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Editors

Stable Isotopes in Ecological Research

With 164 Illustrations

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Preface

In past years, ecologists and environmental biologists have largely equated the word "isotopes" with short-lived radioactive isotopes useful in tracer studies. However, virtually all of the elements of biological importance occur naturally with two or more stable isotopes. There are two stable isotopes of hydrogen, ^1H and D or deuterium. Similarly, there are two stable isotopes of carbon, two of nitrogen, three of oxygen, and four of sulfur. These stable isotopes, which vary in their ratios of natural abundance, offer tremendous potentials for new approaches to research on a wide range of ecological processes.

Natural differences in the stable isotope composition of biological and abiotic compounds of ecological interest result from differences in a variety of predictable factors which influence fractionation. These include source effects, diffusional constraints, enzyme selectivity, and/or interactions between compounds. Stable isotope investigations can thus provide new insights into flux rates among organisms, between organisms and their abiotic environment, and between compartments of the abiotic environment.

Much of the early research on stable isotope ratios in biological tissues came from the geological sciences. This work was a logical outgrowth of pioneering applications of stable isotope analyses to research in geochemistry, sedimentology, and oceanography. Applications of stable isotope analyses in environmental biology were slow to develop, largely due to a combination of ignorance in the field and the difficulty of access to isotope ratio mass spectrometers. Until recently, applications of stable isotope ratios to ecological research were largely in the novelty or descriptive stage. In the last few years, however, innovative applications of stable isotope ratios to physiological and process-level studies have been expanding rapidly. This increased pace of research has resulted from improved access by biologists to the necessary instrumentation, and reduced costs of analyses. As a result, there is every indication that stable isotope approaches to ecological research will become increasingly common and will lead to significant new levels of understanding of physiological processes and elemental fluxes through biological and abiotic systems.

Our objective in this volume has been to provide both general background information and illustrative case studies to demonstrate how differences in stable isotope composition can be used as powerful tools for measuring integrated physiological responses and elemental fluxes through both abiotic and biotic compartments of natural ecosystems. Following an introductory chapter of background material on the history, units, and instrumentation used in stable isotope research, we have divided our book into three parts. The first of these deals with ecophysiological studies in plants, focusing on approaches to utilizing isotopes of carbon, hydrogen, and oxygen in research on physiological processes in plants.

In the second section on animal food webs and feeding ecology, seven chapters describe ways in which stable isotope ratios can be used to study food web dynamics. These contributions add to our understanding of the principles that "we are what we eat, plus or minus a few parts per million" as originally demonstrated by Michael DeNiro and Samuel Epstein. Our focus in this section is on natural food chains, with only a single chapter on human diet analysis. Anthropologists and archaeologists, nevertheless, should find this section, as well as other parts of the volume, highly relevant to the rapidly expanding interest in stable isotope approaches to their fields.

The final section of eleven chapters broadly treats ecosystem process studies utilizing stable isotope ratios. Aspects of pedogenic processes, nitrogen fixation, paleoclimate, atmospheric fluxes of gases and particulates, and pollutant transfers are all included. While these chapters only highlight the range of potential applications of stable isotope ratios to investigations of ecosystem-level fluxes, they should provide a good appreciation of the scope of the promise that such applications offer to researchers.

Stable Isotopes in Ecological Research is an outgrowth of a workshop on this subject held at the Lake Arrowhead Conference of the University of California, Los Angeles, in April 1986. We are indebted to Drs. Helen McCammon and Janet Dorigan of the Ecological Research Division of the Office of Health and Environmental Research, U.S. Department of Energy, for sponsoring this workshop. Cosponsorship was provided by the National Center for Intermedia Transport Research at UCLA.

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Contents