SEASCAPE ECOLOGY: THE LANDSCAPE ECOLOGY OF THE COASTAL ZONE

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Introduction: The 440,000km belt that girdles the world's oceans (Komar, 1976) is, arguably, the single most important region of the earth's surface. It represents a unique interface between the three major global environments, namely the marine, the terrestrial and the aeolian respectively. Across and along the coastal zone, major exchanges of energy, matter and organisms occur. The coast is also of vital importance to Man. Throughout history, the sea has provided food and defence, cultural and individual mobility and, for many maritime peoples, an important aesthetic and spiritual foundation upon which civilisations could be built. Today, some two-thirds of the world's population lives on or near the coast, and we all depend to a greater or lesser degree upon the sea for sustenance, raw materials and energy resources (Komar, 1976; Carter, 1988).

Seascape Ecology as a Sub-discipline of Landscape Ecology: The relationship between Man and his environment, and between the aesthetic and the 'scientific' perspectives on landscape are subjects of a continuing debate that transcends the frontiers of academic specialism (eg. Bates, 1969; Bartowski, 1984; Olweg, 1984; Cosgrove, 1985). In geography, for example, after several decades of objective 'science', a growing number of academics are returning to the landscape concept as one 'whose subjective and artistic resonances are to be actively embraced' (Cosgrove, 1985, p45). Much of the broader discussion has focused on the recognition of what Vernadski (1945) termed the 'noosphere' (Danserau, 1957, etc.; Naveh and Lieberman, 1984). The noosphere may be defined in the present context as 'the sphere of the earth based on Man's perception of his surroundings' (Bartlett, 1986). From this artistic/humanistic perspective, the landscape painting may be seen as a branch of art dealing with the representation of the noosphere.

Finki (1985) has suggested that a 'broad subject area (exists) that is composed of many different, yet interrelated, fields of study. The fabric that holds (these threads) together is a specific concept of "place or space", a global geographic region that marks the broad interface between land and water'. He terms this interdisciplinary study area 'coastal science'. However, by focusing on 'science', Finki ignores 'the individual, imaginative and creative human experience... of the geographical environment' (Cosgrove, 1985, p45). Landscape ecologists, on the other hand, have long recognised the value of incorporating the more subjective cultural and psychological aspects of the environment into the overall synthesis. At the same time, it is recognised that landscape ecological concepts such as spatial heterogeneity, connectedness and isolation, patch shape and size, transport and migration networks, etc., (see, eg., Brandt and Agger, 1984; Schreiber, 1988) may be highly relevant in marine or coastal studies.

These considerations have let Bartlett (1986) to suggest that coastal science should be seen as a sub-discipline of land ecology. In popular terminology, any landscape painting with a maritime theme is commonly described as a 'seascape'. Hence the term 'seascape ecology' is preferred to the alternative 'coastal science'.

Spatial and Functional Relationships in Seascape Ecology: In its simplest form, the coast may be treated as a one-dimensional entity (Weyl, 1982), representing the line along which land, sea and air all meet. For many seascape ecological studies, the relative simplicity of this coastal model may be sufficient: examples might include studies of the function of the coast as a conduit for and barrier to the movement of species. However, in any detailed study, this linear representation rapidly becomes inadequate, and other forms of data structure including point, area, volume, vector and time-series also have to be considered (Bartlett, 1988).

One particular problem is that the coastal system has very few rigidly defined boundaries. This situation arises partly because the demarcation between land and sea requires constant revision as greater levels of topographic detail are brought into focus; partly because the sea can give way to land almost imperceptibly (for example in salt marsh or mangrove swamp environments); and partly because the position of the shore varies over a variety of time scales. These problems are well known to cartographers, who have traditionally employed a variety of generalisation techniques including, recently, the application of fractal geometry (Muller, 1986, 1987), to portray different levels of coastal detail of different scales of map.

One particular characteristic, which although not completely unique, is of especially high significance to the coastal zone, is its dynamism. The coast is a region of perpetual movement of mass, energy, organisms and information (see, for example, Carter, 1988). This activity may be seen, for example, in the cyclic and progressive changes in shoreline position; in the movements of waves, currents, and tidal cycles; in the incidence of coastal erosion and the silting-up of harbours; in the penetration of sunlight into the upper reaches of the sea, and the evaporation of ocean water as part of the hydrological cycle; and even in the predation of marine organisms by terrestrial species, including Man.

Despite the long history of Man's interaction with the sea, we are only just beginning to understand the bewildering complexity and organisational principles of coastal zone. Traditional coastal management has inevitably tended to reduce the variety of the coastal processes and attributes to more manageable proportions, for example, by attempting to arrest the fluctuating position of the shore through coastal armouring; by interrupting the natural exchanges of sand and energy across the shore by building groynes and stabilising dunes; or by culling seals and other predators in order to 'protect' and enhance fisheries resources.

The dangers of such policies are well known. The U.S. Committee on Resources and Man concluded, for example, that 'above all, we must be wary of Man's tendency to reduce the variety of components in his ecosystem, for this increases susceptibility to adverse change' (Committee on Resources and Man, 1969, p2). On the coast the truth of this statement may frequently be seen in, for example, enhanced erosion down-coast of groynes and harbours, or the rapid loss of beach sand following construction of energy-reflective sea walls (Carter, 1988). However, while this risk has been appreciated for at least twenty years, it is only recently that data handling tools and integrating concepts matured to the point when they could be brought to bear on coastal management problems.

Tools for Integrated Coastal Management: The examples given illustrate just some of the problems facing the seascape ecologist, and emphasise the need for a holistic approach to coastal management. For this integrated approach to be effective, four conditions have to be met: it will be readily seen that these are conditions common to many Total Human Ecosystem studies (Egler, 1970; Naveh and Lieberman, 1984). It is not, therefore, surprising that many of the solutions suggested here are based on standard paradigms and techniques of landscape ecology.

The first requirement to be addressed is the acquisition and collation of large amounts of data, relating to all identifiable facets of the coastal zone. As has been shown above, many of these data are spatially defined. Weyl (1982) suggests that the broad categories of information needed in coastal management should include physical, biological, chemical, climatological, geological, ecological, social, legal and political processes and phenomena. The thermodynamic and cybernetic (feed-back regulatory) mechanisms within and across the coastal zone also require to be investigated and understood (see Vester, 1980; Vester and van Hesler, 1980; Bartlett, 1986; Naveh, 1987).

Secondly, a conceptual model of the coast has to be developed within which these data and their interrelationships may be defined. The problems of coastal management, as with landscape ecology, are essentially multi-variate and require a single model capable of dealing at the same time with elements (entities), states (attributes) and relationships between elements and states (topology and cybernetics). It is suggested here that General Systems Theory (von Bertalanffy, 1968, 1969, 1976; Barry and Chorley, 1978; Haggett, 1980) is well suited to the development of such a model.

The original Theory of systems behaviour arose 'as an expansion of conventional physical chemistry, kinetics and thermodynamics' (von Bertalanffy, 1976, p31). Sadly, since the concept was first proposed, a 'terminological labyrinth' on the subject has arisen (Haggett, 1980): some of the ensuing classifications of systems have been reviewed by Barry and Chorley (1978), Haggett (1980), Naveh and Lieberman (1984) and Bartlett (1986). In the present context the definition of a system offered by Schultz (1980, p140) may be adopted. 'A system', he suggested, is 'an organisation for control, wherein... control includes understanding as well as management'. Thus it may be seen that the system concept is both an intellectual construct and a tool to be applied.

The relevance of General Systems Theory to geography, ecology and landscape ecology have been thoroughly reviewed by Haggett (1980), Jones (1983) and Naveh and Lieberman (1984), respectively, and need not be reiterated here. Most of their arguments may equally be applied to coastal studies.

The third requirement in integrated coastal management is for the provision of data handling tools. Geographic Information Systems hold particular value in this context. The theory, design and sociological implications of these techniques are well documented (eg. Blakemore, 1986 a,b; HMSO, 1987) while, more specifically, the application of some of these techniques to coastal management has been discussed by Weyl (1982) and by Bartlett (1988, 1989). It is important, however, to avoid the trap of thinking that simply by entering the data into a computer all other worries will be solved, for this is not the case. For all of their sophistication and power, the usefulness of these tools is as much a function of intelligent design of the database (see, eg. Kent, 1983) and a knowledge of the data structures involved, as it is on the technical specification of the hardware or software being used.

Lastly, guidelines have to be developed for sustainable coastal management strategies. It is in this, probably more than any other aspect, that coastal management stands to benefit from lessons learned from landscape ecology. The cybernetic and thermodynamic approaches to landscape, as advocated and explained by Vester (1980), Vester and von Hestler (1980), Naveh and Lieberman (1984) and Naveh (1987), are of particular interest here since they are integral to the systems paradigm as discussed above (Bartlett, 1986). Briefly, cybernetics is the study of regulation and control of systems through the operation of 'feedback' processes while principles of thermodynamics help us to understand how energy, mass and information are transferred within a system.

The cybernetic concept, enhanced by observations gleaned from study of the biosphere, has been used by Vester (1980) to draw up a suite of 'biocybernetic rules'. Using these rules, he suggests, 'it is possible to evaluate almost anything one is planning or deciding within the sense of a surviving system' (1980, p124). Vester's rules have been discussed at length by Naveh and Lieberman (1984) and Bartlett (1986). The basic philosophy behind the rules is the idea that nature has developed and perfected a method of organisation, based on cybernetic principles, over four million years, and 'other organisational principles than these have obviously not survived' (Vester, 1980, p123). Thus, rather than attempting to impose new, man-made, methods upon the natural world, 'we must learn to recognise more precisely... the cross-linked processes (and) cybernetic roles of the things that we deal with' and play within the rules imposed by Nature (Vester, op cit). In the present context, one example may be advanced to illustrate the importance of the cybernetic and thermodynamic concepts within the coastal system.

Special attention was drawn, earlier in this paper, to the dynamic character of the coast. The manifestation of this dynamism is never more spectacularly displayed than in the attack of storm waves upon the shore. Where the coast is relatively unmodified by Man, the excess wave energy is transmitted to the shore and work may be performed through the removal of sediment from the backshore. However, in the subsequent calm conditions, there will be an excess of sediment over the wave energy available, and normal beach processes will cause the gradual replacement of this material. Thus over a time a state of dynamic equilibrium prevails.

All too often, however, Man's response to wave attack upon the shore is the application of technocratic, civil engineering 'solutions': the imposition of static structures between the sea and the shore (Carter, 1988, p443). In such circumstances, instead of dissipating wave energy harmlessly, the resulting structure may simply reflect (and thus focus or amplify) the energy in such a way that work is concentrated upon one part of the coast. In extreme circumstances, a deviation-amplifying (positive) feedback coupling is created within the system, with expensive or even catastrophic consequences. Such is the complexity of cause and effect within the coastal system that this may frequently result in accelerated erosion or large-scale sediment movement, although often at some distance from the original trouble-spot (Carter, 1988), or only manifested after a period of years. This type of situation is particularly hard to analyse and rectify because of the large time-lag between cause and effect, but illustrates clearly the need for careful understanding of all the system variables before the system is disrupted.

Conclusion: Soucie has suggested that 'the real conflict of the beach is not between sea and shore, for theirs is only a lover's quarrel, but between man and nature' (1973, quoted in Komar, 1976, p2). However, the accumulated experience of many coastal communities shows clearly that it is necessary to escape from the anthropocentric and largely technocratic tradition in shoreline management, a tradition whose methods have rarely been successful. This escape can best be achieved, it is suggested, through the development of 'seascape ecology': the application and adaption of landscape ecology to coastal and maritime issues.

Examination of the literature (eg. Brandt and Agger, 1984; Schreiber, 1987) reveals the coastal zone to be an area generally neglected by landscape ecologists. The primary emphasis of landscape ecology is on understanding the development, dynamics and management of spatial heterogeneity: yet the coast is definitely as dynamic, and arguably as spatially heterogenous, as any other region of the earth's surface.

Landscape ecologists may or may not feel that they need the coast. The coastal zone, however, needs landscape ecologists.

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