

# Contents

## Part I The growth of a single population

<b>1</b>	<b>Malthus, Verhulst and all that</b> .....	3
1.1	A look at exemplary data .....	4
1.2	Malthus model .....	6
1.3	First extensions of Malthus model: exogenous variability .....	10
1.4	Endogenous variability of the habitat .....	12
1.5	Intraspecific competition: the logistic effect .....	15
1.6	The Allee effect .....	19
1.7	Contest and scramble competition .....	20
1.8	Generalist predation .....	22
1.9	The spruce-budworm system .....	27
1.10	Harvesting .....	31
	Problems .....	33
	References .....	36
<b>2</b>	<b>Population models with delays</b> .....	39
2.1	Why delays, and how .....	40
2.2	Analysis of the delayed Malthus model .....	43
2.3	Analysis of nonlinear models with delay .....	45
2.4	Distributed delay logistic model .....	47
2.5	Age structure and the renewal equation .....	50
2.6	Analysis of characteristic equations .....	56
	Problems .....	59
	References .....	62
<b>3</b>	<b>Models of discrete-time population growth</b> .....	65
3.1	Discrete Malthus and Verhulst .....	66
3.2	Other simple models .....	73
3.3	Discrete dynamics involving age-classes .....	77
3.4	A non-linear model of adult-juvenile dynamics .....	82

Problems .....	86
References .....	90
<b>4 Stochastic modeling of population growth .....</b>	<b>91</b>
4.1 Birth and death models .....	92
4.2 Stationary distribution .....	94
4.3 Probability of extinction .....	97
4.4 Time to extinction .....	100
4.5 Extinction time with a bound on population size .....	104
4.6 Relations with deterministic processes .....	105
Problems .....	109
References .....	111
<b>5 Spatial spread of a population .....</b>	<b>113</b>
5.1 A general framework .....	114
5.2 The random-walk interpretation .....	117
5.3 Diffusion under Malthusian growth (Skellam model) .....	118
5.4 The heterogeneous habitat .....	123
5.5 Diffusion under logistic growth .....	128
5.6 Traveling waves .....	133
Problems .....	140
References .....	142

**Part II Multispecies Models**

<b>6 Predator-prey models .....</b>	<b>145</b>
6.1 Volterra model .....	146
6.2 Prey with Verhulst-logistic growth .....	153
6.3 Gause-type models .....	159
6.4 The Rosenzweig-MacArthur model .....	162
6.5 Growing bacteria in a chemostat .....	166
6.6 Kolmogorov's framework .....	169
Problems .....	171
References .....	173
<b>7 Competition among species .....</b>	<b>175</b>
7.1 Volterra's competition model .....	176
7.2 Modeling resource availability .....	181
7.3 Competition for one static resource .....	182
7.4 Competition in the chemostat .....	188
7.5 Two species living on two static resources .....	190
7.6 General aspects of two species dynamics .....	193
7.7 The case of a globally more efficient competitor .....	196
7.8 Possible coexistence of two competitors .....	197
7.9 Lotka-Volterra models .....	201

7.10	General properties of competition models	203
	Problems	204
	References	207
<b>8</b>	<b>Mathematical modeling of epidemics</b>	<b>209</b>
8.1	The basic elements for a description	210
8.2	The single epidemic outbreak	215
8.3	Stochastic modeling of an epidemic outbreak	223
8.4	Disease endemicity	231
8.5	$R_0$ : herd immunity, vaccination, estimation	237
8.6	Distributed infection period and variable infectiousness	240
8.7	Variable population	245
8.8	Heterogeneity in contacts	252
8.9	The general multi-site model and the next generation matrix	257
	Problems	261
	References	263
<b>9</b>	<b>Models with several species and trophic levels</b>	<b>265</b>
9.1	A case of non transitive competition	265
9.2	Two predators feeding on the same prey	270
9.3	The food chain model	277
9.4	One Predator feeding on two Preys	287
9.5	Chaos in Ecology	291
	Problems	292
	References	293
	<b>Appendix A. Basic theory of Ordinary Differential Equations</b>	<b>295</b>
A.1	The Cauchy problem	295
A.2	Equilibria and their stability	297
A.3	Linear systems	298
A.4	The non-linear case	303
A.5	Limit sets	305
A.6	Planar case: Poincaré-Bendixson theory	306
A.7	Planar competitive and cooperative systems	307
A.8	Lyapunov functions	308
A.9	Persistence	308
A.10	Elementary bifurcations	309
	References	314
	<b>Appendix B. Delay Equations</b>	<b>315</b>
B.1	On the nature of delay equations	315
B.2	Linear delay equations	316
B.3	Non-linear delay equations, stability of steady states, bifurcations	318
	References	319

<b>Appendix C. Discrete dynamics</b> .....	321
C.1 One dimensional dynamics .....	321
C.2 $n$ -dimensional discrete dynamical systems .....	323
C.3 Bifurcations .....	324
C.4 Bifurcations of periodic solutions of ODE .....	326
References .....	328
<b>Appendix D. Continuous-time Markov chains</b> .....	329
D.1 Markov processes .....	329
D.2 Holding times and the jump Markov chain .....	331
D.3 Stationary distributions .....	333
References .....	334



<http://www.springer.com/978-3-319-03025-8>

An Introduction to Mathematical Population Dynamics

Along the trail of Volterra and Lotka

Iannelli, M.; Pugliese, A.

2014, XIV, 346 p., Softcover

ISBN: 978-3-319-03025-8