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Allochthonous ecosystems

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Abstract

In extreme deserts with precipitation of less than 10–20 mm/yr, biocoenoses occur which are void of producers but show ecosystem functions such as food chains and energy flow. Since they are fed by the importation of allochthonous organic material the term 'allochthonous ecosystems' is proposed to designate these systems. The application of this term to other incomplete ecosystems without producers is discussed.

Introduction

Ecosystems are open systems in the landscape. The import and export of organic matter interferes with the production by green plants. The main agents for the transport of organic matter are water, wind, and man. Odum (1971) described four basic types of ecosystems, three of them solar-powered, one fuel-powered (urban-industrial ecosystem). The solar-powered ecosystems are divided into unsubsidized, naturally subsidized and man subsidized ecosystems according to their dependency on external sources (Table 1). It is a well-known fact that many aquatic ecosystems are naturally subsidized: they receive quantities of external 'allochthonous' (organic and inorganic) material not only by water but also by wind (Naumann 1931; Thienemann 1955; Odum 1971). Much less is known about the degree of heterotrophy in terrestrial ecosystems.

The import of organic matter increases the ratio of heterotrophic to autotrophic organisms in the biocenoses. Odum (1955, Fig. 74) calls communities autotrophic when the ratio of photosynthetic production (P) to respiratory consumption (R) is greater than 1, but heterotrophic if P:R is less than 1. Here autotrophy and heterotrophy are used in relative terms. In the most extreme landscapes, heterotrophy is absolute: no producers exist, only heterotrophic organisms occur, and the ratio P:R becomes zero. With respect to desert dunes, Walter (1973) called such systems 'dependent ecosystems'. This expression is not sufficiently specific. In the present paper, therefore, systems in which carbon input is completely allochthonous will be described using the term 'allochthonous ecosystems'. Several examples will be given, and it will be discussed whether these systems can be regarded as ecosystems or not.

Allochthonous desert ecosystems

The need to introduce the term, allochthonous ecosystems, arose during investigations in the western desert of Egypt (E-Sahara) where precipitation ranges from 150 mm at the coast to practically zero in the Central part (Fig. 1). The extreme desert, with approximately 1–10 mm of rainfall (Stahr *et*

Table 1. The four basic ecosystem types according to Odum (1971).

Organic matter provided by	Main energy source	
	sun	others
Producers	Unsubsidized natural solar-powered ecosystems	
Natural forces (winter, water)	naturally subsidized solar-powered ecosystems	
Human activity	Man-subsidized solar-powered ecosystems	Fuel-powered urban-industrial systems

al. 1985), bears accidental vegetation, in the sense of Kassas (1952), a very interesting vegetation type. It is episodic, but not periodical, in other words, not annual. Most species are potential perennial woody plants which, however, are able to flower in the first year. The vegetation can last as long as a water body is available, several months or longer, and may produce some dwarf shrubs or, at very favorable sites, even small trees. Their production is on the lowest level ever recorded (Bornkamm 1987).

In the very center of the E-Sahara with rainfall < 1 mm/yr, not even accidental vegetation occurs (Alaily *et al.* 1987). In spite of the lack of producers, animal life is found here. Small food chains are existent, beginning with detritivores based on litter, which were investigated, mainly in the Namib desert, by Kuehnelt (1965, 1976), see also Walter (1985). The input of organic matter is in two forms: litter blown by the wind and biomass dropped by migrating birds. The litter is deposited mainly on the leeside, the south slopes (because the most frequent wind direction is from the north), between rocks in sand fillings and even under single stones. It consists mainly of awns of grasses (*Stipagrostis*). This kind of input is continuous, but is very scarce especially in serir and dune areas. The other source, from migrating birds, is periodical in time but absolutely haphazard in space, being spotlike.

In Fig. 2 the functional scheme of allochthonous

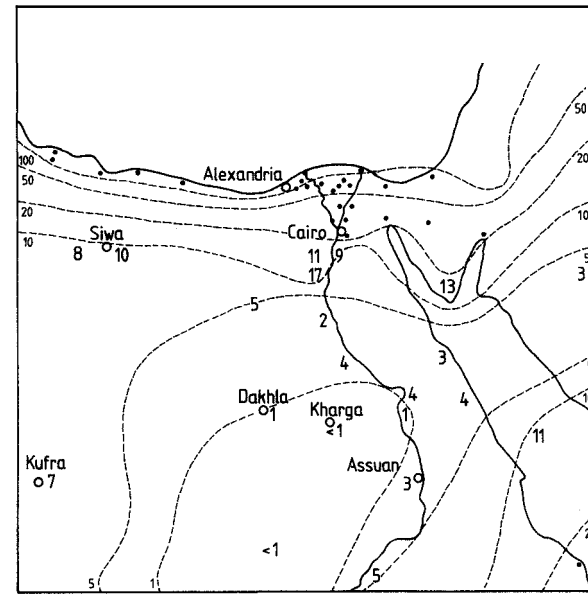

Fig. 1. Isohyctes of Egypt and some adjacent regions according to the data from Walter and Lieth 1967. Dots represent meteorological stations.

ecosystems (I) is compared with a scheme of autochthonous ecoystems (11). The allochthonous ecosystem is obviously incomplete:

- producers are lacking;
- food chains are short;
- detritivores prevail;
- the very local food import prevents a high rate of predation;
- the lack of water suppresses decomposition. Dead animals are weathered rather than decomposed. Under sand cover, they will stay more or less unchanged for a long time.

Metahemerobiotic and other allochthonous ecosystems

The same type of ecosystem occurs in places where heterotrophic life exists, but growth of green plants is prevented by the extreme influence of one inhibiting factor. As an example, in caves this factor is light. In many places, mechanical factors caused by human impact are effective in limiting growth of green plants. From Odum's basic ecosystems (Table 1), it becomes clear that the amount of

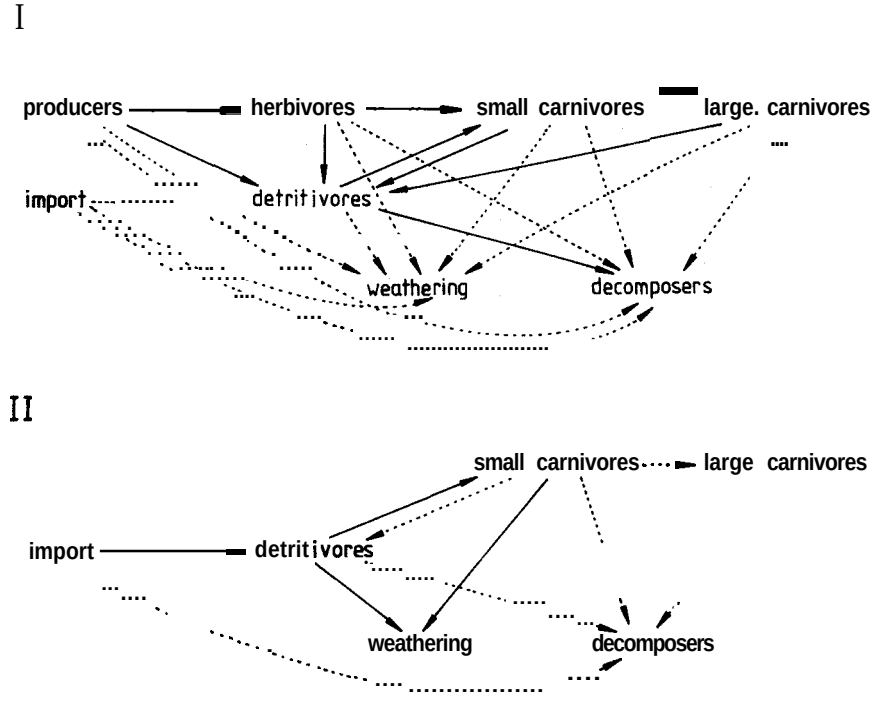

Fig. **2. Functional relationships I in a typical autochthonous ecosystem. II in an allochthonous ecosystem. Solid lines = main processes, dotted lines = subordinate processes.**

anthropogenous influence is an integrating character of many ecosystems. In the concept of ***hemerobiosis,*** the human impact is rated in a half-quantitative way using seven grades (Jalas **1955;** Sukopp **1969;** Van der Maarel **1975,** see Table **2).** The highest grade (metahemerobiosis) is characterized by the lack of producers and by the occurrence **of** incomplete ecosystem processes. Paved roads, intact buildings, and some other construction exactly fit our definition of allochthonous ecosystems. They are sections of Odum's urban-industrial ecosystems, which are very complex. Parts of them are allochthonous.

Discussion

Along with the considerations stated above, the question as to what is an ecosystem and what is just a system is discussed. As far as I can see, three problems are involved:

- the problem of scale;
- the problem of human impact;
- the problem of completeness.

The scale I propose for use is the same (small) scale as is used widely in vegetation science: The size of the units (*e.g.*, forest, meadow, reed stand, ruderal forb stand) is bound to the size of its components.

With respect to human impact, it must be remembered that Tansley **(1935)** included man-organized ecosystems, like agricultural ecosystems, in his definition of ecosystems. The same is true for Odum **(1971),** and the term urban ecosystems has been accepted widely since (see the discussion in Bornkamm ***et al.*** **1982).** It would, indeed, be difficult to judge at which threshold value of human impact an ecosystem loses its character as an ecosystem. It is much clearer to recognize human impact as a character of a given ecosystem and to speak of ecosystems exhibiting different grades of hemerobiosis.

Regarding completeness, we have to judge how great the biological activity has to be in order to evoke ecosystem character. Therefore, a broad definition of ecosystem is much more convincing.

Table 2. Grades of hemerobiosis in a region with forest climax (C Europe).

Number	State	Cultural influence	Land use	Occurrence
1	a-hemerobiotic	± not influenced	Nature conservancy or lacking	Nearly extinct
2	Oligohemerobiotic	Low intensity of grazing and cutting in forests, original vegetation ± preserved	Extensive forestry	Rare
3	Mesohemerobiotic	Forest vegetation changed or replaced by extensively used heathlands and grasslands	Intense forestry extensive agriculture	Frequent
4	β-euhemerobiotic	Forests replaced by fields, meadows or alien tree plantations	Traditional agriculture	Frequent
5	a-euhemerobiotic	Area deforestated, drainage, heavy fertilizing, use of pesticides	Industrial agriculture, gardening	Frequent
6	Polyhemerobiotic	Vegetation heavily affected by mechanical and chemical factors	Fallow lands, rudera, plant production not intended	Local (frequent in settlements)
7	Metahemerobiotic	Vegetation completely removed	Buildings, roads	Local (frequent in cities)

If we regard the biosphere as a spheric phenomenon of the globe and exclude allochthonous ecosystems, it would result in a biosphere with holes. Theoretically this is very unsatisfying. **As** long as one can describe a system with the criteria of ecosystems (*e.g.*, food chain, energy flow, nutrient cycling, biological interference) we can call it an ecosystem. In many cases, we are, of course, able to describe a system also as a social system, and economic system, or for its beauty. This last remarkshould clarify that in the present paper the ecosystem concept is regarded as a methodical concept and not as an ontological one.

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