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COVER PHOTOGRAPH:

India is currently facing the worst drought of this century.
People in Rajasthan are particularly hard hit (UNEP/Daniel Stiles)

Desertification Control Bulletin is an international bulletin published at six monthly intervals by the United Nations Environment Programme (UNEP) to disseminate information and knowledge on desertification problems and to present news on the programmes, activities and achievements in the implementations of the Plan of Action to Combat Desertification around the world.

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comes from livestock or grain. It is not normally the principal commercial pursuit of a settled farmer. Therefore, a more appropriate evaluation of runoff farming is in terms of labour input against the energetic value of food produced. Cash inputs are only required for the purchase of seedlings and such items as salt, pickling containers and oil pressing for olive production, the latter often being paid for by a share of the produce. Often the owners of orchards work for wages elsewhere and their labour input into their own land should not be costed.

Conclusion

A brief introduction is given to runoff farming based on the author's experiences in Israel. Two methods are advocated: where microcatchments are used, it is suggested that trees be planted on top of the dyke to avoid seasonal flooding. Where contour dykes are used, trees should be planted at either side of the water collection ditch. The size and layout of orchards where runoff farming is used is determined by the type of cultivation envisaged. In terms of economics, runoff farming is seen as a subsistence or subsidiary activity to the principal source of income but that where olives or similar fruit trees are grown, the net return in terms of food energy per hectare or per tree is substantial.

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Desert Encroachment

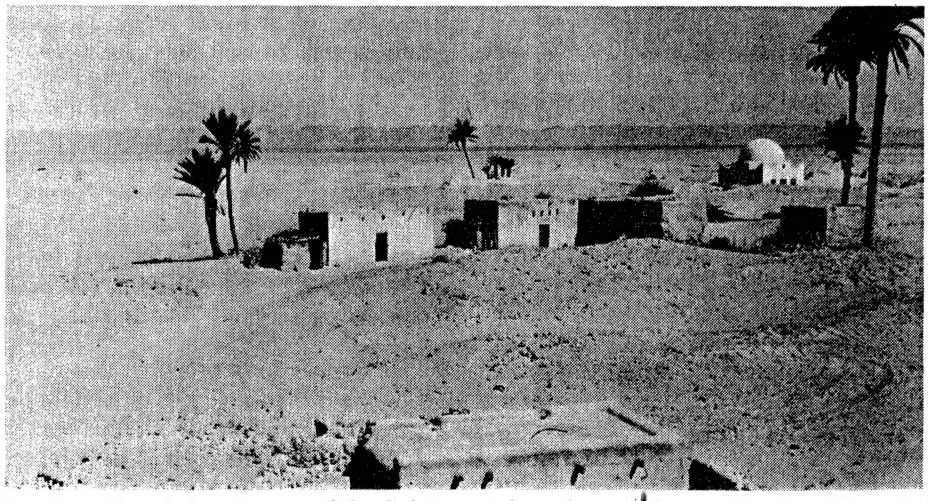
H.E. Dregne and C.J. Tucker

Desertification is a term that evokes visions of an expanding Sahara destroying villages, water supplies, and fields in its path while sand dunes move inexorably forward like waves on the ocean. In fact, desertification does bring destruction of people's livelihoods and land resources, but usually in a stealthy and insidious fashion which is usually less dramatic than burying a village under moving dunes. Convenors of the 1977 United Nations Conference on Desertification made it clear in the preamble to the Plan of Action to Combat Desertification that desertification was a complex process having many causes and effects. Nevertheless, it has been difficult to get the message across in both the popular press and in scientific journals. A recent paper in a respected soil and water conservation journal repeats the claim that drought is the cause of desertification (Smith, 1986). Furthermore, the article makes the unequivocable judgement that "the Sahara Desert continues to creep southward, claiming an area the size of New York State every decade". That is about 1,300,000 hectares per year and is almost certainly based on no quantitative ground studies of any kind.

The Encroaching Sahara

The originator of the "encroaching Sahara" concept apparently was a Briton, E.W. Bovill. He published a paper in 1921 in which he described some of the manifestations of desiccation south of the Sahara in West Africa, which he called the Sudan (Bovill, 1921). Bovill said that rivers in Senegal between the Gambia and Senegal rivers had dried up within the lifetime of people still living in 1920. He also noted that wells were going dry in Senegal and in the vicinity of Sokoto in Nigeria. He attributed the increasing desiccation to shifting cultivation. Bovill remarked that not all observers of the Sahara agreed with him. He said that Gautier believed that the Sudan (Sahel) was becoming wetter and that while the desert was encroaching on the steppe vegetation on the north side of the Sahara, just the opposite was occurring on the south side.

The person who brought widespread attention to the "encroaching Sahara" threat was E.P. Stebbing, a British forester. He read a paper at a 1935 meeting of the Royal Geographical Society entitled, "The encroaching Sahara: The threat to the West African colonies" (Stebbing, 1937) in which he described the degraded condition of the mixed deciduous forest and the savannas in northern Nigeria, southern Niger, and eastern Mali. His transects in the early part of 1931 went from Kano to Damaturn to Geidan, and back to Kano — all in Nigeria — then to Maradi, Birni-n-Konni, and Niamey in Niger, continuing to Gao in Mali before crossing the Sahara to Morocco. He was struck by the sand invasion from the Sahara, and by what he termed the first stage of the approaching conversion of the mixed deciduous forest to true savanna. Stebbing quoted a French political officer who had served in Niger and Mali as saying that the Sahara had advanced toward the south at a rate of 1 km per year for the past



Bovill attributed the advance of the Sahara southwards to shifting cultivation. The 'encroaching Sahara' left abandonned villages in its wake. (UNEP/T. Farkas)

three hundred years. That was probably the first estimate ever made of the rate of desert encroachment, but like other estimates, it was based on anecdote. Stebbing attributed the advance to deforestation, overgrazing, and cultivation. Drought was not mentioned but increasing desiccation was said to follow land degradation. The sand front was supposed to lie on a line from Sokolo in Mali to Ansongo, Tahoua, and Zinder in Niger and from there to northern Lake Chad.

Stebbing's paper is a fascinating document. It recommends establishing two forest belts to halt the advance of the Sahara. The northern belt, a minimum of 24 km wide and extending 2200 km from Segou in Mali to Niamey in Niger and on to Lake Chad, was supposed to stop the southward movement of sand. The southern belt, about 50 to 55 km wide and somewhat shorter than the northern belt, was intended to re-establish the moist mixed deciduous forest in the Guinean vegetation zone and, by so doing, reduce the aridity of the regional climate. Stebbing's northern afforested zone is a shorter and narrower version of the Sahel Green Belt project proposed at UNCOD (1977a).

Most of Stebbing's conclusions about the advancing sand of the Sahara were derived from observations made by others. In one case, however, he saw what he thought was the encroaching sand, three miles north of the town of Maradi, in Niger, close to the Nigerian border.

A commentator at the Royal Geographical Society meeting, the director of the Royal Botanical Gardens at Kew, made a trenchant assertion about encroachment. He stated that the Sahara was not encroaching on agricultural land, it was only responding to man's stupidity in cutting down, burning, and destroying the forest. He did not think the forest belt concept was practical, however desirable it might be.

Reactions

Several of the letters written about Stebbing's paper disagreed with his conclusions. Rodd (1938) chided Stebbing for being persuaded by the dry season appearance of the landscape that lasting changes in vegetation had occurred. He noted that desert conditions along the southern fringe of the Sahara "ebb and flow over periods of a few years as well as over longer periods". Rodd also said that it was his distinct conclusion that deforestation had been arrested and reversed, at least in some regions. The dramatic difference between the desolate countryside near the end of the dry season and the lush greenness of the same area in September can easily lead to different perceptions of land degradation, depending upon when a person travels through the area.

Criticism of Stebbing's paper led him to say that he regretted using the term "encroaching Sahara" because it implied that he thought the Sahara was advancing in great waves (Stebbing, 1938). He said that he meant that forest degradation led to erosion and finally to barren land. The latter interpretation reads very much like Aubreville's description of desertification (Aubreville, 1949) and could be accommodated in the UNCOD definition (UN, 1977).

Anglo-French Commission

The most striking refutation of Stebbing's thesis about the advancing Sahara came from an Anglo-French forestry commission study conducted in northern Nigeria and southern Niger in December 1936 and January and February of 1937. Initiation of the study appeared to be a consequence of the controversy engendered by Stebbing's paper and a book he wrote later on the same subject. The commission toured the country on both sides of the Niger-Nigeria border. It concluded that there was no danger of desiccation in the region and no evidence of large-scale sand movement but there was much destruction of forests almost entirely resulting from the uncontrolled expansion of shifting cultivation. These findings are consistent with what the author of the UNCOD Niger case study concluded in 1977 (UNCOD, 1977b).

The observations of Stebbing and the Forestry Commission about desiccation are interesting. Stebbing probably connected degradation of the tree and shrub cover with increased aridity since he spoke of the mixed deciduous forest being changed to savanna, and he associated savannas with dry regions. The desiccation which he noted was very likely the same phenomenon as that called edaphic aridity (Dregne, 1983). Edaphic (soil condition) aridity is common where degradation of the surface soil leads to increased runoff, thereby reducing the quantity of soil moisture available to plants. The Forestry Commission, on the other hand, very likely was referring only to rainfall when it concluded that increased desiccation was not expected to occur. They were correct on that point, at least up to the 1960's.

Desert Advance

In 1971, the encroaching Sahara was again a concern to delegates to a United Nations Seminar on the Environment and Development held in Ethiopia (AID, 1972). The seminar recommended that desert expansion in Africa be studied so that precise measures could be devised to control desert creep. The U.S. Agency for International Development (AID) mission in Tunisia, for example, considered the "northward march of the Sahara" to be a priority environmental problem. The AID report of 1972 estimated the advance of the Sahara in some places along a 3,000 km southern front to be as much as 45 km per year, but the source of that data was not supplied. The description of desert encroachment in the AID report was similar to that of Stebbing: arable land laid waste either through the burial of land by wind-blown desert sands or through an expanding aridity induced by climatic changes, causing a loss of soil moisture.

Kassas (1970) described a type of desertification in the Sudan that was similar to Stebbing's observations on vegetation changes in the Sahel but which did not implicate climatic change. He considered desert creep to be a largely man-made process of shifting of vegetational belts both north and south of the Sahara. With proper care, reversal of the degradation process appeared for the most part to be possible.

The first and only study professing actually to measure the shift of vegetation zones resulting from desert encroachment was a survey in the Sudan (Lamprey, 1975). He concluded that the Sahara had advanced 90 to 100 km between 1958 and 1975, an average rate of about 5.5 km per year. As far as we can ascertain, all quantitative statements about the rate of worldwide desert expansion rely either on this study or use unsubstantiated assertions.

Monitoring Encroachment

Hellden (1984) cast doubt on Lamprey's conclusion based on results from his analysis of Landsat imagery, aerial photographs, and ground conditions from 1961 to 1979. He stated that there did not seem to be any evidence to substantiate the conclusion that the Sahara had advanced southward. Among other things, Hellden could not find the extensive sand dune encroachment that Lamprey had mapped. More importantly, the distribution of cultivated land in 1979 was about the same as it had been in 1962. There was no systematic change observable

in the size of the degraded land areas around water sources and villages; indeed, there was a major expansion in cultivated land during the drought at the end of the 1960's and beginning of the 1970's, followed by a contraction again after the drought.

In our opinion, Hellden's findings do not prove that there has been no shift in vegetational belts during recent decades. Rather, they demonstrate the great difficulty in assessing and monitoring vegetation degradation. Interannual variations in land use, rainfall, disease and insect infestations, effectiveness of burning practices, and availability of water supplies complicate interpretation of observed changes in vegetative cover and crop yields.

The problem in interpreting observations of land degradation is illustrated by the conclusions of El Hag (1984). Whereas Hellden's study led him to believe that there was no sustained increase in degraded areas around villages, El Hag's study of approximately the same region came to the opposite conclusion. El Hag derived his information from comparison of Landsat images for 1972 and 1979, but without ground surveys.

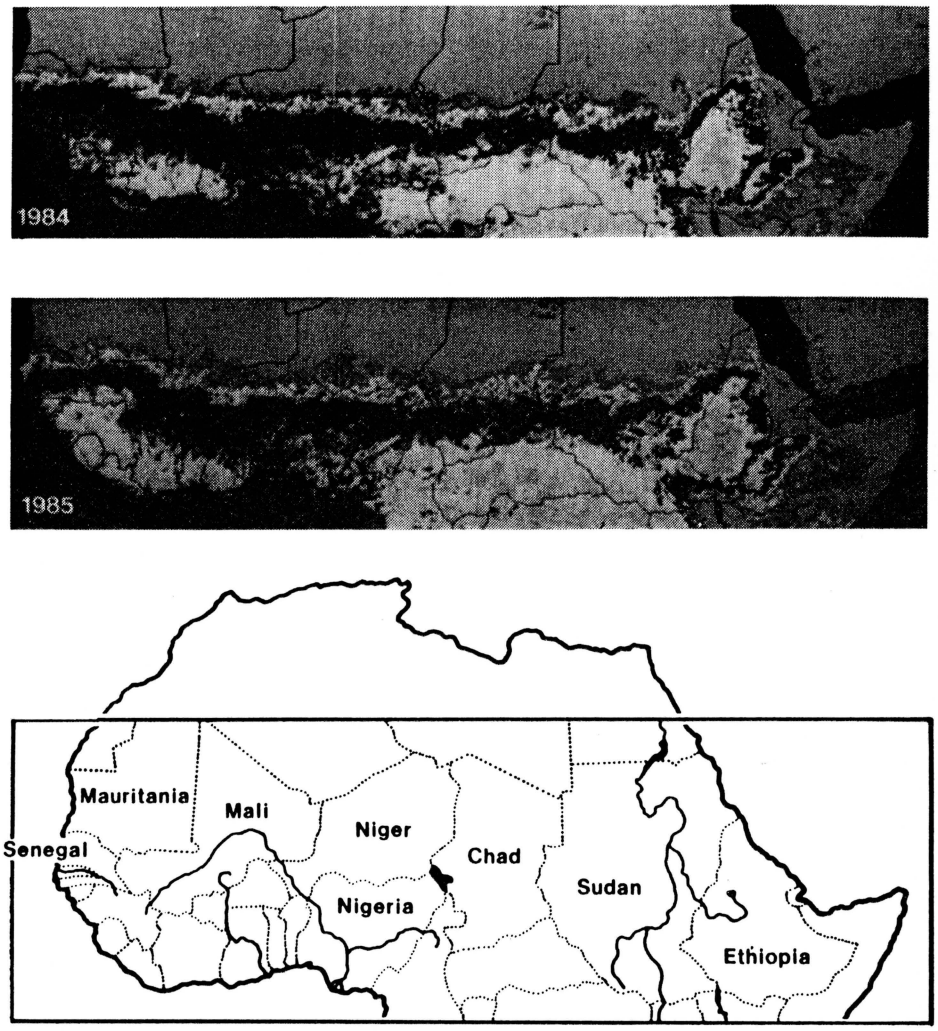


Fig. 1 Demonstration of fluctuations between wet and dry seasons.

Meteorological Satellite Studies

The very great changes in green biomass production that are possible from year to year in the dry regions are illustrated in Figure 1. The images represented the normalized difference vegetation index (NDVI) data from the Advanced Very High Resolution Radiometer (AVHRR) carried on polar-orbiting meteorological satellites of the U.S. National Oceanic and Atmospheric Administration (NOAA). Tucker and Justice (1986) described the methodology as it would apply to the measurement of the spatial extent of deserts. The great merit of using meteorological satellites is the wide view angle of the AVHRR and the twice-daily sun-synchronous coverage of the entire world. As a result of this, the cost of scenes embracing entire continents is low compared to the cost of Landsat images. The principal deficiency, for some uses, is the much lower resolution of meteorological satellites (1 or 4 km) than Landsat (30 meters) or SPOT (10 meters). For monitoring large areas, high ground resolution is less important than synoptic and frequent wide-area coverage, especially in arid and semi-arid areas. Cloud cover is also less of a problem when images are available daily.

A comparison of the integrated seasonal NDVI for the south side of the Sahara in 1984 and 1985 (Figure 1) demonstrates the magnitude of green biomass fluctuations from year to year. In 1985, the arid/semi-arid boundary (the northern limit of the brown zone on the maps) was shifted northward about 200 km along the Sudan-Chad border and about 150 km along the Sudan-Ethiopia border. 1984 was one of the driest years in at least three decades, whereas 1985 was the wettest year since 1981. Crop failures were widespread in 1984. By contrast, in 1985 near-average rain fed grain production occurred in Senegal and Niger and the best yields in several years were recorded in Mauritania, Mali, Chad, and the Sudan. In the vicinity of El Obeid in the Sudan south of the area where Lamprey conducted his survey, and which has a mean rainfall of 386 mm, the 1984-1985 green biomass shift approximated 130 km. However, 200 km west of El Obeid, the northward shift in 1985 was only 50 km, so regional differences are marked and these can obscure long-term trends.

A north-south oscillation in vegetation boundaries along the south side of the Sahara amounting to 50 to 250 km interannually or over a period of a few years, of the kind shown in Figure 1, appears to be fairly normal. If that is correct, a permanent vegetational shift of 5 to 6 km per year would require perhaps 30 to 40 years of observation by meteorological satellites and ground studies before it would be possible to conclude that the shift was, indeed, permanent. A permanent shift of 5 km per year seems to be rather fast since it means the shift would amount to about 100 km in only 20 years. If the desertification were patchy, as it usually is, the time for determining whether changes were temporary or permanent probably would be even longer.

The absence of good quantitative data on vegetational and sand dune shifts resulting from desertification, rather than drought, calls for organized monitoring efforts to provide the information needed to assess the severity of the desertification problem. Meteorological satellites, Landsat and SPOT satellites, aerial photography, and ground studies constitute the components of a surveillance programme that can furnish data ranging from local to global scales. The detail supplied would vary directly with scale; ground studies would produce the greatest detail, meteorological satellites the least, but these provide the only practical means of observing the temporal dynamics of biomass production over entire ecological zones. Landsat and SPOT leave gaps of several days in the coverage.

The technique of ground and aerial monitoring developed through co-operation between the Global Environmental Monitoring System (GEMS) of UNEP and the Kenya Rangeland Environmental Monitoring Unit (KREMU) of the Government of Kenya is an example of the monitoring of national territories. Landsat and SPOT could be used for less detailed studies, as was done by Hellden and El Hag. Meteorological satellites would produce the regional, continental, and global data. Each level of detail complements the other. All require adequate ground measurements to establish the validity of the remotely sensed data.

Conclusions

Meteorological satellite observations have demonstrated the large interannual shifts in green biomas production levels possible on the south side of the Sahara. Those observations have thrown doubt on the validity of statements claiming that permanent shifts in vegetation zones have occurred in that part of the Sahara as the result of desertification. Attractive though the "encroaching Sahara" idea is, it is no more credible now than it was in Stebbing's day.

Permanent shifts in vegetation belts may well be occurring or may already have occurred but there are not enough data to resolve the question. Circumstantial evidence of vegetation zone movement, as noted by Kassas (1970), seems to be adequate to warrant carrying out a definitive study to settle the question.

A small-scale study covering a few hundred hectares will not suffice. What is needed is a research project designed to monitor vegetation changes by conducting ground transects across representative vegetation zones, then extrapolating results at the national or continental scale through the use of aerial photography and satellite imagery. The time required for the project will have to be decades; part of the time could include retrospective analyses of data accumulated over the past 20 to 40 years. The project could be a significant contribution to the proposed International Geosphere-Biosphere Programme.

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