

## CONTENTS

*Introduction*

*Stephen R. Carpenter:*

Dedication

Preface

I PREVALENCE AND IMPORTANCE OF REGIME SHIFTS

A Tale of a Lake

Changing Baselines of Ecosystem Dynamics

Regime Shifts, Thresholds and Resilience

Resilience and Thresholds

Alternate Stable States

Ecological Surprise

Parallel Work in Related Fields

Regime Shifts in Oceanography

Regime Shifts in Econometrics and Statistics

Confronting Models with Data in Population Ecology

Overview of the Book

Purpose

Why Lakes?

Questions

Chapters to Come

Summary

## II REGIME SHIFTS IN LAKES

### Introduction

### Phosphorus and Eutrophication

Definition and causes

Shallow lakes: a special case

Deep lakes: biogeochemical basis of alternate states

Recovery from eutrophication: delays and irreversibility

Model for eutrophication

### Depensatory Dynamics in Aquatic Food Webs

Pelagic Regime Shifts

Processes and Models

### Trophic Cascades

Comparisons and Experiments

Long-Term Observations of Trophic Cascades

Models

### Summary

## III ANALYSIS OF REGIME SHIFTS: ROLES OF STOCHASTICITY AND EXPERIMENTS

### Introduction

Detecting Regime Shifts: A Graphical Model

Prospects for Identifying Alternate Equilibria: A Simulation

A Minimal Model for Studying Alternate Equilibria in Time Series

Detection of Alternate Equilibria

Multiple Lines of Evidence: A Case Study

Summary

#### IV ASSESSING REGIME SHIFTS IN ECOSYSTEM EXPERIMENTS

Introduction

Description of the Ecosystem Experiments

Linear Model of Plankton Dynamics

Linear Modeling Approach

Linear Model Results

Implications of the Linear Model

A Nonlinear Model for Plankton Dynamics

Nonlinear Model

Fitting the Nonlinear Model

Nonlinear Model Stability

Changing Drivers and Ecosystem Dynamics

Changes in Parameters Over Time: Nonlinear Dynamic Regression

Implications of the Nonlinear Model

Conclusions from Both Linear and Nonlinear Models

Summary

#### V CAN WE PREDICT THRESHOLDS WITHOUT CROSSING THEM?

Introduction

Today's Actions Affect Tomorrow's Predictions

Continent at risk of ice age

Lake at risk of eutrophication

Motivation for the Model

Model

Ecosystem Model

Statistical Estimation

Management Strategies

Monte Carlo Analyses

Results

Management Strategies and Regime Shifts

Management Strategies, Regime Shifts and Learning

Discussion

Implications for lake management

Implications for actively adaptive management

Summary

## VI FORECASTING AND DECISION FOR MULTIPLE ECOSYSTEMS SUBJECT TO REGIME SHIFTS

Introduction

A Landscape of Lake Fisheries

Model

Results

Discussion

Data and inference about thresholds

Effect of the threshold on policy choice

Implications for experimental management

Summary

## VII UNDERSTANDING, PREDICTING, AND MANAGING REGIME SHIFTS IN LAKES

Introduction

Synopsis of Previous Chapters

Understanding Regime Shifts

Field Marks of Regime Shifts

Basic Research on Regime Shifts

Predicting Regime Shifts

Managing Regime Shifts

Summary

## VIII CONCLUDING REMARKS

## APPENDIX: BAYESIAN REGRESSION METHODS

### Introduction

Prior Probabilities and Bayes' Theorem

Subjectivity

Further reading

### Bayesian Linear Regression

Linear Regression with Noninformative Prior

Linear Regression with Informative Prior

### Bayesian Inverse Modeling

### Bayesian Dynamic Regression

### References