Contents

	eface		xiii	
Ab	brevi	ations	xxi	
1.	Introduction: Why Scale?			
	1.1	1 Time and Space		
	1.2	Genes to Ecosystems	3	
	1.3	Modeling: Metabolic Theory and Macroecology	5	
	1.4	Mechanisms at Scales	6	
	1.5	Organisms as Model Systems	7	
	1.6	Summary	8	
Pa	rt I	Ecophysiology, Nutrient Limitation, and Stoichiometry	11	
2.	Context: Nutrient Limitation, the Evolution of Botanical Carnivory, and Environmental Change			
	2.1	Background	13 14	
	2.1	2.1.1 Nutrient Acquisition, Plant Traits, and the Evolution	14	
		of Botanical Carnivory	14	
		2.1.2 Anthropogenic Activities Alter Resource Availability	14	
		and Fluxes	14	
	2.2	Next Steps	18	
		•		
3.	The Small World: Stoichiometry and Nutrient Limitation in			
	Pitcher Plants and Other Phytotelmata			
	3.1	Stoichiometric Manipulations of Sarracenia	21	
		3.1.1 Effects of Soluble N from Atmospheric Sources	21	
		3.1.2 Effects of Nutrient Inputs from Supplemental Prey	23	
		3.1.3 Synthesis of Supplemental Feeding Experiments	26	
	3.2 Nutrient Additions in Other Phytotelmata			
	3.3 Summary			

VIII CONTENTS

4.	Scaling Up: Stoichiometry, Traits, and the Place of Sarracenia						
	in G	lobal S	pectra of Plant Traits	31			
	4.1	Globa	l Plant Trait Spectra	31			
		4.1.1	Traits	32			
		4.1.2	Trait Data	32			
	4.2	Carniv	vorous Plants in Global Trait Spectra	33			
		4.2.1		33			
		4.2.2	Nutrient Stoichiometry	37			
		4.2.3	Stoichiometric Effects of Supplemental Prey on				
			Carnivorous Plants	37			
		4.2.4	Stoichiometric Effects of Adding Inorganic Nutrients				
			to Carnivorous Plants	42			
		4.2.5	Photosynthesis and Construction Costs	47			
	4.3	Synth	esis	48			
Pa	rt II	Demo	graphy, Global Change, and Species				
			bution Models	51			
5.	. Context: Demography, Global Change, and the Changing						
			ns of Species	53			
	5.1	Backg	rround	54			
	5.2	s, Demography, and Anthropogenic Drivers: Moving	٥.				
	0.2		nd Temperature	54			
		5.2.1	Weak Responses to Temperature	55			
		5.2.2		56			
		5.2.3	_	57			
	5.3	Next S	• •	57			
_	The Corell World, Democrather of a Love L' of Brown of						
6.		The Small World: Demography of a Long-Lived Perennial Carnivorous Plant 5					
	Can	Laminyolous Plant 5					
	6.1	Demo	graphic Models of Sarracenia purpurea	59			
		6.1.1	,,				
			Sarracenia purpurea	59			
		6.1.2	ε	63 67			
	6.2 Experimental Demography						
	6.3	Demo	graphy in a Changing World	70			
		6.3.1	8 8	70			
		6.3.2	Linking N-Deposition Rates to Stage-Transition Matrices	71			

CONTENTS

		6.3.3 6.3.4	Modeling Population Growth The Future Is Now: Nitrogen Deposition and Extinction	74	
		0.5.4	Risk in 2020	77	
	6.4	Summ		80	
7.	Scal	ing I In:	Incorporating Demography and Extinction Risk		
, .			s Distribution Models	82	
	7.1	Availa	ble Data	82	
		7.1.1	Sarracenia purupurea Occurrence Data	82	
		7.1.2	Environmental and Climatic Data	83	
	7.2	Contir	nental Scaling of Demographic Models	83	
		7.2.1	Challenges and Simplifying Assumptions	83	
		7.2.2	Including P Introduced Additional Complexity	86	
		7.2.3	Continental Forecasts for S. purpurea Persistence	88	
	7.3	Foreca	asting the Future Distribution of Sarracenia purpurea	91	
		7.3.1	A MaxEnt Model for Sarracenia purpurea	91	
		7.3.2	Comparison of Forecasts of Demographic and		
			MaxEnt Models	91	
	7.4	Additi	onal Forecasting Scenarios, Past and Future	93	
	7.5	Synthe	esis	95	
Pa	rt III	Ecolo	ogy of the Sarracenia Community	97	
8.	Con	text: Co	ommunity Ecology, Community Ecologies,		
			unities of Ecologists	99	
	8.1	Backg	round	100	
		8.1.1	What Is an Ecological Community?	100	
		8.1.2	Substituting Space for Time, and Vice Versa	100	
		8.1.3	The Importance of Networks	103	
	8.2	Next S	Steps	103	
9.	. The Small World: Structure and Dynamics of Inquiline Food Webs				
	in S	in Sarracenia purpurea			
	9.1	-	osition and Structure of the Sarracenia purpurea Food Web	104	
		9.1.1	The Inquilines	104	
		9.1.2	Network Structure of the Sarracenia purpurea Food Web	105	
	9.2		currence Analysis of Sarracenia purpurea Inquilines	107	
		9.2.1	Quantifying and Testing Inquiline Co-occurrence	107	

X CONTENTS

	9.3	Succession of the Inquiline Food Web	114
	9.4	Dynamics of the Sarracenia purpurea Food Web	117
		9.4.1 Temporal Changes in Food-Web Structure	117
		9.4.2 A Model of Food-Web Temporal Dynamics	118
	9.5	Summary	123
10.	Scali	ing Up: The Generality of the Sarracenia Food Web	
	and	Its Value as a Model Experimental System	124
	10.1	The Sarracenia Food Web and Other Container Webs Are	
		"Normal" Food Webs	125
		10.1.1 Food-Web Data	125
		10.1.2 Food-Web Structure	126
		Spatial Scaling of the Sarracenia purpurea Food Web	126
	10.3	The Sarracenia purpurea Food Web as a Model Experimental	
		System for Understanding and Managing Food Webs	132
		10.3.1 Fishing Down the <i>Sarracenia</i> Food Web	135
		10.3.2 Is Wyeomyia smithii a Keystone Predator?	136
		10.3.3 Dynamic Food Webs in Dynamic Habitats	137
	10.4	Synthesis	143
Pa	rt IV	Tempests in Teapots	145
11.	Cont	ext: Tipping Points and Regime Shifts	147
	11.1	Background	148
		11.1.1 Examples of Regime Shifts and Alternative States11.1.2 Linking Empirical Data with Mathematical Models of	149
		Alternative States	150
	11.2	A Potential Need for Interventions	151
	11.3	Next Steps	151
12.	The	Small World: Tipping Points and Regime Shifts in the	
		acenia Microecosystem	153
	12.1	State Changes in the Sarracenia Microecosystem	153
		12.1.1 Temporal Dynamics of Aerobic and Anaerobic	
		Conditions in Sarracenia purpurea Pitchers	154
		12.1.2 An Alternative Approach	157
	12.2	Summary	161

CONTENTS XI

13. Scaling Up: Using *omics to Identify Ecosystem States and Transitions	162
13.1 Protein Surveys of the Sarracenia Microecosystem	162
13.2 Proteomics of Sarracenia Fed Supplemental Prey	163
13.3 The Cybernetics and Information Content of the S. purpurea	
Proteome	166
13.4 Early Warning Indicators, Hysteresis, and the Twisted Path of	
Funded Research	168
13.4.1 Hysteresis, Environmental Tracking, and Anti-hysteresis	
in the Sarracenia Microecosystem	170
13.5 Synthesis	173
14. Conclusion: Whither Sarracenia?	175
14.1 Resources, Nutrients, and Stoichiometry	176
14.2 Demography and Species Distributions	177
14.3 Food Webs and Other Networks	178
14.4 Tipping Points, Regime Shifts, and Alternative States	180
Appendices	183
Appendix A: The Natural History of Sarracenia and Its Microecosystem	185
Appendix B: The Basics of Resource Limitation	212
Appendix C: Deterministic Stage-Based Models	215
Appendix D: The Basics of Species Distribution Models	218
Appendix E: A Brief History and Précis of Methods for Analyzing	
Ecological Communities	221
Appendix F: On Tipping Points and Regime Shifts	238
Appendix G: On Biodiversity, Ecosystem Function, and *omics	249
Notes	255
References	259
Subject Index	303
Taxonomic Index	309