Appendix G

Monitoring Desertification Processes* by Landsat

The Landsat remote-sensing system has proven uniquely effective for measuring and determining changes in the global landscape. It is particularly applicable to monitoring and assessing processes that lead to desertification. About one-third of the Earth's surface is arid or semi-arid and therefore highly vulnerable to a variety of degradation processes. Such stresses, if continued unchecked, may lead to ecological impoverishment and, ultimately, to desert-like conditions.

Most commonly, desertification is triggered or intensified by periods of drought, and exacerbated by poor land-use practices such as rapid land clearing for agriculture or fuel. As food production becomes more important, large land areas run the risk of becoming less and less productive as a result of losing forest. Until recently, attempts to quantify and map the locations of desertification were based on fragmentary and highly local data subject to differing interpretation. Land remote sensing from space could provide the necessary information to monitor desertification.

The Conference on Desertification, held in Nairobi, Kenya, in **1977**, recognized the need for developing a means for systematic land assessment. Agencies of the U.S. Government, especially the Agency for International Development and the National Aeronautics and Space Administration, have since experimented with using the Landsat system as a primary land survey tool to monitor desertification.

The global dimensions of desertification are not precisely known but, by any account, are grave indeed. Each year, as many as **14** million acres of previously productive land become barren. Acreage lost to production represents a substantial economic loss to the global economy. One study[2] estimates $7 billion in losses from loss of range and pastureland and $9 billion in lost agricultural production each year. Financial losses in industrialized countries are paralleled by adverse human and social consequences in arid lands of the less developed world.

With the advent of satellite multispectral scanners (MSS) it has become possible to sweep Earth's surface repetitively, depict the scene in pixels about 1 acre across, determine surface reflectance characteristics in multiple bandwidths, and process these data rapidly by computer for interpretation and presentation. Based on this capability, desertification specialists, meeting under the international auspices of the U .N. Food and Agriculture Organization (FAO) and the U.N. Environmental Program (UNEP), have concluded that land condition should be expressed in gradation of geographical units.[3] The objective is to enable land comparisons on the basis of vegetation complexes, ecosystems, soil associations, and other qualities amenable to identification by remote sensing. They have created models which permit Landsat data to be combined with meteorological and other data to determine general conditions over relatively vast and sometimes remote areas. Use of this new technology presently offers the only economical y feasible method for obtaining synoptic information over wide areas, which is essential to understanding and controlling desertification.

The special properties of the Landsat system which permit development of a global data base and the means for accomplishing resource inventory and continuing monitoring are summarized as follows:

- perspective over a range of selected scales,
- combination of spectral bands for categorization and identification,
- repetitive coverage under comparable viewing conditions,
- direct measurement based on one set of reflectance conditions for a wide area,
- signals suitable for digital storage and subsequent manipulation, and
- accessibility over remote and difficult terrain and across political divisions.

With the establishment of baseline conditions it is possible to monitor the severity, rate, and trends based on standard sets of indicators (see table G-1)[4] The absence of this type of information in the early 1970's contributed to the failure to institute relief measures in the drought-stricken Sahel region of West Africa

*Desertification is the sustained decline and destruction of the biological productivity of drylands owing to stress caused by humans sometimes in conjunction with extreme weather or drought

[1] U.N. Conference on Desertification September 1977 Roundup Plan of Action and Resolutions New York, 1978

[2] Desertification papers prepared for the Nairobi Seminar on Desertification Priscilla Reining (ed) American Association for the Advancement of Science Washington D C 1978

[3] U.N. Food and Agriculture Organization and U.N. Environmental Program (FAO-UNEP) Expert Meeting on Methodology for Desertification Assessment and Mapping, Geneva, May 1979.

[4] Handbook on Desertification Indicators, compiled by Priscilla Reining (ed.), American Association for the Advancement of Science, Washington, D.C. 1978.

Table G-1 .—Implementation of Desertification Indicators With Remote Sensing

Detailed	Reconnaissance	Synoptic	Repetition Rate
SOIL			
1. Mosaic coloring	+	+	–
2. Surface seals	–	+	+
3. Major dust storms	+	+	+ daily
4.Sand drift, dunes	+	+	– annual or longer
5. Remobilized dunes.	+	+	+ annual
6. Obliteration of field patterns	–	+	+ annual
7.Salt crust	+	+	– annual
Water			
1. Falling water tables or increasing saline ground water (depth or stress on phreatophyte)	+	+	– annual
2. Abandonment of irrigated lands based on ground water	+	+	+ annual
3. Waterlogging moist ground	+	+	– annual
4. Abandoned land in irrigated systems	+	+	+ annual
5. Surface water changes in extent and duration	+	+	+ half monthly
6, Silting ...	+	+	+ annual
7. Turbidity.	+	+	+ half monthly, event related
8. Extension of gully sytems	+	+	+ 5 years
9. Regional changes in seasonal limits on rainfall (climate and water balance)		–	+ half monthly, daily over long period
Vegetation:			
1. Changes in cover or perennial vegetation	+	+	+ dry season, 5 years
2. Changes in distribution	+	+	– dry season, 5 years
3. Annual vegetation (crops)	+	+	+ half monthly
4. Denuded areas	+	+	+ half monthly
5. Biomass of crops	+	+	+ seasonal
Animals:			
1. Key species, populations, herd composition (larger animals)	+		– annual
Land use:			
1. Changes in irrigation	+	+	+ annual or longer
2. Changes in dryland area	+	+	+ annual or longer
3. Proportion of fallow to cropland	+	+	+ annual
4. Stressed rangeland areas	+	+	+ annual
5. Devegetation of mined areas	+	+	+ 5 years
6. Ground disturbance around mines	+	+	annual
7. Mine waste disposal	+	+	– 5 years
8. Deforestation around settlements	+	+	+ annual
9. Deforestation in relation to sand drift	+	+	+ annual
10. Tourism and recreation (ground disturbance)	+	+	– annual
11. Change in settlements (new settlements, expansion of existing settlements, and abandonment of settlements).	+	(ma; or may not be seen)	(+) annual

Key +can be used
– cannot be used

Notes
Detatied = scale 1 10,000, Iow.level aircraft
Reconnaissance = scale between 120,000 and 1 100,000 (Landsat.TM or SPOT-M LA)
Synoptic = scale 1250,000, satellite (Landsat.MSS)

SOURCE UNEP, Report of Expert Meeting on Methodology for Desertiflcation Assessment and Mapping until after thousands had died of starvation and many more had been forced to migrate, a condition that led to enormous social and political instability in the area.

With U.S. help, several international organizations are attempting to monitor and understand desertification.[5] A Global Environmental Monitoring System (GEMS) is being coordinated under the U.N. Earthwatch Program. FAO has under construction a Global Information and Early Warning System aimed at mitigating the effects of famine around the world. These systems will not become fully operational until civilian satellite remote sensing attains greater maturity. Land and meteorological satellites and a full panoply of aerial and ground observations will eventually be required to carry out the objectives of these ambitious but feasible programs.

The World Weather Watch (WWW) provides an important input to monitoring desertification through the Global Observing System (GOS). WWW is a collaborative effort by which 145 member nations pool meteorological capabilities and the data from 8,500 synoptic stations and other sources. GOS acquires data from both polar-orbiting and geostationary satellites.

In the United States, desertification is a major land problem for substantial portions of 17 Western States. The United States and Mexico have made the combatting of desertification in their common arid ecoregions a major continuing item of technical cooperation, and have placed particular emphasis on common use of Landsat imagery. The Department of State has been responsible for organizing periodic joint meetings of experts, and has directed U.S. contributions to monitoring activities.

Within the United States, a number of agencies and institutions are active in studying, assessing, and monitoring desertification processes. Those most prominent are:

- U.S. Department of Agriculture
  - — Soil Conservation Service
  - —National Forest Service
- Department of the Interior
  - --Bureau of Land Management (BLM)
  - —Bureau of Indian Affairs
  - —U.S. Geological Survey
  - —Office of Surface Mining
- Department of Commerce
  - —Climate Change Assessment
  - —National Weather Service
  - —National Environmental Satellite System

In April 1982, a comprehensive interagency study published by BLM reported the status of desertification in the United States.[6] It emphasized monitoring needs and statutes mandating land condition-monitoring projects including:

1. the Soil and Water Resources Conservation Act of 1977 (RCA), Public Law 95-192;
2. the Forest and Rangeland Renewable Resources Planning Act of 1974 (RFP); and
3. the Federal Land Policy and Management Act of 1976 (FLPMA).

Collectively, the RCA, RPA, and FLPMA direct in very specific terms the preparation and maintenance of continuous resource inventories by the Federal agencies. Congress has further recognized the importance of effective coordination of the collection and analysis of natural resources information. One active vehicle for accomplishing this was provided by the Interagency Agreement Related to Classifications and Inventories of Natural Resources, which was signed by five leading land agencies in 1978. It has produced several standard manuals. The product of a single national land satellite system, has helped pull together resource specialists who are addressing different tasks using the same basic data.

BLM, custodian of 427 million acres of public land, provides one specific example of response to monitoring requirements. BLM joined with the U.S. Geological Survey in modeling and categorizing Landsat digital data for purposes of mapping and describing wildland vegetation for a large section of the arid southwest. Strict cost records were kept, and the task was accomplished at a favorable rate of $0.07 per acre, including labor, computer time, and cost of tapes.

[5] International Symposium on Remote Sensing of Environment Conference on Remote Sensing of Arid and Semi-Arid Lands November 1981 Cairo Egypt

[6] U S Department of the Interior Bureau of Land Management Desertification in the U S Status and Issues Washington D C April 1982