

Contents

1	Introduction	1
1.1	What are agroecosystems?	1
1.2	Why study the biology of agroecosystems?	2
1.2.1	<i>The extent and characteristics of agroecosystems</i>	2
1.2.2	<i>Studying the biology of agroecosystems</i>	3
1.3	The purpose and organization of the book	4
2	Agricultural Environments	5
2.1	Introduction	5
2.2	The origins and historical development of agriculture	5
2.3	Contemporary agriculture	9
2.3.1	<i>Spatial patterns of agriculture</i>	10
2.3.2	<i>Agricultural classifications</i>	11
2.4	Characteristics of agricultural systems	11
2.4.1	<i>Temporal patterns in agricultural systems</i>	17
2.4.2	<i>Pest management in agroecosystems</i>	17
2.4.2.1	<i>Husbandry</i>	17
2.4.2.2	<i>Chemical interventions</i>	18
2.4.2.3	<i>Ecological management</i>	19
2.4.3	<i>Plant and animal selection</i>	19
2.4.4	<i>Nutrients on farmland</i>	20
2.4.4.1	<i>Nitrogen</i>	22
2.4.4.2	<i>Phosphorus</i>	22
2.4.4.3	<i>Potassium</i>	22
2.5	Unproductive areas on farmland	23
2.6	Ecosystem impacts of agriculture	25
3	Biodiversity	27
3.1	Introduction	27
3.1.1	<i>Biodiversity and agrobiodiversity</i>	27
3.2	Patterns of biodiversity within and between agroecosystems	27
3.2.1	<i>Global and temporal patterns of agrobiodiversity</i>	31
3.2.2	<i>Landscape-scale agrobiodiversity</i>	36
3.2.3	<i>Farm-scale agrobiodiversity</i>	38
3.2.4	<i>Species and genetic agrobiodiversity</i>	39

3.3	The importance of biodiversity in agricultural systems	41
3.3.1	<i>Ecosystem functioning and provision of ecosystem services</i>	41
3.3.2	<i>Stability and resilience</i>	41
3.3.3	<i>Productivity</i>	43
3.4	Issues and challenges for management of biodiversity in and around agroecosystems	43
3.5	Tools for sustainable management of biodiversity in agroecosystems	44
4	Biotic Interactions and Ecosystem Functioning	45
4.1	Introduction	45
4.2	Ecosystem services	45
4.2.1	<i>Ecosystem services in agricultural ecosystems</i>	45
4.3	Functional traits	46
4.4	The value of different functional groups for delivering ecosystem services in agricultural systems	47
4.5	Key ecosystem services in agroecosystems and the organisms that deliver them	48
4.5.1	<i>Carbon and nutrient cycling</i>	48
4.5.1.1	<i>Nutrient cycling organisms</i>	51
4.5.2	<i>Soil engineering</i>	53
4.5.3	<i>Water quality</i>	54
4.5.4	<i>Primary production</i>	54
4.5.5	<i>Pest regulation</i>	55
4.5.5.1	<i>Importation or classical biological control</i>	57
4.5.5.2	<i>Augmentation</i>	57
4.5.5.3	<i>Conservation</i>	58
4.5.6	<i>Pollination</i>	59
4.6	Issues and challenges for management of functional groups and ecosystem services	62
4.7	Tools for management of functional groups and ecosystem services	63
5	Soils	67
5.1	Introduction	67
5.2	What is soil?	68
5.3	Types of soil in agroecosystems	68
5.4	Importance and role of soil in agroecosystems	70
5.5	Soil structure	71
5.6	Soil biodiversity	72
5.6.1	<i>Microbes</i>	72
5.6.2	<i>Microfauna</i>	75
5.6.2.1	<i>Protozoa</i>	75
5.6.2.2	<i>Nematodes</i>	75

5.6.3	<i>Mesofauna</i>	76
5.6.4	<i>Macrofauna</i>	77
5.7	Issues and challenges for soil management in agroecosystems	80
5.7.1	<i>Soil erosion</i>	82
5.7.2	<i>Soil quality</i>	84
5.7.3	<i>Salinization and desertification</i>	84
5.7.3.1	<i>Salinization</i>	84
5.7.3.2	<i>Desertification</i>	86
5.8	Tools for sustainable soil management in agroecosystems	87
5.8.1	<i>Conservation tillage</i>	87
5.8.2	<i>Green manures and cover crops</i>	89
5.8.3	<i>Terracing</i>	90
5.8.4	<i>Conservation grazing</i>	90

6	Water (Hydrology)	91
6.1	Introduction	91
6.2	Importance of water in agricultural systems	91
6.3	Water use in different agricultural systems	92
6.3.1	<i>Rainfed systems and irrigated systems</i>	93
6.3.2	<i>Water-based agricultural systems: hydroponics, aquaponics, and aquaculture</i>	94
6.4	Issues and challenges for water in agroecosystems	95
6.4.1	<i>Availability of water in agricultural systems</i>	95
6.4.1.1	<i>Aridity, drought, and agricultural production</i>	97
6.4.1.2	<i>Salinization and agricultural production</i>	99
6.4.1.3	<i>Waterlogging and agricultural production</i>	99
6.4.2	<i>Manipulation of natural water systems for agriculture</i>	100
6.4.2.1	<i>Water abstraction for agriculture</i>	101
6.4.2.2	<i>Drainage of land for agriculture</i>	102
6.4.2.3	<i>Hard landscaping for agriculture and impacts on water distribution</i>	102
6.4.3	<i>Water pollution from agriculture and the impact on fresh and coastal waters</i>	103
6.4.3.1	<i>Pollution from aquaculture</i>	104
6.5	Tools for water management in agroecosystems	104
6.5.1	<i>Sustainable water use</i>	104
6.5.2	<i>New crop varieties</i>	105
6.5.3	<i>Land and soil management</i>	105
6.5.4	<i>Anti-transpirants (waterproof crops)</i>	106
6.5.5	<i>Sustainable aquaculture</i>	106
6.5.6	<i>An integrated approach to water management for agriculture</i>	106

7	The Biological Impacts of Globalization of Agriculture	108
7.1	Introduction	108
7.2	Shifting diets and commodities	109
7.2.1	<i>General trends</i>	109
7.2.2	<i>Globally traded cash crops</i>	109
7.2.3	<i>The shift towards more meat-based diets</i>	111
7.2.3.1	<i>Environmental impact of livestock</i>	112
7.2.4	<i>Agriculture and GHG emissions</i>	112
7.2.5	<i>Loss of traditional crops and varieties</i>	115
7.3	Global nutrient flows	115
7.4	The spread and impact of exotic pest species linked to agroecosystems	117
7.5	Patterns of land ownership	122
7.5.1	<i>Impact of land grabbing on agricultural systems</i>	123
7.6	The influence of technological advances on global agroecosystems	124
7.7	Next steps	125
8	Conservation and Sustainable Management of Agroecosystems	126
8.1	Introduction	126
8.2	Reintroducing diversity into agroecosystems	126
8.2.1	<i>Crop rotations</i>	127
8.2.2	<i>Intercropping and polycultures</i>	128
8.2.3	<i>Agroforestry</i>	130
8.2.4	<i>Alternative grassland management</i>	131
8.2.4.1	<i>Sward diversification</i>	131
8.2.4.2	<i>Rotation grazing systems</i>	132
8.2.5	<i>Genetic diversity</i>	132
8.2.6	<i>Reintegrating cropping systems with livestock</i>	133
8.2.7	<i>Regionally appropriate breeds</i>	133
8.2.8	<i>Diversification of food systems</i>	134
8.2.9	<i>Creating or enhancing non-productive areas on farmland</i>	134
8.3	Managing pests and nutrients sustainably	136
8.3.1	<i>Integrated pest management</i>	136
8.3.1.1	<i>Classical biological control</i>	136
8.3.1.2	<i>Augmentation</i>	137
8.3.1.3	<i>Conservation biological control</i>	137
8.3.2	<i>IPM in protected cropping systems</i>	137
8.3.3	<i>Sustainable nutrient management</i>	138

8.4	Alternative agricultural approaches	138
8.4.1	<i>The organic approach</i>	138
8.4.1.1	<i>Weed management</i>	139
8.4.1.2	<i>Insect pests and pathogens</i>	140
8.4.2	<i>Biodynamic agriculture</i>	140
8.4.3	<i>Integrated approaches</i>	140
8.5	Incentivizing a more agroecological approach	142
8.5.1	<i>Funding</i>	142
8.5.1.1	<i>A European example</i>	142
8.5.1.2	<i>A USA example</i>	143
8.5.1.3	<i>An Indian perspective</i>	143
8.6	Future perspectives	143
9	Future Perspectives	144
9.1	Introduction	144
9.2	Key drivers of agricultural change	144
9.2.1	<i>Population growth</i>	144
9.2.2	<i>Changing consumer habits</i>	145
9.3	Future challenges and issues for the biology of agroecosystems	146
9.3.1	<i>Competition for resources</i>	146
9.3.2	<i>Climate change</i>	147
9.3.3	<i>Biodiversity losses</i>	148
9.3.4	<i>Antimicrobial resistance</i>	148
9.4	Potential solutions for sustainable intensification in agroecosystems	149
9.4.1	<i>Ecological approaches</i>	149
9.4.1.1	<i>Ecological intensification</i>	149
9.4.1.2	<i>Agroecology</i>	150
9.4.1.3	<i>Climate-smart agriculture</i>	151
9.4.2	<i>Emerging innovations for agroecosystem biology</i>	151
9.4.2.1	<i>Elite rhizobia</i>	151
9.4.2.2	<i>Genetically modified crops</i>	151
9.4.2.3	<i>Precision agriculture using new technologies</i>	153
9.4.2.4	<i>Nanotechnology in agriculture</i>	153
9.4.3	<i>Taking agriculture out of the fields: alternative food production systems</i>	154
9.4.3.1	<i>Aeroponics</i>	154
9.4.3.2	<i>Insect farming</i>	154
9.4.3.3	<i>Meat substitutes</i>	158
9.4.4	<i>One answer is not enough</i>	159
	Glossary	161
	References	165
	Index	191