

CHAPTER 3

Ecology and Dust Transport

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ABSTRACT

Erosion is closely correlated with the vegetation cover. The boundary between areas with vegetation and areas without is always changing. Decreased vegetation cover gives increased erosion and dust transport. When human impacts damage vegetation cover the erosion and dust transport is accelerated.

Through erosion valuable nutrients concentrated in the surface are removed and transported away. The transported material with nutrients and organic material which is transported outside the desert areas is trapped in vegetation or in the oceans. This material will increase the productivity both in the terrestrial and marine ecosystems. However, our information about these effects is very limited and pilot research is needed.

The dust transported in the air is also of importance from human health point of view. Particles less than $2\ \mu\text{m}$ are trapped in the lungs and may affect the physiology of the lung.

From pollution point of view arid areas are very different to humid areas. In humid areas the water sediments act as sinks for the pollutants. In arid areas pollutants in the dry fall out may be removed by soil erosion and re-enter the circulation.

In relation to monitoring of the desertification process it is necessary to include variables to follow changes in productivity.

The soils are protected from erosion by the vegetation cover. If this is broken or too thin the erosion can start. The thickness of the vegetation depends mostly on rainfall and temperature and, in tropical and subtropical areas, the rainfall is the determining factor. Is the precipitation too low there will be no vegetation at all. The boundary between areas with vegetation and areas without is always changing. We have seasonal changes, annual changes and in some cases periodical changes or long term changes. The vegetation is well adapted to the seasonal changes. There are also adaptations not only in the vegetation but in the whole ecosystem to the annual changes. Erosion is closely correlated to these changes. I will here elaborate on the effects of these annual changes on the erosion.

The rainfall in arid areas shows a large variation both in time and in space. The

meteorologists have studied the time variation intensively, but they have mostly neglected the variation in space. This space variation with its patchiness gives the same pattern to the vegetation. The wild animals and the nomads have adapted themselves to this patchiness — for this they need a high degree of mobility.

Figure 3.1 shows the conditions in an 'undisturbed' area, that is before modern technology and so-called aid appeared. The upper part of the diagram shows a year with good rains and the lower a dry year. All the time there is moderate grazing, that is not destroying the roots and underground reserves of the plants. During the next rainy year the vegetation will recover. During the dry year there is a moderate increase in soil erosion compared with the rainy year.

Figure 3.2 shows the conditions in an area with overexploitation. During the rainy year there is overgrazing. The grass-roots are damaged and the nutrient reserve is taken away. Trampling is damaging to the vegetation cover and to the soil structure. Agricultural activities may completely remove the natural vegetation cover. Fuel collecting might remove the woody plants. All these activities will result in increased soil erosion, even during the wet year. When the first dry year arrives, there will be a strong increase in soil erosion. At the same time the pressure on the remaining vegetation cover will be harder. A second dry year will complete the catastrophe.

The plants depend not only on moisture, but also on the structure and nutrient content of the soil. In arid areas the moisture transport is towards the surface resulting in a concentration of nutrients in the surface layer. Is this taken away by erosion, the productivity decreases. The most critical nutrient is nitrogen, as the supply is limited. The higher plants get nitrogen from two main sources, from

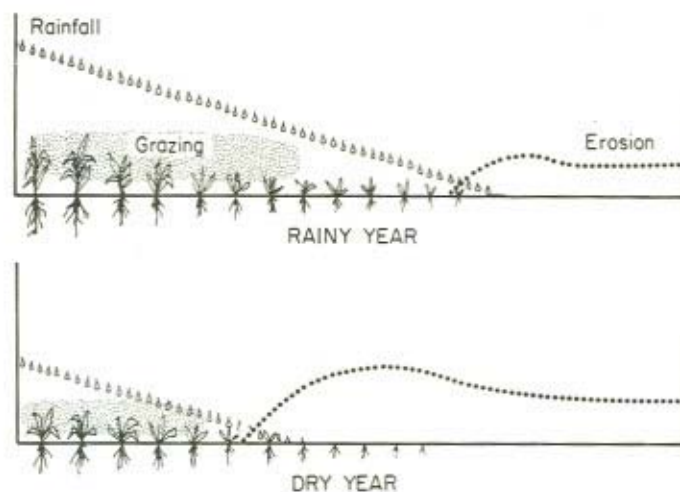


Figure 3.1

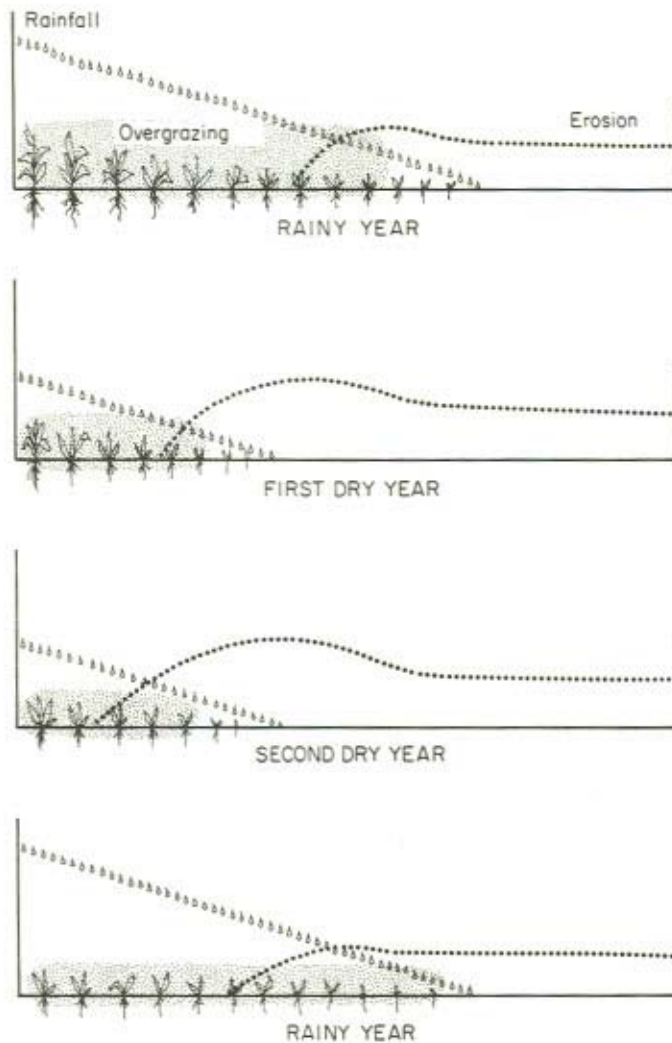


Figure 3.2

mineralization of organic matter and from nitrogen-fixing organisms. In both cases microorganisms are active. Nitrogen fixation in arid areas is done both by bacteria and algae. These organisms form a surface matting. If these algae mats are broken and fragmented and blown away, the nutrient situation is deteriorating. The organic matter in the soil is not only an important source for plant nutrients as nitrogen and phosphorus, but also of importance for the soil structure. Removal of the surface soil with its nutrients and microorganisms is a very serious event.

Also the organic material on the soil surface, wilted plants attached to the soil

with roots are important. If these parts are fragmented by trampling and get loose they are blown away. The result is decreased infiltration ability for rain water and increased erodibility. To sum up, surface erosion is not only removal of the valuable top soil, but it may also have very important consequences for the whole ecosystem.

Figure 3.2 shows also what happens when the good rains come back. We get a vegetation cover, but not so good as earlier and with different species composition. Earlier the perennials dominated now the annuals have taken over. The grazing is not so good any longer. The result depends, of course, on how far the destruction went. The question is if these changes are reversible or irreversible. The answer to the question depends on three factors. The first is the time factor. Within which time frame should the ecosystem recover? Given sufficient time – hundreds or thousands of years – a new similar ecosystem will appear. It is, however, remarkable how quickly eroded areas will recover. The second factor of importance is that no species are lost. If that is the case, a complete recovery is impossible. The dry grazing systems have evolved with large herbivorous mammals as important factors. If these large grazers are taken away, the whole system and its productivity changes. Also other important species may disappear and that may prevent complete recovery. The third consideration relates to the top soil. If this is gone, with its valuable content of nutrients and microorganisms, it takes such a long time to restore the conditions, that the changes might from man's short perspective be regarded as irreversible.

If we consider dust again some material is air-borne and transported over long distances. Figure 3.3 shows this outblow from Africa. Some of the particles settle in the Atlantic. Figure 3.4 shows dust fall over the Atlantic. This dust fall may be important from an ecological point of view. The nutrients to the sea may promote the growth of phytoplankton and contribute to the Atlantic fishing results. Figure 3.5 shows the plankton distribution in the Atlantic. This area of the Atlantic was earlier called 'the dark sea'. The name may have something to do with the African Savanna burning, which nowadays forms a black belt across the southern border of the Sahara, according to satellite images.

Over the continents the dust particles may settle on vegetation and get thus incorporated in the ecosystems. The mechanisms of this incorporation and its ecological importance is not well known or rather unknown. In Europe we are now dealing with a similar problem in relation to the so-called acid rain. We hope to be able to use the ideas and the technique which now is emerging from these European studies and apply it to the African problems.

What is the ecological importance of this wind-blown material? Taking the geological perspective we know that some of the most fertile soils are the loess soils and they are originated from wind-borne material caught in suitable vegetation. During the ice age, wind-transported material from the naked moraines deposited in central Europe. In Asia the Gobi Desert is mother to the fertile loess deposits in China to take a few examples. Since classical times Greece has lost 95% of its fertile soils. Where has this ended up?

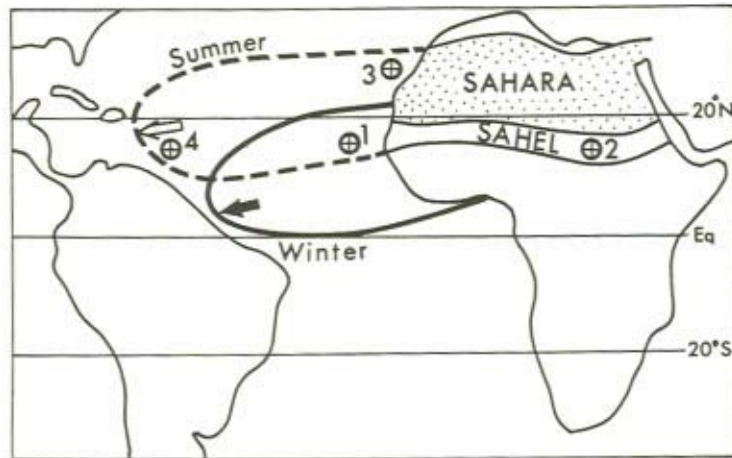


Figure 3.3 Dust transport over the Atlantic (after Rapp, 1974)

- 1 = Tenerife
- 2 = Jebel Marra Mountains, Sudan
- 3 = Cape Verde Islands
- 4 = Barbados

Most of these wind deposits are close to the origin. In our case we have to look for them in Africa at suitable places. A well-known Swedish traveller has recently told us in a book about a conversation on a Nile boat with an Egyptian. The Swede pointed out that the fertility in the Nile Valley ought to decrease as the fertile sediments are trapped in Lake Nasser (Nubia). The Egyptian replied that this was wrong as 'the Nile Valley is fed by the desert'. To me this reply opens up a new area of research.

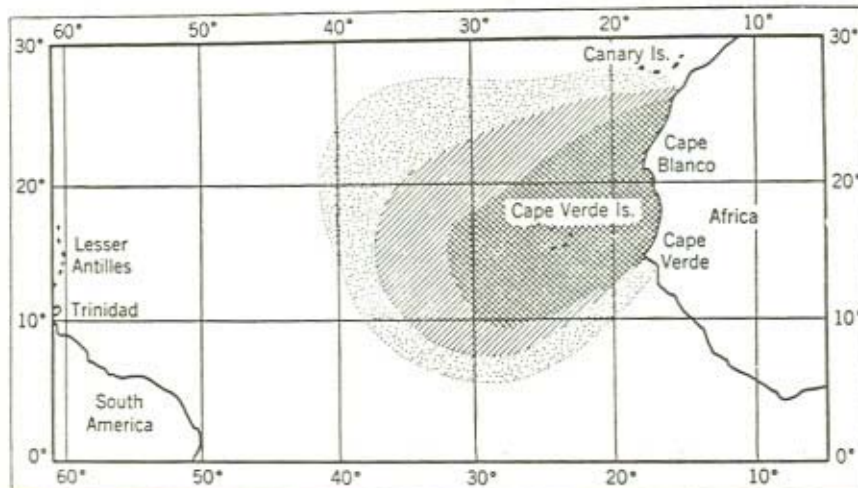


Figure 3.4 Dustfall over the Atlantic (after Kuenen, 1950)

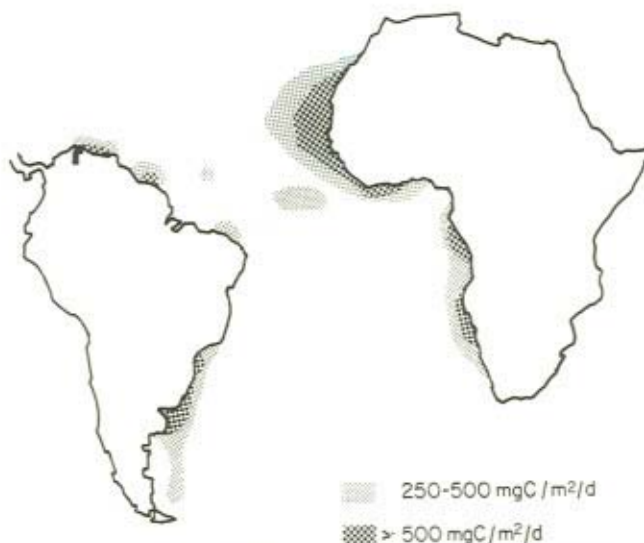


Figure 3.5 Phytoplankton production based on information from *Atlas of the Living Resources of the Sea* (FAO, Rome, 1972)

The vegetation outside and inside the Sahara is without any doubts trapping dust. We do not know to what extent and we can only speculate on its ecological importance. We know from air pollution research that vegetation and forests are acting as a filter for air-borne particles. We know that different types of vegetation have different ability to collect particles. When Professor Goodman worked out his method with moss bags (Goodman *et al.*, 1979) experiments in wind tunnels showed that different sizes of particles acted in a different way.

In the arid areas there are different traps for wind-transported material. Materials moving along the ground are deposited on the leeward side of solid objects such as plants.

The ideal dust traps are the date palms in the oasis. I have in vain tried to find information on the nutrient flow in an oasis. Such a research project, rather easy to carry out, would indicate the importance of dust-blown material. Considering the age of the oasis-culture without decreased productivity, it might be assumed that the nutrient inflow from the air is very important indeed.

It would also be of importance to study those problems when larger areas are involved. There is often an immense soil erosion during dry years from agricultural areas, where the soil has been laid bare. Some of this material is blown in overgrazing lands and might influence the productivity in a positive way. This is, of course, of special importance in Africa south of the Sahara where grasslands border the arid areas.

There is also another type of trap for erosion material. During the dry season soil

containing clay material has a tendency to crack. These cracks may be filled with material moving along the surface. These cracks improve the infiltration of rain water and the structure of the soil.

Dust in the air is also important from another point of view. Particles less than $2\ \mu\text{m}$ are retained in the human lung. Particles more than $5\ \mu\text{m}$ are filtered away in the nose, and particles between 5 and $2\ \mu\text{m}$ are on the way down to the alveoli. The airflow through the windpipe is about $150\ \text{cm}$ per second but in the alveoli it is zero. Here in the alveoli the small particles are trapped by different mechanisms. This particle load may influence the physiology of the lung and may be a threat to health. I suppose that many of you have personal experiences of the effect of desert dust. If the particles carry materials or consist of material which is biologically active the impact on human health may be considerable.

As I pointed out earlier there is a tendency that water soluble material concentrates in or on the surface. In dry areas we find surface concentrations of all chemicals often forming salt pans. If this material is distributed and gets air-borne, we might expect a dust which is rather unhealthy. Very little is known about these effects. From the Kalahari area which partly is very overgrazed, a report states that Botswana has the highest death rate in lung diseases in the world.

There is a principal difference between dry and humid areas in relation to pollution in general and especially when air pollution is considered. In Figure 3.6 we have the situation in a humid area. Pollutants emitted by a factory are either washed out by rain or they are removed by dry fall out. These rather complicated mechanisms are now studied in relation to the 'acid rain'. The sink for these pollutants are the wet sediments, in these the pollutants are sealed off and withdrawn from the general circulation. During very special conditions this seal can be broken and the real final sinks are the marine sediments. Figure 3.7 shows emissions in a dry area. Here you have only a dry fallout and deposition in the vegetation. If the vegetation cover is disturbed the pollutants can return into the general circulation. The pollutant levels may thus be steadily increasing.

But are these speculations of any importance in Africa where we have so few industries? There might however be a very real danger in relation to mining

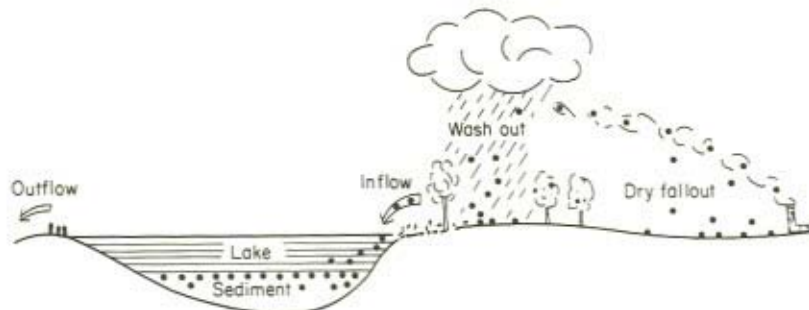


Figure 3.6 Emissions in a watershed

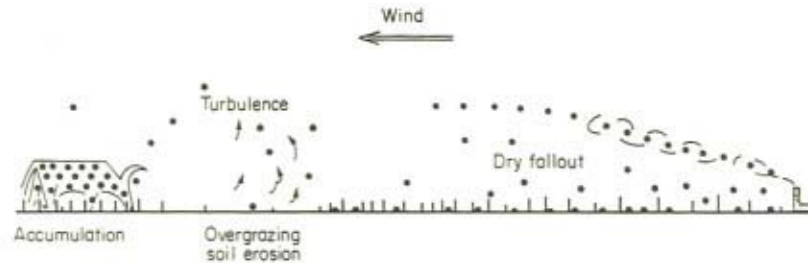


Figure 3.7 Emissions in an airshed

activities. In connection with copper mining there are emissions of both lead and cadmium. Both these metals have a very serious effect on human health. In the copper-mining areas in Zaire and Zambia as well as in the new mines at Selebi Pikwe in Botswana these problems with dry sedimentation in grasslands must be watched.

I am sorry that I have presented my case with so many question-marks and speculations. It is, however, strange that these problems have been so neglected. It would however be fairly easy to find out the fundamentals about the ecological effects. The first task should be to establish the quantity and quality of dry material trapped in the vegetation and its ecological effect. This might be called the *oasis-effect*. This project could also be described as a study of nutrient flow in an oasis.

There are several suggestions to monitor the desert encroachment. I think that it is important not only to measure the physical and vegetational changes, but also to include variables of relevance to the functioning of the whole ecosystem. Such variables are the soil structure (organic material), soil nutrients and micro-organisms.

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