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978-1-107-05420-2 - Vegetation Dynamics: A Synthesis of Plant Ecophysiology, Remote Sensing and Modelling

Derek Eamus, Alfredo Huete and Qiang Yu

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## VEGETATION DYNAMICS

Understanding ecosystem structure and function requires familiarity with the techniques, knowledge and concepts of the three disciplines of plant physiology, remote sensing and modelling. This is the first textbook to provide the fundamentals of these three domains in a single volume. It applies cross-disciplinary insights to multiple case studies in vegetation and landscape science. A key feature of these case studies is an examination of relationships among climate, vegetation structure and vegetation function, to address fundamental research questions. This book is for advanced students and researchers who need to understand and apply knowledge from the disciplines of plant physiology, remote sensing and modelling. It allows readers to integrate and synthesise knowledge to produce a holistic understanding of the structure, function and behaviour of forests, woodlands and grasslands.

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VEGETATION DYNAMICS  
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Contents

<i>Preface</i>	<i>page xi</i>
<b>Section One Plant Ecophysiology</b>	
1 An Introduction to Biogeography: Broad-Scale Relationships Amongst Climate, Vegetation Distribution and Vegetation Attributes	3
1.1 Large-Scale Patterns in Climate	3
1.2 Climate Classification Systems	10
1.3 Atmospheric and Oceanic Circulation Influence Regional Climates	14
1.4 Biome Classification Systems	22
1.5 Classifying Vegetation by Function and Form	26
1.6 Global Traits of Leaf Attributes and Leaf Function	32
1.7 Leaf Lifespan: “Live Fast Die Young” Interpreted Through Cost-Benefit Analysis	37
1.8 Root Depth as a Function of PFTs	39
1.9 References	41
2 An Introduction to Plant Structure and Ecophysiology	43
2.1 Leaf Anatomy and Leaf Attributes	43
2.2 Vascular Tissues	49
2.3 Root Anatomy	56
2.4 Stomatal, Mesophyll and Canopy Conductances	57
2.5 Photosynthetic Processes: Leaf-Scale	78
2.6 GPP, NPP and NEE	89
2.7 Optimisation Theory as Applied to Leaf-Scale CO <sub>2</sub> and Water Fluxes	93
2.8 Water-Use-Efficiencies of Leaves and Canopies	97
2.9 Trade-Off of N <i>versus</i> Water Allows Maintenance of High Rates of Photosynthesis in Arid Sites	101

vi	<i>Contents</i>	
	2.10 Nitrogen, Phosphorous and Drought	104
	2.11 References	106
3	Water Relations, Hydraulic Architecture and Transpiration by Plants	110
	3.1 Functions and Properties of Water	111
	3.2 The Water Relations of Plant Cells	113
	3.3 Water in the Atmosphere	119
	3.4 Daily and Seasonal Patterns of Leaf Water Potential	122
	3.5 Anisohydric <i>versus</i> Isohydric Leaves	124
	3.6 Transpiration at the Leaf and Plant Scale	126
	3.7 Hydraulic Architecture	132
	3.8 Field Studies of Hydraulic Architecture of Stands of Trees	145
	3.9 References	149
<b>Section Two Remote Sensing</b>		
4	An Overview of Remote Sensing	155
	4.1 Introduction	155
	4.2 A Framework of Remote Sensing	156
	4.3 Advantages of Remote Sensing	158
	4.4 Conclusions	164
	4.5 References	165
5	Fundamentals and Physical Principles of Remote Sensing	167
	5.1 Fundamentals of the Remote Sensing Signal	167
	5.2 Properties of Electromagnetic Radiation	168
	5.3 The Electromagnetic Spectrum	170
	5.4 Basic Energy Concepts	171
	5.5 Defining Spectral Units	173
	5.6 Defining Directional Quantities	175
	5.7 Introduction to Thermal Measurements	178
	5.8 The Role and Influence of the Atmosphere	180
	5.9 References	183
6	Satellite Sensors and Platforms	184
	6.1 Introduction	184
	6.2 Sensor Resolution	185
	6.3 Orbital Systems	191
	6.4 Hyperspectral Sensors	198
	6.5 Microwave Sensors	199
	6.6 Solar-Induced Chlorophyll Fluorescence	200
	6.7 LiDAR	200
	6.8 GRACE	201
	6.9 Airborne Sensors	201

<i>Contents</i>	vii
6.10 Continuity and Fusion of Data	202
6.11 References	203
7 Remote Sensing of Landscape Biophysical Properties	206
7.1 Introduction	206
7.2 Spectral Signatures	206
7.3 Landscape Optics	215
7.4 Canopy Biophysics	217
7.5 Conclusions	231
7.6 References	232
<b>Section Three Modelling</b>	
8 An Introduction to Modelling in Plant Ecophysiology	239
8.1 Introduction	239
8.2 Canopy Photosynthesis and Water Flow through the SPAC	239
8.3 References	242
9 Modelling Radiation Exchange and Energy Balances of Leaves and Canopies	244
9.1 Introduction	244
9.2 Solar Radiation	244
9.3 Canopy Light Environment	252
9.4 References	256
10 Modelling Leaf and Canopy Photosynthesis	260
10.1 Introduction	260
10.2 Models of Leaf-Scale Photosynthesis	261
10.3 Modelling the Biochemistry of Photosynthesis	266
10.4 Parameter Optimisation for Photosynthesis Models	272
10.5 Modelling Canopy Photosynthesis	273
10.6 References	278
11 Modelling Stomatal and Canopy Conductance	281
11.1 Introduction	281
11.2 Semi-Empirical Models of Stomatal Conductance	282
11.3 Models Based on Conservative Water-Use-Efficiency	287
11.4 Canopy Conductance/Resistance Models	289
11.5 References	293
12 Modelling Leaf and Canopy Transpiration and the Soil-Plant-Atmosphere Continuum	296
12.1 Introduction	296
12.2 Canopy Radiation Exchange	296
12.3 Transpiration at the Leaf-Scale	297

viii	<i>Contents</i>	
	12.4 Water Flow through the Soil-Plant-Atmosphere Continuum and Evapotranspiration Models	299
	12.5 Microclimate Within and Over Canopies	306
	12.6 Soil Water and Heat Dynamics	310
	12.7 Dynamic Water and Heat Exchanges Across the SPAC	313
	12.8 Model Solution	315
	12.9 References	317
13	Coupling Models of Photosynthesis, Transpiration and Stomatal Conductance and Environmental Controls of Leaf Function	321
	13.1 Introduction	321
	13.2 Leaf Temperature	321
	13.3 Numerical Solutions for Combined Leaf Models	323
	13.4 Uncoupling of Integrated Photosynthesis-Transpiration-Stomatal Conductance Models	325
	13.5 A Modelling Perspective of Physiological Responses to Environmental Variables	326
	13.6 Environmental Controls of Diurnal Variation of Photosynthesis, Transpiration and Stomatal Conductance	336
	13.7 References	341
<b>Section Four Case Studies</b>		
14	Boreal Forests	347
	14.1 Introduction	347
	14.2 Coping with Freezing Winters: Photosynthetic C Gain and Transpiration	347
	14.3 Climate and Vegetation Interactions in a Canadian Boreal Forest: ET and WUE	353
	14.4 Controls of <i>ET</i> and Carbon Flux in a Scots Pine ( <i>Pinus sylverstris</i> ) Forest	357
	14.5 Comparing Carbon Balances of Boreal Humid Evergreen Forests with Semi-Arid Boreal Forests	360
	14.6 Permafrost, ET and NPP	362
	14.7 Modelling Controls of ET in a Scots Pine Boreal Forest	364
	14.8 References	366
15	Arid and Semi-Arid Grasslands	368
	15.1 Introduction	368
	15.2 Intra-Annual Patterns of Carbon Flux in Grasslands	368
	15.3 Inter-Annual Patterns of Carbon Flux in Grasslands	371
	15.4 Responses of Arid and Semi-Arid Zones to Pulses of Rainfall	377
	15.5 References	381

	<i>Contents</i>	ix
16	Savannas	383
16.1	Introduction	383
16.2	What Are Savannas?	383
16.3	Daily and Seasonal Patterns in C and Water Flux	384
16.4	Modelling Seasonal Changes in Canopy C Uptake: Application of Optimality Theory to Savannas	393
16.5	Productivity Along Rainfall Gradients	396
16.6	GPP, NEE and Respiration Differ in Their Response to Temperature and Aridity	403
16.7	Inter-Annual Variations in Rainfall and Productivity: Comparisons Within a Single Site	404
16.8	Woody Thickening and Atmospheric CO <sub>2</sub> Concentrations	408
16.9	References	411
17	Seasonal Behaviour of Vegetation of the Amazon Basin	415
17.1	Introduction	415
17.2	Biogeography of the Amazon Basin	416
17.3	Seasonality in Tropical Forest Function	419
17.4	Field Phenology Studies	421
17.5	Flux Tower Measurements in the Amazon	423
17.6	Satellite-Based Studies of Landscape Seasonality	424
17.7	Model Results	431
17.8	Modelling, Remote Sensing, Ecophysiology and Drought in the Amazon	434
17.9	Conclusions	437
17.10	References	437
18	Tropical Montane Cloud and Rainforests	442
18.1	Introduction	442
18.2	Types of Tropical Montane Cloud and Rainforests	442
18.3	The Climate of Tropical Montane Cloud Forests	444
18.4	Leaf Structure Varies with Altitude	446
18.5	Does Photosynthetic Capacity Vary with Altitude in Tropical Montane Trees?	446
18.6	NPP and C Allocation Patterns in Tropical Montane Cloud Forests	448
18.7	Transpiration, Evapotranspiration and Stomatal Conductance	450
18.8	Remote Sensing of ET	453
18.9	Climatological Links Between Tropical Lowland and Montane Forests	455
18.10	References	457

x	<i>Contents</i>	
19	Groundwater Dependent Ecosystems	460
19.1	Introduction	460
19.2	Groundwater and Groundwater Dependent Ecosystems	460
19.3	Classes of GDEs	463
19.4	Identifying Groundwater Dependent Vegetation	464
19.5	Ecophysiology of Terrestrial GDEs Subject to Groundwater Abstraction	469
19.6	Estimating Rates of Water-Use of GDEs	472
19.7	Groundwater Recharge, Climate and Vegetation	478
19.8	References	480
20	Global-Change Drought and Forest Mortality	484
20.1	Introduction	484
20.2	Global Change-Type Droughts	485
20.3	Field Observations of Drought and Mortality	488
20.4	Remotely Sensed Observations of Drought and Mortality	490
20.5	Mechanisms that May Explain Tree Mortality	496
20.6	Global Convergence in Vulnerability of Forests to Drought	502
20.7	Modelling the Interactions Amongst Drought and Increased Temperatures and VPD	503
20.8	An Integrated View of Mortality	506
20.9	Ecological Modelling of Mortality at Landscape Scales	506
20.10	Summary	508
20.11	References	508
	<i>Index</i>	513

## Preface

“Classical” plant physiology is the study of physiological processes of individual plants of a single species growing in pots in glasshouses, growth cabinets and controlled-environment chambers. Single-factor experiments are frequently used to manipulate one variable (e.g. water supply, temperature) in order to establish the response of individual processes (e.g. transpiration rate, phloem loading) or whole plants (e.g. growth rate) to that variable. It has been an immensely powerful science, contributing to increased food productivity and crop genetic selection for many decades.

Ecophysiology takes knowledge gained from plant physiological studies and applies them to plants growing “in the wild”, in real landscapes. This adds several layers of complexity arising from (a) large spatial and temporal variations in multiple variables (e.g. rainfall, temperature, solar radiation); (b) the interactions amongst multiple variables; and (c) complexities arising from the fact that landscapes are composed of multiple species. Although manipulative experiments can be undertaken in ecophysiology (e.g. rainfall exclusion, and rainfall redistribution troughs), the majority of ecophysiological studies do not manipulate environmental variables. Rather, they allow natural seasonal and inter-annual variation to impact on the structure and function of natural vegetation and measure the response of individual leaves, plants (trees, grasses, etc.) and canopies and use statistical inferences and models to analyse these responses.

Modelling of plant function can similarly be undertaken at small (leaves; xylem function), intermediate (trees, canopies) and large scales (stands, regions, sub-continental, global) across a range of temporal scales (typically hours to centuries). These models incorporate plant physiological and ecophysiological data (e.g. light response curves of leaves, eddy covariance tower flux data) to model the function (e.g. gross primary productivity [GPP], net primary productivity [NPP], evapotranspiration [ET]) of landscapes and biomes.

Remote sensing (RS) uses air-borne and satellite platforms for remote surveillance of land and vegetation surfaces (e.g. reflectance of solar radiation across multiple wavebands, land surface temperature). Using these remotely sensed data, plant structural attributes (e.g. LAI) and functional attributes (e.g. NPP, ET) can be calculated. As is the case for modelling, RS as a discipline is increasingly using physiological

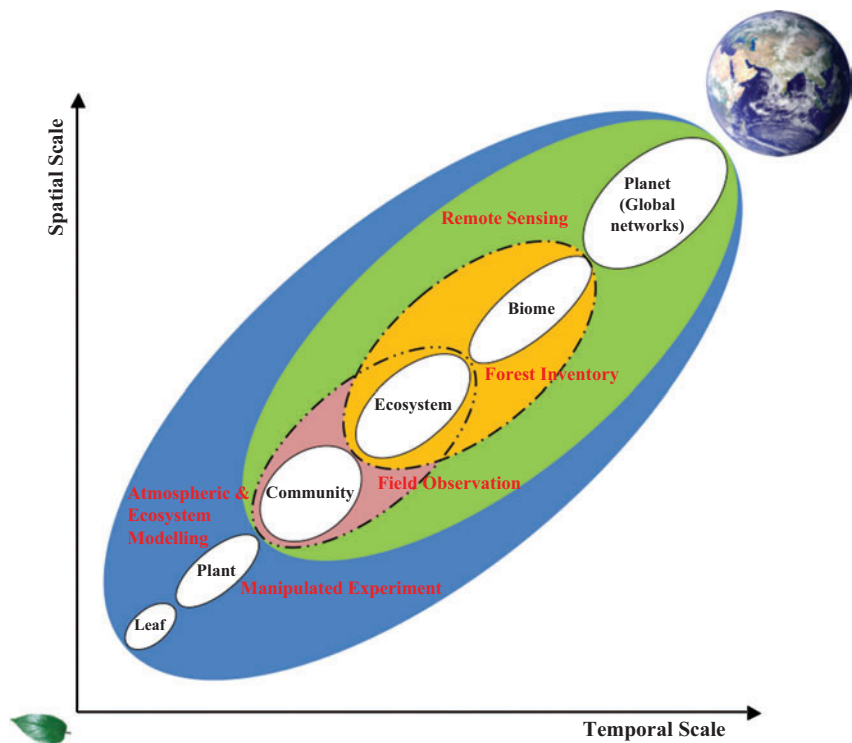


Figure I.1. A simplified conceptual representation of the different spatial and temporal scales of organisation (and study) encompassed in this textbook. Plant physiological and ecophysiological observations are mostly confined to cellular, leaf, whole plant, community and ecosystem spatial scales; most observations are made at sub-annual temporal scales and few observations have been made for longer than 15 years. In contrast, modelling can be undertaken from leaf-to-global-scales at almost any required temporal scale. Remote sensing is generally applied at community-to-global spatial scales and with weekly-to-decadal temporal scales.

and ecophysiological (e.g. canopy conductance, canopy gas fluxes, LAI) data to validate/test/compare remotely sensed estimates of landscape processes and vegetation structure. Figure I.1 provides a simplified representation of these three disciplines and their overlap.

Aims of This Book

The first aim of this book is to provide a relatively simple guide to some key aspects of plant physiology and plant ecophysiology, as they relate to the functional behaviour of natural landscapes, with particular emphasis on carbon (C) and water fluxes. This section should be of most value to those who are experienced modellers and remote sensing practitioners who need to increase their knowledge of plant physiology and ecophysiology. The focus on physiology pertaining to C and water fluxes is deliberate because these fluxes are two of the principal vegetation functions that drive

all downstream aspects of landscape function (e.g. catchment water balance, productivity, biogeochemical cycling). The second and third aims are to provide similar introductions to the disciplines of remote sensing (RS) and modelling of vegetation structure and function. It is likely that ecophysiologicalists will, at some point in their career, need to include aspects of these two disciplines in their work; similarly, modellers will increasingly use RS data in conjunction with ecophysiological information whilst RS practitioners increasingly need the ability to develop and apply models and incorporate/understand ecophysiological data in relation to the insights generated through remote sensing.

Thus, the final aim of this book is to provide some level of integration of the three disciplines. It is our contention that a full understanding of landscape function requires integration across these disciplines. We hope that this text may facilitate that integration.

**Structure of the Content of the Book**

The book has four sections. Section One contains the basic plant physiology and ecophysiology required to examine landscape carbon and water fluxes. The second section provides an overview of the techniques available in remote sensing, including consideration of the physical principles of remote sensing and the different platforms available to examine landscape structure and function. The third section provides descriptions of the basic modelling of vegetation and landscape processes across multiple scales. The final section contains seven case studies where data from ecophysiological, modelling and RS studies are presented and combined to provide a richer and deeper understanding of landscape structure and function. These case studies include (1) Carbon and water fluxes of five contrasting biomes (boreal forests, arid and semi-arid grasslands, tropical montane forests, Amazonian forest, savannas); (2) groundwater-dependent ecosystems; (3) and global drought and forest mortality.

We hope you enjoy the read.