops for, 165, 233
prices received by growers in, 215, 217
resources for, 217–218
safflower and, 199–200
short-run costs of changing cropping systems in, 210
spring barley and, 202–203
spring cereals and, 200–203
tillage systems in, 206
Transition AEC and, 169, 171–172
white spring wheat and, 201
winter cereals and, 203–206
winter triticale and, 203–204, 204
yellow mustard and, 198–199
dockage
Italian rye grass and, 387
weed control timing and, 364
wheat protein levels and, 246
winter wheat varieties and planting decisions and, 386
double cropping systems, 29
downy brome, 182, 194, 357, 376, 382–384, 433
drones (aerial vehicles), 333, 473, 555
drought
canola planting and, 190
climate data resource for, 39
climate modeling of stressors in, 164
delayed seeding in weed control and, 183
excess soil salt levels and, 67
fallow used to lessen effects of, 101
global climate change impacts on, 21, 42, 174
Grain-Fallow AEC with, 172
grain legume production and, 174, 179
dryland agricultural systems
diversity of, 21–27
geographic area of, 21
precipitation ranges in, 22–24
predominant crops of, 21, 22
soil orders and, 23, 24
temperature ranges in, 21–22
topography influences on, 24
dust emissions
particulate matter standards for, 374
soil erosion and, 109
tillage causing, 374
undercutter tillage to reduce, 206
wind erosion and, 172–173
dust mulch fallow systems, 116
Index

E
early season weed management programs, 397
earthworms
  soil aggregate stability and, 82, 83
  soil pH and, 59
  weed seed germination and, 362
economic factors
  fungal pathogen damage and, 400, 401
  land acquisition and, 36
  manure use and, 297
Economic Research Service (ERS), 549
economic return
  conventional tillage and, 211, 212
  crop plant population for, 388
  weed management and, 377
  economic thresholds, in weed management, 363, 375, 377
electrical conductivity (EC). See soil electrical conductivity
El Niño Southern Oscillation (ENSO), 19–20
Entisol soil order, 23, 24
environmental considerations
  crop residue burning and, 152
  crop rotation and, 166
  dust in wind erosion and, 172–173
  herbicide drift and, 374
  leaching and, 255
  volatilization drift and, 256
  weed management and, 374
  ergosterol, 75
erosion. See also water erosion; wind erosion
  changing growing practices and, 27
  climate change adaptation strategies for, 35
  climate change impact on, 30
  direct seed for controlling, 111, 170
  inland PNW soil susceptibility to, 24
  phosphorus loss from, 261
  safflower and, 199
  soil health and resistance to, 49
  steep topography and winter precipitation and, 170
  tillage systems and, 58, 58, 110, 355, 374, 381
eutrophication, 255, 261
Extension programs, 4, 90, 325, 538, 543, 549
Extension publications and resources, 3, 4, 37, 38, 118, 149, 250, 269–272, 291, 297, 298–299, 301, 346, 376, 380–381, 462, 463, 469, 528, 529, 530
eyespot (strawbreaker foot rot), 448–453
  background on, 448–449, 449
  causes of, 449
  characteristics and management options for, 448
  disease cycle and conditions favoring, 451–452
  diseases similar to, 449–450
  distribution of, 438
  key diagnostic features of, 450–451
  management strategies for, 452–453
  potential climate change effects on, 452
F
farm assessment tools, 559–567
farm machinery and equipment costs of owning and operating, 118
weed management program's use of, 378, 380
wheel soil compaction from, 54, 55
farm management
  climate change impact on, 32
  decision support tools for, 40–42
  land transaction decisions and, 36
  soil organic matter (SOM) dynamics and, 72, 78–83
farm policies
  alternate crop explorations and, 165
  brief history of, 538–542, 540–541
  climate change impacts on, 35
  decision support tools for, 550–567
  farm support programs and, 166, 538
  future prospects for, 544–548
  impacts on PNW of, 542–544
farm software. See also decision support tools
  precision agriculture with, 338–339
weed management using, 379
Advances in Dryland Farming in the Inland Pacific Northwest

federal farm support programs, 166, 538
fertilizers. See also nitrogen fertilizers
CO₂ fertilizers, 31, 35, 42
crop residue burning and cost of, 153, 153
low cation exchange capacity (CEC) and, 64
organic sources of, 238
soil aggregate stability and, 53, 53
soil salt levels and, 68
variable rate applicator systems for, 339
field bindweed, 359, 376
flex cropping
diversification strategy using, 206–207, 207
grain legumes in, 173, 175, 179
Transition AEC and, 171–172
flocculation, 66
forecasts
disease prevention using, 407
longer term climate projections in, 33–34
seasonal climate forecasts, 33, 34, 554
weather forecasts, 32, 34
fungal pathogens
economic damage from, 400, 401
microorganism suppression of, 76–77
root infections from, 402, 403
seed treatments for, 409
soil pH and, 59
stem diseases and, 401
fungi
manure applications increasing, 303
rotation benefits and, 189
soil microorganisms and, 74–75, 75
soil organic matter (SOM)
decomposition and, 75–76, 76
soil salt tolerance of, 68
tillage impact on, 79, 80
fungicides, 401, 406, 408–409, 417, 419
Fusarium crown rot, 433–437
background on, 433
characteristics and management options for, 434
disease cycle and conditions favoring, 435–436
distribution of, 433–434
key diagnostic features of, 434–435, 435
management strategies for, 436–437
potential climate change effects on, 436
G
government policies
alternate crop explorations and, 165
brief history of, 538–542, 540–541
climate change impacts on, 35
decision support tools for, 550–567
farm support programs and, 166, 538
future prospects for, 544–548
impacts on PNW of, 542–544
resources for, 548–550
Grain-Fallow agroecological class (AEC) alternative crop sequences in, 169
Annual AEC compared with, 102
camelina and, 197
canola and, 187, 191, 193, 194
crop diversity in, 167–170, 168, 172–173
crop residue production in, 131, 146–147
description of, 26, 26, 27, 167
diversification strategies in, 169, 173
economic analysis of net returns in, 215, 216
general water holding capacity and productivity by crop in, 234–235
grain legumes in, 175, 176
predominant crops in, 21, 22
production issues and adaptive strategies in, 169
Index

soil aggregate stability in, 52
soil organic matter (SOM) in, 80
spring barley and wheat and, 200, 202
tillage systems and, 200, 206
Transition AEC compared with, 102
wind erosion in, 131, 172–173
winter cereals and, 203, 204, 205

grain-fallow systems
water infiltration and hydraulic
conductivity in, 57
weeds from early seeding in, 382

grain legumes
benefits of using, 173
diversification strategy using, 173–186
fall planting window for, 182
N fertilizer use with, 184
nitrogen management for, 183–184
N management for crops following, 184–185
plant establishment in, 179–182
red lentil characteristics in, 178–179
rotation effect of, 185–186
rotation fit of, 173–179
soil pH in, 62, 64
weed management for, 182–183
winter pea characteristics and, 175–178, 177, 178

grazing
Aridisol soil order and, 23
cover crops and, 209, 298
decision-support tool for, 552
first season’s canola and, 191–192, 192
green bridge effect
disease management and, 402, 407, 411, 424, 428, 432, 442, 447
insect management and, 482, 514–515
weeds from early seeding in, 382
weeds from early seeding in, 382

ground cover
crop residue estimates with, 137, 137, 138
soil erosion in tillage systems and, 58, 58, 111
water storage efficiency and, 132

Growing degree days
AgClimate Atlas on, 40–42
future climate projections for inland PNW on changes in, 29, 30
inland PNW agronomic zones on, 25, 26

H

Haanchen barley mealybugs, 521
description of, 521, 522
host plants and damage with, 523–524, 523, 524
integrated management of, 524–525
life cycle of, 522–523
resources for, 529–530
status and distribution of, 521
Haney’s soil health testing method, 87–88
hard red winter wheat
rotational use of, 204–205
tilling systems for, 205
Harrington Seed Destructor, 388
harvest equipment, and weed seed movement, 361
harvest index, 137, 367
healthy soil. See soil health
heavy equipment, soil compaction from, 54, 55
heavy metals, in biosolids, 296–297
herbicide resistance
assessment matrix for likelihood of developing, 380, 381
causes of, 355
downy brome and, 376
herbicide rotation and, 379
Italian ryegrass and, 376
managing for, 379–380
testing for, 379
herbicides
camelina and, 197
canola and, 188, 192
crop rotation and, 377
downy brome and, 383–384
early season use of, 397
environmental considerations with, 374
erosion potential and, 377
grain legumes and, 182–183
Italian ryegrass and, 388–389
precision management of, 321
prohibition on volatile formulations of, 374
rotation of modes and sites for, 379
Russian thistle and, 385–386
soil acidity and, 264, 265
soil chemistry and, 376
soil pH and, 377
thresholds in, 364
tillage systems and, 377
weed management program fit with, 381
Hessian fly, 483–487
climate change impacts on, 486–487
description of, 484, 485
host plants and damage with, 484
identifying characteristics of, integrated management of, 486
life cycle of, 484
resource for, 528
status and distribution of, 483–484
high-disturbance direct seeding, 103
hydraulic conductivity
cropping systems and, 57–58, 57
measurement of, 57
seasonal variations in, 58
soil bulk density and compaction and, 54
improvement of dryland practices, 35
Inceptisol soil order, 23, 24
infiltration. See water infiltration
inland PNW
agricultural and ecological zone classifications for, 24–26
agroecological classes (AECs) of, 22, 26–27, 26
agronomic zones in, 25, 26, 167, 327
conservation tillage systems in, 100, 104–105, 108
dryland agricultural system diversity in, 21–27
future climate projections for, 28–30, 29, 30
geographic area of, 21
grower considerations for improving soil health in, 90–91
precipitation ranges in, 22–24, 26
predominant crops of, 21, 22
production practices for climate change adaptation and mitigation in, 35–36
soil fertility factors in, 238
soil health assessment and, 87–89
soil orders of, 23, 24
soil organic matter (SOM) dynamics in, 24, 70–72
temperature ranges in, 21–22
topography influences on, 24
insect management, 469–530. See also integrated pest management
climate change adaptation strategies using, 35
key points for, 469–470
pests affecting inland PNW cereal production and, 470
resources for, 528–530
integrated pest management (IPM), 354–355, 471–475
changing crop systems and, 474–475
climate change impacts on, 473
elements and principles of, 471–472
inland PNW wheat production systems and, 472–473
principal inland PNW insect pests in, 475
variability and change in technology used in, 473–474

I
immobilization, 78, 144, 248, 287, 304, 327
Integrated Scenarios of the Future Northwest Environment, 42
integrated weed management (IWM)
application of concept of, 355
components of, 354
conceptual model for, 355, 356
developing system for, 375–381
ecological principles in, 355–359
economic thresholds in, 363, 375, 377
key points for, 353–354
integrated pest management compared with, 354–355
method evaluation in, 375, 380–381
problem diagnosis in, 375–377
program execution in, 375, 380
program selection in, 375, 377–380
public opinion and social considerations in, 373–374
selected problematic inland PNW weeds and, 382–389
steps in developing, 356, 375
thresholds in, 354, 363–364, 364, 366, 375, 377
weed reproduction and dispersal and, 361
interference, and weed management, 354, 362–363
Intergovernmental Panel on Climate Change (IPCC), 28, 33
invasive species, 21
inversion tillage, 110, 111, 112, 264, 360
Italian ryegrass herbicides for, 182, 193, 194, 387–389
weed management of, 357, 362, 376
J
jointed goatgrass, 151, 182, 194, 357, 360, 365, 369, 376, 386–387
K
L
lambsquarters, 194, 355, 358, 359–360, 376
land acquisition economic considerations in, 36
longer term climate change projections for, 34
large yellow underwing, 494, 496, 497. See also cutworms
leaching environmental impact of, 255
factors affecting, 254–255
nitrogen loss through, 78, 174, 183, 241, 254–257, 329
nitrogen use efficiency (NUE) and, 250, 253
nutrient cations and, 64
soil organic matter (SOM) decay and, 69
legumes. See grain legumes
lidar sensors, 141, 151
lime application
high cation exchange capacity (CEC) and, 66
measuring effectiveness of, 265–266
resources for, 271
soil pH and, 62, 63, 82, 263–266, 271
line-transect method, in crop residue estimates, 137
loess soils, 24
low-disturbance direct seeding, 103
M
magnesium cation exchange capacity (CEC) and, 64, 66
pH range and availability of, 59
soil aggregates with, 51
soil flocculation and, 66
manganese deficiency, and disease, 427
manganese toxicity, and crop yields, 59
manure antibiotics in, 305
cation exchange capacity (CEC) and, 67
composition of, 299
composting and, 298, 301–303, 302, 304, 305, 309
contaminants in, 304–306
copper toxicity from, 305–306
cover crops with, 298
crop rotation with, 298
economic factors in use of, 297
grain quality considerations with, 301
management planner for, 299–301
phosphorus from, 261
plant-available nitrogen in, 299, 301, 302
resources for, 298–299, 299–301
safety regulation of production of, 305
secondary solids in, 301, 302
separated dairy solids in, 298, 305–306
soil aggregate stability and, 53, 53
as soil amendments, 289, 289, 297–306
soil carbon accumulation using, 289, 289
soil health benefits of, 301–303, 303
soil organic matter (SOM) dynamics with, 69, 71, 78, 82
soil pH and, 62
treatment processes used with, 298
weed seeds in, 305
mapping, of weed populations, 381
mapping technology
precision agriculture and, 325, 326, 338, 342, 573
resources for, 345–346
site-specific management zones (SSMZs) on, 327–328, 328, 339
matric potential, tillage systems related to, 52, 52
mayweed chamomile, 194, 358, 362, 376
mealybugs. See Haanchen barley
mealybugs
meter stick method, in crop residue estimates, 137
microbes/soil microbes
soil pH and, 59
soil salt levels and, 68
microbiological controls, in disease management, 410
micronutrients, and soil fertility, 261, 263
mineralization
lime application for soil pH and, 62
nitrogen release from organic compounds and, 247
plant-available N from, 240, 240
repeated tillage encouraging, 112
soil organic carbon (SOC) loss in, 79, 112
soil water holding capacity and, 247
minimum tillage, 104
mites, 509–515
climate change impacts on, 515
descriptions of, 509–513, 510, 512
host plants and damage with, 513
integrated management of, 513–515
life cycles of, 513
resources for, 530
status and distribution of, 509
mitigation strategies
climate change impacts and, 17, 35–36
diversification in, 166
models and modeling. See also climate change modeling
disease prevention using, 407
global climate models (GCMs), 27–28, 31, 33
precision agriculture’s use of, 338
moldboard plow tillage, 131, 114, 128, 129, 370
Mollisol soil order, 23, 24
mulch tillage, 103, 111
N
National Agricultural Statistics Service (NASS) crop data, 1, 22, 26, 167, 168, 178, 202
National Association of Agricultural and Food Policy, 552
National Association of Wheat Growers, 549
Natural Resources Conservation Service, 87, 131, 404, 547
National Weather Service, 32
nematodes. See also cereal rust nematodes; root-lesion nematodes
soil health and, 83–84
nitrification, 251
electrical conductivity (EC) levels and, 68
N retention and, 241
soil pH and, 61, 62
nitrifier populations, and lime application for soil pH, 62
nitrogen (N)
carbon ratio with. See carbon-to-nitrogen (C:N) ratio
crop comparisons for requirements and water use with, 236
crop residue burning and loss of, 153, 154
crop residue concentrations of, 136
crop residue estimates using, 141
denitrification and loss of, 241, 256–257
leaching and loss of, 78, 174, 183, 241, 255, 329
natural forms available to plants, 240
nitrogen cycle and release of, 240, 240
organic amendment use and temporary loss of, 287, 288
pH range and availability of, 59
potentially mineralizable (PMN), in soil, 78
soil organic matter (SOM) with, 72, 74, 75, 78
tillage systems and dynamics of, 70
wheat-based cropping systems and high demand for, 239–240
nitrogen (N) fertilizers
calculating needed annual rates for, 244–247
canola and, 196, 195
cation exchange capacity (CEC) increase with, 67
climate change and, 322
grain legumes and, 184, 185
nitrogen use efficiency (NUE) and, 241–242
precipitation and soil relationships and, 243–244
precision management of, 329–333, 341
soil aggregate stability and, 53, 53
soil pH and, 59–61
volatilization and, 255–256
water availability and, 245, 246
wheat yields and, 240
nitrogen immobilization, 78, 144, 248, 287, 304, 327
nitrogen management, 239–257
biosolid application rate and, 292, 293
canola and, 195–196
climate change adaptation strategies using, 35
denitrification and, 241, 256–257
factors driving, 242–248
grain legumes and, 183–184
grain protein levels and, 246
leaching and nitrogen losses in, 78, 174, 183, 241, 255
Liebig versus Mitscherlich approaches in, 250–251, 250
nitrogen availability and, 240–241
nitrogen cycle in, 240, 240
nitrogen rate variation and, 243–244, 243
nitrogen recommendation factors in, 244–245
nitrogen use efficiency (NUE) and, 241–242
precipitation and soil relationships and, 243–244
precision agriculture and, 329–333
residual soil nitrogen and, 246–248, 248
resources for, 268–269
site-specific, 329–330
strategies for improving, 251–254
typography variations and, 242–243, 242
variable rate nitrogen (VRN) applications in, 330–331, 332, 341, 344
volatilization and, 255–256
water and nitrogen relationships and, 242–244
water availability and, 245, 246
nitrogen use efficiency (NUE)
canola and, 195
components of, 241
crop management decisions and, 248–249
crop rotations and, 253–254
factors impacting, 241, 248–251
fertilizer placement and, 251–253, 252
fertilizer rates based on soil tests in, 242
leaching and, 241, 250, 253
nitrogen management for, 241–242
precision agriculture and, 320, 332
soil and plant processes in, 241
strategies for improving, 251–254
unit nitrogen requirements (UNRs) and, 248–251, 250, 267
wheat cultivar yield and, 253
normalized difference vegetation index (NDVI), 336–336
no-till tillage systems
Annual Crop AEC and, 170
benefits of, 165
biosolid application rates in, 292–283
crop residue amounts produced in, 128, 129
crop residue for erosion control in, 128, 130, 131
diversification strategy using, 206
earthworm populations in, 84, 85
Grain-Fallow AEC and, 173
ground cover, runoff, and soil erosion in, 58, 58
herbicide use with, 377
increased acreage under, 105
snow depth in, 133–135, 134
soil aggregate stability in, 52
soil organic carbon (SOC) dynamics and, 69, 70, 78–79
Transition AEC and, 171
water hydraulic conductivity and water infiltration with, 57, 58
water storage efficiency in, 132, 133
nutrient management resources for, 269–270

O
oilseed production. See also specific crops
average net returns for, 215
challenges to adopting, 187–188
one-pass direct seeding, 103–104, 105
OreCal, 549
Oregon Lime Score, 265
Oregon/Washington Phosphorus Indexes, 261, 270
organic amendments
soil aggregate stability and, 53, 53
soil bulk density increased by, 55–56
soil salt levels and, 68
organic matter
cation exchange capacity (CEC) with, 66, 67
soil enzymes and decomposition of, 77
soil fauna and, 84
soil organic matter (SOM) with, 74

P
Pacific Decadal Oscillation (PDO), 19–20
Pacific Northwest (PNW)
average annual maximum temperature (1981–2020) across, 17, 18
average annual precipitation (1981–2020) across, 17–18, 18
climate change impact on, 38
climate overview of, 17–21
farm policy impact on, 542–544
global climate change impacts in, 20–21
primary drivers of climate variability in, 19–20
year-to-year variability in annual temperature and precipitation in, 18, 19
Pacific Northwest Direct Seed Association, 105
paper-manufacturing, black liquor from crop residue used in, 151, 286, 308, 309
paper manufacturing waste, as soil amendment, 308–309
particulate matter
crop residue burning producing, 152
standards for, 374
volatilization and, 256
particulate organic matter (POM), in soil organic matter (SOM), 72, 74
pea vine (PV) application benefits of, 303
cation exchange capacity (CEC) with, 67
soil organic carbon (SOC) dynamics with, 71, 82
penetration resistance, and soil health, 49
period thresholds, in weed management, 363, 364
permanganate oxidizable carbon, in soil organic matter (SOM), 74, 79
pesticides
environmental considerations with, 374
precision management of, 322
soil salt levels and, 68
weed management program fit with, 381
pests. See also insect management and specific pests
climate change impacts on, 21, 29, 30
crop residue harvesting and, 149
pH
alternative ways of increasing or maintaining, 62
aluminum levels and, 59, 60
biochar application and, 62, 63, 306, 308
conservation tillage systems and, 113–115
crop rotation and, 62, 64
fertilizer efficiency and, 264, 265
grower resources on, 269
herbicide use and, 377
landscape-specific processes affecting, 325
lime application increases in, 62, 63, 263–266, 271
long-term winter wheat-spring pea (WW-SP) cultivation and, 61, 61
macronutrient availability ad, 59
measurement of, 59
N fertilizer use and, 59–61
phosphorus fixation and, 259–260
resources for, 269, 271
soil acidification and, 263, 266
as soil health indicator, 49
soil processes impacted by, 59
tillage practices and, 78
phosphorus (P)
crop residue concentrations of, 136
deficiency of, 259
erosion loss of, 261
factors impacting requirements for, 260–261
fertilizer placement of, 260
indexes for, 261, 270
manure application for, 261, 304
manures with, 301, 302
pH levels for fixation of, 259–260
soil amendments using, 289, 290
soil organic matter (SOM) with, 75
soil test for levels of, 259, 261
physiological leaf spot (PLS), 262, 272, 414
plant diseases. See disease management; diseases
planting dates
climate change adaptation strategies for shifting to earlier, 35
climate change impact on, 29, 30
disease prevention and, 407–408
seasonal climate forecasts for, 34
weather forecasts for, 34
polysaccharides, 50, 53, 75, 76, 136, 143, 152
potassium (K)
crop residue burning and loss of, 153, 154
fertilizer application of, 262
manure applications for, 304
paper manufacturing waste as source of, 309
pH range and availability of, 59
soil fertility and, 64, 261, 262
potassium chloride (KCl), 262
precipitation
average annual (1981–2020) across PNW, 17–18, 18, 22
climate change adaptation strategies for changes in, 35
dryland agricultural systems and, 22–24
future climate projections for inland PNW on changes in, 29, 29, 31
global climate change impacts on, 20–21
greenhouse gas emissions and, 20, 21
inland PNW agronomic zones on, 25, 26
inland PNW classes for, 24
primary drivers of variability in, 19–20
rain shadow effect from Cascade Mountains and, 12, 15, 17, 277
seasonal climate forecasts of, 33
soil organic carbon (SOC) and level of, 71
variability across decades in, 20
water conservation needs and, 132
water storage efficiency and, 132
year-to-year variability in annual temperature and precipitation in, 18, 19
precision agriculture, 319–346
additional research needs for, 344–345
climatic change adaptation strategies using, 36, 321, 329
Advances in Dryland Farming in the Inland Pacific Northwest

- concepts (4Rs) in, 321
- crop residue harvesting and, 151
- decision considerations for, 342–343
- description of, 320–321
- farm equipment in, 338–339
- farmer case studies for, 344
- field-scale variability in, 322–325
- future directions for, 343–345
- geospatial referencing technology in, 337
- history of, 321–322
- inland PNW adoption of, 339–342, 340
- key points for, 320
- landscape-specific process affecting, 323–325, 324
- lateral water flow and, 323, 323
- models in, 338
- number of farmers using technology from, 341–342, 340, 344
- remote sensing technology in, 333–337, 335
- resources for, 345–346
- prescription maps with site-specific management zones (SSMZs) in, 327–328, 328, 339
- site-specific management process in, 325–329, 327
- site-specific nitrogen management in, 329–333
- soil electrical conductivity (EC) used in, 336, 336
- soil mapping in, 325, 326, 338, 342, 573
- steps in, 321
- technologies in, 321
- variability within fields and across years in, 325, 326
- winter wheat performances classes example in, 332–333, 333
- Prevent, Avoid, Monitor, and Suppress (PAMS) approach, 404–410
- prickly lettuce, 358, 376
- pulse crops
  - crop residue nutrients in, 136, 143–144
  - early season use of, 379
  - federal programs encouraging, 166
  - herbicide resistance and, 379
- nitrogen fixing with, 298
- rotational use of, 176, 181–182, 183, 184, 366, 387–388
- seeding rate for, 368, 388
- Purdue University
  - Agronomy Guide, 128
  - Manure Management Planner, 299–300
- Pythium root rot, 428–433
  - background on, 428
  - characteristics and management options for, 429
  - disease cycle and conditions favoring, 431
  - key diagnostic features of, 428–429, 430
  - management strategies for, 431–433
  - potential climate change effects on, 431
- Q
- R
- rain. See precipitation
- recrop wheat, 178, 206, 207
- red lentils. See also grain legumes
  - crop rotational characteristics of, 178–179
- reduced tillage, 104, 106–108, 173
- Regional Approaches to Climate Change (REACCH)
  - climate and weather tools from, 40, 41
  - decision support tools from, 40
  - geographic area of dryland agricultural systems and, 21
  - webinar series from, 257, 268–269, 346
- regulation. See government policies
- remote sensing spectral indices, in crop residue estimates, 14
- remote sensing technology, in precision technology, 333–337, 335
- Representative Concentration Pathways (RCPs), for greenhouse gas emissions, 28, 28, 29, 29, 30
- residue burning. See crop residue burning
- residue cover
  - conservation tillage and, 115
evaporation rates and, 58
fallow and flex cropping and, 200
indices for predicting, 141, 335
reduced tillage and, 104
residue decompensation rates and, 143
soil fauna population and, 83
soil hydraulic properties and, 57
soil organic matter (SOM) and, 80–81, 82
soil pH and, 62
tillage systems and, 105, 106, 111, 128
water infiltration and evaporation suppression and, 132
wind and water erosion related to, 131
residue-to-grain ratio (R:G ratio), 137, 138, 139, 141
resistance. See herbicide resistance resources
biosolids, 291, 297
climate change, 37–42
climate modeling, 37–38
conservation tillage systems, 116–118
decision support tools, 40–42, 552–567
disease management, 412, 462–463
diversification, 217–218
farm policies, 548–550
insect management, 528–530
manures, 298–299
precision agriculture, 345–346
soil amendments, 310
soil acidification, 266
soil fertility, 268–271
soil health, 91–92
soil sampling methods and tests, 268
weather and climate data, 38–40, 41
Rhizoctonia root rot, 419–425
background on, 419
causes of, 420–421
characteristics and management options for, 420
disease cycle and conditions favoring, 422–423
distribution of, 420
key diagnostic features of, 421–422, 421
management strategies for, 423–425
potential climate change effects on, 423
ridge tillage, 102–103
rodweeding, 52, 101, 104, 370, 385
root development
compaction impacts on, 49
seasonal variations in soil hydraulic properties from, 58
soil acidity and, 264
root-lesion nematodes, 437–442
background and causes of, 437–438
characteristics and management options for, 438
disease cycle and conditions favoring, 439–440
distribution of, 438
key diagnostic features of, 438–439, 439
management strategies for, 440–442
potential climate change effects on, 440
root rot, 77, 402, 403, 408. See also
Pythium root rot; rhizoctonia root rot
chloride and, 262
cropping practices and, 410
cultural practices and, 411
diagnostic features of, 434
nutrient management and, 408
Rhizoctonia solani causing, 77, 439, 456
seed treatment and, 409
surface residue and, 408
rotation. See crop rotation
rotational diversification, 35
runoff
canola and reduction in, 188, 190
compaction of soil affecting, 54
direct seeding for controlling, 10, 111
drinking water sources and, 255
fertilizer use and, 10, 237, 250, 254, 255, 268
frozen soil and, 101, 110
snowmelt and, 133
soil aggregate stability and, 52
as soil health indicator, 50
steep topography and winter precipitation and, 170
tillage systems and, 58, 58, 110
water infiltration and control of, 132
water conservation needs and, 132
Russian thistle, 197, 358, 359, 376, 384–386
safflower, diversification strategy using, 199–200
salt levels in soil
electrical conductivity (EC) and, 67, 68
factors adding, 68
scenarios tools
climatic change and need for changes in, 36
resources for, 42
seasonal climate forecasts, 33, 34, 554
seedbank, weed, 361–362, 382
seed management, in weed control, 359, 388
seed treatment, in disease prevention, 409
sensing technology
crop mapping using, 141
herbicide application using, 385–386
precision agriculture with, 151, 333–337, 338, 335, 555
silt loams
seed management in, 359, 388
biochar performance and, 306
cation exchange capacity (CEC) of, 65
deep-injected fertilizer use with, 256
inland PNW wheat production and, 24
land-use management effects on, 73
organic soil amendment use and, 289
potassium levels in, 262
runoff and erosion related to waereholding capacity of, 170
soil erosion effects on, 109
soil organic carbon (SOC) and bulk density in, 56
soil organic carbon (SOC) depletion rates in, 70
site-specific management zones (SSMZs), 327–328, 328, 339
snow capture, and crop residue, 133–135, 134, 135
snowpack, mountain
global climate change impacts on, 20
scenario tool for, 42
SOC. See soil organic carbon
sodium acetate test, for potassium, 262
soil acidification
conservation tillage systems and, 105
pH levels and, 263, 266
resources for, 266
soil aggregation
biosolid applications and, 294
conservation tillage systems and, 111
crop residue burning and, 152
soil health and stability of, 50–54
soil organic matter (SOM) decomposition and, 75–76, 76
soil amendments, 283–310
biochar for, 306–308
biosolids for, 289, 289, 290–297
carbon-to-nitrogen (C:N) ratio for selecting use of, 287
climate change mitigation strategies using, 36, 285–286
common organic materials in, with C:N composition, 287, 288
considerations in using, 286–289
factors in selecting, 289
key points for, 283–284
manures for, 289, 289, 297–306
paper manufacturing waste and, 308–309
quality and type of, and amount of carbon stored in soils, 287–289, 289, 290
resources for, 310
soil health improvements using, 284–285, 285, 286
temporary loss of plant-available soil nitrogen upon addition of, 287, 288
types of variability seen in, 286–287
soil chemistry, and herbicides, 376
soil color, as soil health indicator, 50, 51
soil compaction. See compaction of soil
soil depth
agroecological class characteristics with, 26, 167
inland PNW agronomic zones on, 25, 26
soil electrical conductivity (EC) related to, 67
as soil health indicator, 50
soil organic matter related to, 50, 51
Index

soil dispersion
impact of, 66
sodium promotion of, 66
surface residue slowing of, 128
soil electrical conductivity (EC), 67–68
measurement of, 67
precision agriculture’s use of, 336, 336
salt levels and, 67, 68
soil properties and, 67–68
soil enzymes
acidity suppressing, 62
management effects on, 83
permanganate oxidizable carbon and, 74
soil organic matter (SOM) and, 77, 77
soil erosion. See also erosion
conservation tillage systems and, 100, 101, 102, 105, 109–111
cover crops and, 208
crop residue harvesting and, 125
effects of different tillage implements on, 105, 106–108
global climate change impacts on, 21
herbicide use and possibility of, 377
impacts of, 110
tillage systems impacting ground
cover, runoff, and, 58, 58
soil fauna. See also insect management
management techniques for, 82–83
measurement techniques for, 82
soil health and, 82–84
soil fertility, 237–271
chloride and, 261, 262
grower resources for, 268–271
key points for, 237–238
managing soil nutrients in, 238–239
micronutrients and, 261, 263
nitrogen management in, 239–257
nutrient supply and removal at harvest and, 238, 239
phosphorus management in, 259–261
potassium and, 261, 262
soil pH and liming in, 263–266
soil sampling and tests in, 266–268
sulfur management in, 257–259
soil health, 47–92
aggregate stability and, 50–54
assessment of. See soil health assessment
biosolid applications and, 294, 295
bulk density and compaction and, 54–56
carbon loss and, 284
cation exchange capacity and, 64–67
characteristics of, 49
climate change adaptation strategies for, 35
crop residue harvesting and, 135–136
definition of, 48
diversification for long-term
improvement to, 164
grower considerations for improving, 90–91
indicators of, 49–84
intensive tillage and, 164
key points for, 48
management strategies for improving, 90–91
manure applications and, 301–303, 303
organic amendments to improve, 285, 286
potentially mineralizable nitrogen (PMN) and, 78
residual soil nitrogen and, 247
resources for, 91–92
soil enzymes and, 77, 77
soil fauna and, 83–84
soil microbial biomass dynamics as early indicator of, 74
soil electrical conductivity (EC) and, 67–68
soil fauna and, 83–84
soil organic matter (SOM) and, 68–83
soil pH and, 59–64
soil respiration and mineralizable carbon and, 77–78
soil water dynamics in, 57–59
visual indicators of, 50
soil health assessment, 84–89
commonly used properties in, 50
conceptual framework for, 85, 86
criteria for framework for, 85–86
description of, 48–49
difficulty of performing, 84–85
indices used in, 87–89
inland PNW and, 87–89
management systems and, 88–89, 89
qualitative and quantitative indicators in, 48–49
soil health indicators in, 49
variations in regions affecting indicators used in, 49–50
visual observation of soil color in, 50, 51
soil infiltration. See water infiltration
soil mapping
precision agriculture and, 325, 326, 338, 342, 573
resources for, 345–346
site-specific management zones (SSMZs) on, 327–328, 328, 339
soil microbial biomass. See biomass
soil moisture
climate change impact on, 21, 30, 31
global climate change impacts on, 21
soil electrical conductivity (EC) and, 67–68
weed germination and plant development and, 359
soil nutrients. See also specific nutrients
biosolids application and loss of, 296
complicated process of managing, 238–239
crop residue burning and, 152, 153, 153
crop residue harvesting and, 136, 147, 149, 150
disease prevention and, 408
harvest removal of, 238, 239
soil orders, inland PNW, 23, 24
soil organic carbon (SOC)
biosolids applications for, 294
carbon dioxide (CO₂) loss and sequestering of, 68
cropping system effects on, 68, 69
crop residue harvesting and, 136, 146–147, 148
land-use management effects on, 72, 73
tillage effects on, 69, 70
soil organic matter (SOM), 68–83
agricultural management influences on, 72, 78–83
bulk density related to, 55–56, 56
conservation tillage systems and loss of, 105, 111–113, 114
cropping system effects on, 56, 68, 69
crop residue harvesting and, 135–136
dissolved organic matter in, 74
effects of different tillage implements in, 105, 106–108
factors in loss of, 71
flex cropping and, 172
herbicide decisions and, 376
indicators of dynamics of, 72–78
inland PNW agronomic zones on, 25, 26
inland PNW dynamics of, 24, 70–72
lime application for soil pH and, 62
long-term time frame for changing, 71, 72
microbial biomass and, 74–77, 75, 81, 81
nitrogen fertilizer use related to, 247
particulate organic matter (POM) and, 72
permanganate oxidizable carbon in, 74
pools of, depending on turnover time, 68–69
potentially mineralizable nitrogen (PMN) and, 78
range of organic materials in, 68
soil aggregate stability and, 51–52
soil and management practices and dynamics of, 69, 70
soil enzymes and, 77–78
soil erosion and, 110
soil fauna and, 82
as soil health indicator, 49, 50
soil pH and, 59
soil respiration and mineralizable carbon and, 77–78
tillage effects on, 69, 70, 71
visual observation of soil color in, 50, 51
water infiltration and hydraulic conductivity related to, 57
soil pH. See pH
soil quality. See soil health
soil quality index, 88–89, 89
soil structure
biochar and, 306, 310
broadleaf crop sequences for improving, 164
canola production and, 188
compaction leading to loss of, 49
compost and, 304
cover crops benefitting, 208
fallow period reduction and, 9
herbicides and, 376
intensive agricultural systems' impact on, 47
particulate organic matter (POM) and, 72
residual soil nitrogen and, 247
salt levels in, 67
soil acidity impacts on, 265
soil amendments for improving, 283, 285, 310
soil hydraulic properties and, 57
soil organic matter (SOM) and, 68
tillage and, 57
soil tests
nitrogen use efficiency (NUE) and, 242
phosphorus level and, 259, 261
potassium level and, 262
resources for, 268, 271–272
soil fertility management using, 266–268, 271–272
sulfur level and, 258
soil water
dynamics of, 57–59
herbicide use and, 376, 377
tillage systems related to, 52, 52
SOM. See soil organic matter
spectral angle methods, in crop residue estimates, 141
spring cropping
downy brome control during, 382
Russian thistle and, 385
steppe vegetation, 17, 24
strawbreaker foot rot. See eyespot
streamflows
global climate change impacts on, 20
scenario tool for, 42
stripe rust, 412–419
background on, 412
causes of, 412
characteristics and management options for, 413
disease cycle and conditions favoring, 415–416
distribution of, 412–414
key diagnostic features of, 414–415, 414
management strategies for, 417–419, 418
potential climate change effects on, 416–417
stripper header, 125, 141, 142–143, 171, 200, 206
sulfur (S)
application recommendations for, 258
canola nutrient requirements and, 195
crop residue burning and loss of, 153, 154
factors impacting requirements for, 258–259
pH range and availability of, 59
plant absorption process for, 257–258
soil fertility and, 257–259
soil organic matter (SOM) with, 75
soil tests for level of, 258
sulfur dioxide (SO₂), from residue burning, 152
suppressive soils, 409–410
sustainable farming, 99, 105–109
sweep tillage, 104, 105, 106
synthetic fertilizers
manure applications compared with, 303, 303
plat-based soil amendments in place of, 285
soil aggregate stability and, 53, 53
T
take-all disease, 425–428
background on, 425
bacterial inhibition of, 59, 66, 76
characteristics and management options for, 426
disease cycle and conditions favoring, 426–427
key diagnostic features of, 425–427
management strategies for, 427–428
potential climate change effects on, 427
seed treatments for, 409
temperature
average annual maximum (1981–2020) across PNW, 17, 18, 22
climate change adaptation strategies for changes in, 35
climate change indicator using annual changes in, 20
dryland agricultural systems and, 21–22
future climate projections for inland PNW on changes in, 28–29, 29, 30
global climate change impacts on, 20–21
greenhouse gas emissions and, 20
primary drivers of variability in, 19–20
seasonal climate forecasts of, 33
topography influences on, 17
weed growth and, 359
year-to-year variability in, 18, 19
three-year winter wheat rotation. See Annual Crop-Fallow Transition agroecological class (AEC)
thresholds, in weed management, 354, 363–364, 364, 375, 377
tillage systems. See also specific systems
bulk density related to, 55, 55, 56
climate change adaptation strategies using, 35
crop residue amounts produced in, 128, 129
diversification strategy using, 206
earthworm populations in, 84, 85
effects of different implements in, 105, 106–108
erosion from, 58, 58, 110, 355, 374, 381
farm policies on, 547
ground cover production in, 128, 129
ground cover, runoff, and soil erosion and, 58, 58
hard red winter wheat and, 205
herbicide incorporation by, 377
Italian ryegrass and, 388
landscape-specific processes affecting, 324
production issues and adaptive strategies in, 169
Russian thistle and, 385
snow depth related to, 133–135, 134
soil aggregate stability related to, 52, 52
soil compaction related to, 51, 51, 54
soil health assessment and, 88, 89
soil organic matter (SOM) dynamics to, 56, 69, 70, 78
soil water dynamics impacted by, 57–58
variability in agricultural practices and, 322
water conservation needs and, 132
water storage efficiency comparisons in, 132, 133
transgenic glyphosate-resistant wheat, 373–374
Transition AEC. See Annual Crop-Fallow Transition agroecological class (AEC)
two-pass systems in direct seeding, 103–104
U
undercutter fallow tillage, 173, 200
biosolid applications with, 294
conservation tillage using, 104, 105, 115–116
crop residue for erosion control in, 128
diversification using, 171–172, 206
Russian thistle and, 384
soil erosion and, 110–111
unit nitrogen requirements (UNRs)
annual N fertilizer calculations using, 245
calculation of, 249
camelina and, 197
canola and, 196
crop comparisons for, 236
feed barley and, 202
hard red wheat and, 201
nitrogen use efficiency (NUE) in management decisions and, 248–251, 250, 267
nutrient management decisions based on, 249
site-specific nitrogen management and, 329–330
soil fertility management and, 249–251, 250
V
variable rate nitrogen (VRN) applications, 330–331, 332, 339, 341, 344
variegated cutworm, 500, 501. See also cutworms
volatilization, 255–256
ammonium loss through, 299
environmental impact of, 256
factors affecting, 255–256
nitrogen losses through, 250, 329
nutrient loss through, 296

W
Washington State Climatologist, 39
water availability
resource for, 270
water tables overlying clay-rich horizons and lateral flow in, 323, 323
water conservation
crop residue harvesting for, 131–135, 133, 134, 135, 142
snow capture and, 133–135, 134, 135
winter wheat production needs and, 131–132
water content of soil
factors affecting, 57
flex crop recommended minimums for, 207, 207
flex crop yield assessment using, 206
nitrogen management strategies related to, 242–244, 242
residual soil nitrogen and, 247
soil electrical conductivity (EC) and, 67
soil organic matter (SOM) and, 78
tillage systems affecting, 52, 52
water erosion. See also erosion
conservation tillage systems and, 110
crop residue production for, 128, 130
water holding capacity
agroecological class characteristics with, 167, 170, 171
biochar and, 306, 310
biosolids increasing, 294
comparisons by agroecological class and by crop, 234–235
fallow period reduction and, 9
herbicide use and, 376
higher yielding areas related to, 331
inland PNW agronomic zones on, 25, 26
precipitation zones affecting, 26
residue and tillage management and, 132
rotational diversification and, 210
soil electrical conductivity (EC) and, 66, 68
soil organic matter content and, 247, 254
soil texture affecting, 376
wheat yields on hills and, 243
wind erosion related to, 173
water infiltration
canola production and, 164, 188
cover crops and, 80, 208, 209, 553
crop residues and, 136
cropping system related to, 52, 52, 57–58, 57
direct seeding and, 111
liming and reduction of, 265
manure applications and, 303
measurement of, 57
nematode tunneling and, 83
organic materials and crop residues for, 53–54, 53
residue burning and, 152
seasonal variations in, 58–59
soil aggregate stability and, 51, 52, 53–54, 53, 76
soil amendments to improve, 283, 285
soil compaction reduction of, 54
soil dispersion and restriction of, 66
soil health assessment using, 49
soil organic matter (SOM) and, 68
surface residues promoting, 58, 58, 128, 132
tillage management and, 132
visual indicators of, 50
water use efficiencies (WUEs)
atmospheric carbon dioxide and, 16, 21
climate change adaptation strategies using, 35
crop choices in diversification and, 168
Advances in Dryland Farming in the Inland Pacific Northwest

nitrogen fertilizer use and, 245, 246
Russian thistle and, 384
weather data
decision support tools using, 40–42
resources for, 38–40, 41, 345, 554–555
weather forecasts
climate change projections using, 32
limitations of, 32
planting date decisions using, 34
weeds
crop growth interference from, 363
intensive crop rotation to reduce, 366
soil health and, 50
weed ecology, 355–359, 357–358
weed management, 353–392. See also
integrated weed management (IWM)
abundance of weed seeds and, 361–362
canola production and, 193–195
cation exchange capacity (CEC) in, 66
climate adaptation of weeds and, 359
climate change adaptation strategies using, 35
critical model for, 355, 356
critical period thresholds in, 363, 364
crop-weed competition in, 362–363
eyear season programs in, 397
ecological principles in, 355–359, 357–358
economic return and, 377
environmental considerations in, 374
grain legumes and, 182–183
herbicide rotation of modes and sites in, 379
inputs in, 365–373
interference and, 354, 362–363
key points for, 353–354
method evaluation in, 375, 380–381
monitoring and follow-up in, 380
new species recognition and prevention in, 375–376
other crop pests and, 362
perennial weeds versus annual weeds in, 359
pest management compared with, 354–355
problem diagnosis in, 375–377
program execution in, 375, 380
program selection in, 375, 377–380
public opinion and social considerations in, 372–373
resources on, 390–392
seed management in, 359, 388
selected problematic inland PNW weeds and, 382–389
soil chemistry and, 376
thresholds in, 354, 363–364, 364, 375, 377
tillage in, 355, 356, 357, 369–370, 374, 381, 383
weed life cycle stages and, 355, 359
weeds seedbank and, 361–362, 382
weeds. See also specific weeds
abundance of seeds of, 361–362, 375
adaptation to climate by, 359
crop competition with, 362–363
diversity of species of, 375
crop competition with, 362–363
lifecycle of, 355, 359
managing new species of, 375–376
mapping of populations of, 381
other crop pests interacting with, 362
perennials versus annuals in, 359
seed dispersal and, 360–361
seed dormancy and, 360
seed production by, 359–360
weed seedbank, 361–362, 382
weight per unit area method, in crop residue estimates, 137, 138
wheat curl mite, 511–513, 512. See also
mites
wheat head armyworm, 500–504
crop competition with, 504
description of, 500–502, 501, 502
host plants and damage with, 502–503
integrated management of, 503–504
resources for, 528–529
status and distribution of, 500
wheat midge, 504
crop competition with, 504–509
description of, 504, 505
host plants and damage with, 505–506, 506
integrated management of, 506–508
life cycle of, 504–505
relative risk of infection by, 507, 508
Index

resource for, 528
status and distribution of, 504
wheat production. See also grains; spring wheat headings; winter wheat headings
agricultural soils of, 24
biosolid applications in, 291, 293–294
climate change impacts on, 30–31
fungal pathogens and, 76–77
geographic area for, 21
herbicide resistance testing in, 379
inland PNW agronomic zones for, 25, 26
no-till planting in, 105
precision management of, 332–333, 333
precipitation classes for, 22–24
as predominant crop in dryland farming, 21
wheat soilborne mosaic (WSBM) disease, 458
background on, 458
causes of, 458
characteristics and management options for, 459
disease cycle and conditions favoring, 459–461
diseases similar to, 449–450
distribution of, 438
key diagnostic features of, 458–459, 460
management strategies for, 461–462
potential climate change effects on, 461
wheat yield
aluminum toxicity and, 59, 60, 263
biochar application and, 62, 63
equation for predicting, 207
lime application for soil pH and, 62, 63
nitrogen availability and, 243–244, 243
slope location and, 242, 243
soil pH and, 59
wheel traffic soil compaction, 54, 55
white spring wheat, 201
wind erosion
conservation tillage systems and, 109, 111
crop residue harvesting and, 125, 128, 129, 131, 135
Grain-Fallow AEC and, 131, 172–173
ground cover production related to, 128, 129
windrow burning, 151, 365, 369
winter grain mite, 511. See also mites
winter peas. See also grain legumes
rotational fit characteristics of, 175–178, 177, 178, 180
winter triticale, 203–204, 204
winter wheat-fallow (WW-F) tillage
cation exchange capacity (CEC) increase in, 66, 67
ground cover, runoff, and soil erosion in, 58, 58
soil aggregate stability in, 52, 52
soil erosion and, 109, 111
soil organic carbon (SOC) in, 70, 71, 82, 83
soil pH in, 62, 64
subsoil compaction in, 55, 56
water hydraulic conductivity and water infiltration with, 57, 58
winter wheat production
climate change impacts on, 30–31
critical period thresholds in weed management in, 363, 364
inland PNW agronomic zones on yields in, 25, 26
soil erosion and, 110
winter wheat-spring barley-spring legume (WW-SB-SL) tillage
residue harvest and, 147
rotational diversity with, 169, 171
soil bulk density and, 54
soil compaction and, 55
soil organic matter (SOM) and, 79
earthworm populations in, 84, 85
winter wheat-spring pea (WW-SP) tillage
soil organic carbon (SOC) in, 70
soil pH in, 61, 61, 62, 64
winter wheat-winter pea (WW-WP) tillage, soil organic carbon (SOC) in, 80, 81
wireworms, 515–521
climate change impacts on,
description of, 516, 516, 517
Advances in Dryland Farming in the Inland Pacific Northwest

factors affecting, 517-518
host plants and damage with, 517, 518
integrated management of, 519–521
life cycle of, 516–517
status and distribution of, 515

X

Y

yellow mustard
diversification strategy using, 198–199
rotational effect of, 100
yield
atmospheric carbon dioxide and, 21
conservation tillage systems and, 109, 115–116
crop residue estimates using, 138–141, 139, 140
crop-weed competition and losses in, 363
precision agriculture and, 320
soil compaction and, 54, 55
soil pH and, 59
yield monitoring technology, 141, 328, 332, 340, 341

Z

zinc, and soil fertility, 64, 263