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Ecological Use of Natural CO_2 Springs

Raschi, A., F. Milglietta, R. Tognetti, and Paul Richard van Gardingen, editors. 1997. **Plant responses to elevated CO_2: evidence from natural springs.** Cambridge University Press, New York. xiv + 272 p. $69.95 ISBN: 0-521-58203-2.

Successful research often involves a search for the proper material and/or settings to address critical scientific issues. The field of molecular genetics, for instance, has used *Escherichia coli* as a model system to illustrate principles of DNA and RNA transcription. In ecology, different sizes of islands off seashore have been employed to understand relationships between species migration and population/community structure, resulting in the subdiscipline of island biogeography. In order to examine long-term plant and ecosystem responses to rising atmospheric CO_2 concentration in the natural world, global change scientists have also searched for new approaches and natural settings. *Plant responses to elevated CO_2* was born out of such a search and presents research results from natural CO_2 springs. These natural springs provide a unique opportunity for global change research, particularly in relation to long-term issues.

Plant responses to elevated CO_2 have been extensively studied during the past two decades, primarily using growth chambers and greenhouses as controlled environments. More recently open-top chambers and free-air CO_2 enrichment facilities in natural ecosystems have been employed. Although past research has greatly improved our understanding of short-term responses of physiological processes to elevated CO_2, our capability to address long-term issues has been extremely limited because most of the experiments last only from several weeks to a few years. Salient long-term issues, which potentially can be addressed through the use of natural springs, include: 1) regulation of physiological acclimation through slow plant and soil processes, 2) genetic adaptation to a gradual increase in atmospheric CO_2, 3) changes in population structure and species composition of plant communities, and 4) dynamics of soil organic matter and nutrient supply.

Plant responses to elevated CO_2 devotes the majority of its 18 chapters to physiological acclimation. Two basic approaches are presented: one is to measure physiological activities of plants along CO_2 gradients, and the other is to conduct transplant experiments. In the latter case, seeds or rhizomes were collected from sites with different CO_2 exposure and then grown in controlled environments for physiological studies. While data are minimal in most of the chapters, measurements along CO_2 gradients suggest that a few consistent patterns occur in elevated CO_2. These include 1) reduction in stomatal conductance and density, 2) increase in water use efficiency, and 3) increase in plant biomass growth. The chapter by M. C. Fordham et al. presents a rigorous study using the transplant approach. The authors found that the faster growth of plants adapted to high CO_2 sites is strongly correlated with seed weights. Unfortunately, none of the chapters examines adaptation using genetic and/or evolutionary approaches.

Although several chapters describe the vegetation around CO_2-enriched springs, only F. Selvi addresses the question of whether or not elevated CO_2 would induce changes in plant community structure. Selvi's survey of herbaceous communities surrounding the gas vents of six springs in Italy showed that these local grass communities have a consistent and homogeneous species composition, dominated by dense stands of *Agrostis canina* subsp. *Monteluccii.* Since this species is usually a successful colonizer in hostile environments (e.g., peatlike soils with pH ranging between 2.4 and 3.7), the homogeneous community structure surrounding all the springs may be evidence of adaptation to local and peculiar edaphic conditions, rather than adaptation to enriched CO_2 environments. Selvi is not optimistic about using natural springs to study community structure in elevated CO_2, at least in those areas where the survey was conducted.

Plant responses to elevated CO_2 strongly depend on other ecosystem processes (e.g., soil nutrient dynamics and supply). The chapter by P. Ineson and M. F. Cotrufo demonstrates that litter nitrogen concentration of trees from CO_2 springs is lower than that from a control site, leading to slower decomposition rates. A commendable aspect of that chapter is the authors' review on decomposition studies in elevated CO_2, which places their springs study in perspective. Other ecosystem processes (including soil organic matter dynamics, soil chemistry, and physical properties) may be beyond the scope of the book but certainly warrant deliberate investigation in order to understand ecosystem feedback in regulating plant responses to rising atmospheric CO_2.

Plant responses to elevated CO_2 presents ample background information on natural springs which is particularly useful to those scientists who may utilize such springs in their own research. Three types of CO_2-enriched environments in the natural world are described. They are degassing of lakes, seams of burning coal deposits, and mineral springs where CO_2 gas is leaked usually from fractures. The chapters by G. Etiope and by G. Etiope and S. Lombardi provided useful guidelines for identifying and monitoring leakage of CO_2 and other volatile contaminants based on soil-gas, exhalation, and groundwater surveys.

The book provides a balanced view of the advantages and disadvantages of using natural CO_2 springs for ecological research. Advantages include long-term CO_2 enrichments, natural vegetation, and undisturbed soils. A significant disadvantage is the fluctuation of CO_2 concentration in all types of the CO_2-enriched springs, posing a strong limitation for global change research because atmospheric CO_2 concentration is steadily increasing with annual variation only up to ten parts per million. The short-term fluctuations likely induce changes in certain physiological processes, such as stomatal conductance. Other confounding factors associated with coal burning seams include baseline sulfur levels as well as methane and saturated hydrocarbon concentrations associated with incomplete combustion of coal. The challenge in ecological use of mineral springs is to locate control sites with comparable vegetation, soil type, and environmental characteristics.

Plant responses to elevated CO_2 would have benefited from more editorial attention. The first paragraph on one page, for example, is seriously misprinted so that it becomes almost impossible to figure out its meaning. The editors also could have grouped the chapters into sections, such as geological and ecological description of natural springs, physiological acclimation, and community and ecosystem processes. A more comprehensive chapter, either introductory or summary, would greatly help readers grasp the essence of the book.

Plant responses to elevated CO_2 is a useful reference book for CO_2 research scientists but may be too specialized for undergraduate students or general readers. Nevertheless, the book is among the first addressing the use of natural springs in plant-CO_2 research.

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