

# Ecological Studies

*Analysis and Synthesis*

edited by

**J. Jacobs**

München

**O. L. Lange**

Würzburg

**J. S. Olson**

Oak Ridge

**W. Wieser**

Innsbruck

**Volume 14**

*with contributions by*

**Elgene Box**

Institut für Physikalische Chemie, KFA, Jülich, F.R.G., and  
Curriculum in Ecology, University of North Carolina  
Chapel Hill, North Carolina 27514

**John S. Bunt**

Australian Institute of Marine Science  
Townsville, Queensland, 4810 Australia

**Charles A. S. Hall**

Marine Biological Laboratory, Woods Hole, Massachusetts, and  
Section of Ecology and Systematics  
Cornell University, Ithaca, New York 14850

**Helmut Lieth**

Department of Botany  
University of North Carolina  
Chapel Hill, North Carolina 27514

**Gene E. Likens**

Section of Ecology and Systematics  
Langmuir Laboratory, Cornell University  
Ithaca, New York 14850

**Peter L. Marks**

Section of Ecology and Systematics  
Langmuir Laboratory, Cornell University  
Ithaca, New York 14850

**Russell Moll**

Great Lakes Research Division  
University of Michigan  
Ann Arbor, Michigan 48104

**Peter G. Murphy**

Department of Botany and Plant Pathology  
Michigan State University  
East Lansing, Michigan 48824

**Douglas D. Sharp**

Department of Botany  
University of North Carolina  
Chapel Hill, North Carolina 27514

**David Sharpe**

Department of Geography  
Southern Illinois University at Carbondale  
Carbondale, Illinois 62901

**Dennis Whigham**

Department of Biology, Rider College  
Trenton, New Jersey 08602

**Robert H. Whittaker**

Section of Ecology and Systematics  
Langmuir Laboratory, Cornell University  
Ithaca, New York 14850

# Primary Productivity of the Biosphere

edited by Helmut Lieth  
and Robert H. Whittaker

*with 67 figures*



Springer-Verlag

Berlin Heidelberg New York

1975

Library of Congress Cataloging in Publication Data

Lieth, Helmut.

Primary productivity of the biosphere.

(Ecological studies; v. 14)

Includes index.

1. Primary productivity (Biology) I. Whittaker,  
Robert Harding, 1920– joint author. II. Title.  
III. Series.

QH541.3.L5 574 74-26627

All rights reserved.

No part of this book may be translated or reproduced in  
any form without written permission from Springer-Verlag.

© 1975 by Springer-Verlag New York Inc.  
Softcover reprint of the hardcover 1st edition 1975

Distributed in the British Commonwealth Market  
by Chapman & Hall Limited, London.

ISBN-13:978-3-642-80915-6 e-ISBN-13:978-3-642-80913-2

DOI: 10.1007/978-3-642-80913-2

# Preface

The period since World War II, and especially the last decade influenced by the International Biological Program, has seen enormous growth in research on the function of ecosystems. The same period has seen an exponential rise in environmental problems including the capacity of the Earth to support man's population. The concern extends to man's effects on the "biosphere"—the film of living organisms on the Earth's surface that supports man. The common theme of ecologic research and environmental concerns is primary production—the binding of sunlight energy into organic matter by plants that supports all life. Many results from the IBP remain to be synthesized, but enough data are available from that program and other research to develop a convincing summary of the primary production of the biosphere—the purpose of this book.

The book had its origin in the parallel interests of the two editors and Gene E. Likens, which led them to prepare a symposium on the topic at the Second Biological Congress of the American Institute of Biological Sciences in Miami, Florida, October 24, 1971. Revisions of the papers presented at that symposium appear as Chapters 2, 8, 9, 10, and 15 in this book. We have added other chapters that complement this core; these include discussion and evaluation of methods for measuring productivity and regional production, current findings on tropical productivity, and models of primary productivity. The book is directed toward the interests of a range of readers, from those seeking summaries of research techniques to those concerned with our synthesis of global production.

Several institutions and people have helped to complete this work in its present form. The chapters contributed or coauthored by Lieth and Sharpe were supported in part by the Eastern Deciduous Forest Biome US-IBP. The chapters contributed by Whittaker and Hall were supported in part by Brookhaven National Laboratory; the contributions by Likens and Whittaker were supported in part by the National Science Foundation. During the final stage of editing this volume, one of the editors (HL) worked as guest researcher at

the Nuclear Research Center (KFA) in Jülich, West Germany. We gratefully acknowledge the financial and logistic help received at the KFA through Prof. Dr. K. Wagener and his staff at the Institut für Physikalische Chemie. The index was compiled by Margot Lieth and Cyndi Grossman. We thank them both for their assistance. We gladly give credit to the staff of Springer-Verlag New York for excellent assistance in improving the book.

We hope this book will be of value for its characterization of the biosphere as a productive system. We are not confident of man's ability to control the future of the world or even his own existence. Nevertheless, we should be gratified if a focal point of the book—the net primary production of the biosphere—is one day seen as a figure of real significance to man. If in the future man's population and industry are stabilized, then to biosphere production as a steady-state flow of biological energy in the world will be related two other steady-state flows—of food energy from the biosphere to man and of industrial energy—that will support a human world society living in a durable balance with its environment.

Helmut Lieth

Robert H. Whittaker

# Contents

## Part 1 Introduction

Preamble	2
1 Scope and Purpose of This Volume	3
<i>Robert H. Whittaker, Gene E. Likens, and Helmut Lieth</i>	
2 Historical Survey of Primary Productivity Research	7
<i>Helmut Lieth</i>	

## Part 2 Methods of Productivity Measurements

3 Methods of Assessing Aquatic Primary Productivity	19
<i>Charles A. S. Hall and Russell Moll</i>	
4 Methods of Assessing Terrestrial Productivity	55
<i>Robert H. Whittaker and Peter L. Marks</i>	
5 The Measurement of Caloric Values	119
<i>Helmut Lieth</i>	
6 Assessment of Regional Productivity in North Carolina	131
<i>Douglas D. Sharp, Helmut Lieth, and Dennis Whigham</i>	

7	Methods of Assessing the Primary Production of Regions	147
	<i>David M. Sharpe</i>	
<b>Part 3 Global Productivity Patterns</b>		
8	Primary Productivity of Marine Ecosystems	169
	<i>John S. Bunt</i>	
9	Primary Productivity of Inland Aquatic Ecosystems	185
	<i>Gene E. Likens</i>	
10	Primary Productivity of the Major Vegetation Units of the World	203
	<i>Helmut Lieth</i>	
11	Net Primary Productivity in Tropical Terrestrial Ecosystems	217
	<i>Peter G. Murphy</i>	
<b>Part 4 Utilizing the Knowledge of Primary Productivity</b>		
12	Modeling the Primary Productivity of the World	237
	<i>Helmut Lieth</i>	
13	Quantitative Evaluation of Global Primary Productivity Models Generated by Computers	265
	<i>Elgene Box</i>	
14	Some Prospects beyond Productivity Measurement	285
	<i>Helmut Lieth</i>	
15	The Biosphere and Man	305
	<i>Robert H. Whittaker and Gene E. Likens</i>	
	Index	329