

# SCALE RELATIONSHIPS IN THE INTERACTIONS OF CLIMATE, ECOSYSTEMS, AND SOCIETIES

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**Abstract.** Climates, ecosystems, and societies interact over a tremendous range of temporal and spatial scales. Scholarly work on forecasting climate impacts has tended to emphasize different questions, variables, and modes of explanation depending on the primary scale of interest. Much of the current debate on cause and effect, vulnerability, marginality, and the like stems from uncritical or unconscious efforts to transfer experience, conclusions, and insights across scales. This paper sketches a perspective from which the relative temporal and spatial dimensions of climatic, ecological, and social processes can be more clearly perceived, and their potential interactions more critically evaluated. Quantitative estimates of a variety of characteristic scales are derived and compared, leading to specific recommendations for the design of climate impact studies.

## 1. Introduction<sup>1</sup>

Natural and social scientists have devoted much research to the interactions of climates, ecosystems, and societies. The coupling of the earth's climate, its geochemistry, and its large scale biological processes appears ever more intimate, and is the object of much critical research (*e.g.*, Bolin and Cook, 1983; Lovelock 1979). Historians are providing sophisticated assessments of the past influence of climate on human societies (*e.g.*, Lamb, 1982; Wigley *et al.*, 1981; Rotberg and Rabb, 1981). Social scientists have begun to address contemporary problems of human response to climatic variation, to refine their research methods, and to produce a wealth of case studies (*e.g.*, Parry *et al.*, 1987; Kates *et al.*, 1985; Hewitt, 1983). Natural scientists, social scientists, and policy analysts are collaborating to analyze how societies' present and future activities may significantly alter the basic functions of the biosphere (*e.g.*, Clark and Munn, 1986; National Research Council, 1983; Holdgate *et al.*, 1982; IUCN, 1980). The World Climate Impact Studies Program has hosted successful conferences on the interactions of climates, societies, and ecosystems, and is supporting an active research program

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(Parry and Carter, 1984). Other national and international institutions have mounted their own studies.

The lively debate on interactions among climates, ecosystems, and societies engendered by all this research is timely and needed. At a minimum, it provides a middle ground between the past excesses of the climatic determinists on the one hand, and those who would entirely ignore the interactions of climates and societies on the other. The liveliness of the debate has occasionally been more evident than its effectiveness. Shrill exchanges on whether climate fluctuation or social organization is "responsible" for the suffering of peoples and landscapes in drought zones have obscured the complicated interrelations that almost certainly characterize such situations. Case study chronologies and consequences have been transferred indiscriminately around the globe, with little regard for the special circumstances of place or the stage of historical development. Studies of long-term climate impacts have swung between approaches assuming that no adaptation is too great for societies or ecosystems to make, and equally unrealistic analyses that simply impose possible future climates on today's animal, crop, and human distributions and tally the resulting disruptions.

In most of these cases the disagreements stem not so much from ignorance or inadequate scholarship, but rather from the difficulty of establishing useful perspectives from which to view and order the accumulating range of studies, methodologies and theories. The problem is bad enough within the individual natural and social science disciplines involved in the study of interactions among climates, ecosystems, and societies. It is worse when, as is often the case, the nature of the investigation requires that disciplines be bridged and that results, methods, and explanations be exchanged among them. What is needed to complement these individual investigations is a parallel effort to develop synoptic perspectives that can help to show how the individual studies relate to each other, what the case studies of the past can and cannot tell us about the implications of climate change in the future, and which collections of human activities, ecological processes, and climatic variations need to be considered together if we are to achieve balanced, realistic assessments of future prospects. My goal in this paper is to explore the foundations of one such perspective.

My argument will be that climates, ecosystems, and societies can usefully be viewed as interacting at a variety of spatial and temporal scales. These interactions involve not only the responses of ecosystems and societies to changing climates, but also the reciprocal effects of living systems on climate itself. Such interactions contribute to the patterns we observe—patterns of climate like droughts and fronts; patterns of ecological phenomena like distribution and abundance of organisms; patterns of social phenomena like the settlement patterns and wealth of peoples. I will try to show that much confusion can be avoided, and a good deal of progress expected, if care is taken to specify explicitly the scale of pattern and process involved in each particular question of climate-ecosystem-society interaction.