Available online at www.sciencedirect.com

SCIENCE DIRECT®

Palaeogeography, Palaeoclimatology, Palaeoecology 219 (2005) 35–51

PALAEO

www.elsevier.com/locate/palaeo

The contributions of biogeomorphology to the emerging field of geobiology

Larissa A. Naylor*

School of Geography and the Environment, University of Oxford, Mansfield Road, Oxford. OX1 3TB and Honorary Fellow, Tyndall Centre for Climate Change Research, University of East Anglia, Norwich, NR4 7TJ, United Kingdom

Received 13 August 2003; accepted 29 October 2004

Abstract

Biogeomorphology has developed into a well-established research field over the past 15 years, with studies examining a range of two-way interrelations between organisms and geomorphology in a variety of terrestrial and marine environments. This paper starts by defining the core biogeomorphological processes—bioerosion, bioprotection and bioconstruction. Particular emphasis is placed on the study of bioconstructional forms; providing a clear definition, examples of bioconstructions, and, crucially, examining important interactions between bioconstruction and bioerosion. Three key areas where biogeomorphological research can directly contribute to the emerging field of geobiology are identified: (1) the use of biogeomorphological approaches, combined with palaeoecological investigations and predictive modelling, in the growing field of carbon sequestration and climate change mitigation; (2) providing geomorphological expertise to support the emerging field of astrobiology and (3) the potential contributions of biogeomorphology to the blossoming field of bio-geoengineering. Some key research directions and challenges for future biogeomorphological research include: exploring how biogeomorphological studies can contribute to and benefit from collaborations with other fields of geobiology, and assisting in the development of a useful, effective interdisciplinary toolbox of methods to improve quantification of geobiological processes. Importantly, suggestions are made for potentially fruitful collaborations with geomicrobiologists, geochemists and palaeoecologists.

Keywords: Biogeomorphology; Geobiology; Biocomplexity; Bioconstruction; Interdisciplinary approaches; Ecosystem engineers

1. Introduction

"There is no getting away from the fact that good ecological work cannot be done in an atmosphere of cloistered calm, of smooth concentrated focussing upon clean, rounded and elegant problems. Any ecological problem which is really worth working on at all, is constantly leading the worker on to

* Ecosystems Team, Science Group, Environment Agency, Evenlode House, Howberry Park, Wallingford, Oxon, OX10 8BD, UK. Tel.: +1 44 1491 828545; fax: +1 44 1491 828427.

E-mail address: larissa.naylor@environment-agency.gov.uk.

0031-0182/$ - see front matter © 2004 Elsevier B.V. All rights reserved.
doi:10.1016/j.palaeo.2004.10.013

neighbouring subjects, and is constantly enlarging his view of the extent and variety of the animal".

C.S. Elton in Animal Ecology, 1927, p. 188.

Nearly a century after Elton's writing, earth systems scientists from a range of disciplines are developing his insightful suggestion into an emerging field: geobiology. Although the term geobiology was first coined in the 1950s by Koch (1957), and was based on the premise of integrating biogeographical and ecological approaches, there has been little emphasis on geobiology as a distinct field of study until very recently. Geobiology is based on the premise that biological and geological activities are integrated, with complex interactions occurring between the biotic and abiotic systems at a range of spatial and temporal scales (Nealson and Ghiorse, 2001). Thus, geobiology is primarily concerned with exploring the interface and complex interactions between the biosphere and geosphere (Nealson and Ghiorse, 2001). It forms the scientific core of yet another emerging interdisciplinary field called biocomplexity.

Biocomplexity is primarily concerned with exploring between the margins of systems, to understand and begin to decouple the complex interdependencies between organisms and the environments which sustain their populations, affect them and/or are modified by the organisms themselves (www.hsf.gov/od/lpa/news/media/99/fsbioenv.htm). Biocomplex systems are typically non-linear and chaotic which makes prediction difficult; the interactions within a given system can often span multiple spatial and temporal scales (esa.sdsc.edu/factsheetbiocomplexity.htm). This is an interdisciplinary area where biological, chemical and physical scientists work alongside social scientists, economists and computer modellers to grapple with the complex interactions between different components of natural systems and/or natural systems and the human environment (Mervis, 1999). Biocomplexity is viewed here as a form of integrated assessment that focuses on biotic processes and interactions. Interpreted this way, biocomplexity forms the intellectual envelope within which geobiology (and therefore biogeomorphology) sits (Fig. 1). As such, geobiology can form an integral part of such studies, as the interdisciplinary scientific basis for examining systems responses to environmental pressures and change.

One of the subdisciplines contributing to geobiology is biogeomorphology; an approach to geomorphology that focuses on the two-way interplay between ecological and geomorphological processes (Viles, 1988a). This field is based on the premise that the distribution of species is often related to underlying geomorphological forms, while surface morphology may in turn be altered by organisms. There is general agreement that biogeomorphology has much to con-

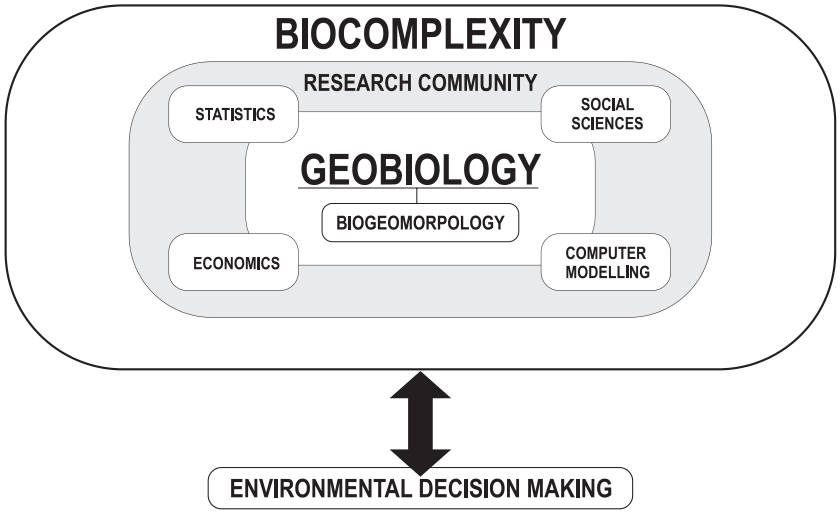

Fig. 1. Conceptual diagram illustrating some of the links between geobiology, integrated environmental assessments (e.g., biocomplexity) and environmental decision-making.