CONTRIBUTION OF LANDSAT DATA TO MAPPING OF LAND RESOURCES IN ARID REGIONS ("TATAHOUINE" AND "ZARZIS" SHEETS OF 1/200 000 SOIL MAP OF TUNISIA)

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ABSTRACT

In the area studied, spectral brightness (MSS Landsat 1-3) depends basically on the characters of the soil surfaces, particularly roughness (stoniness, crusting) and colour, which is also closely connected with soil texture.

Using an approach which closely combines field and laboratory work, a multispectral classification allows us to analyse the MSS data structure and to obtain a computerized map of soil surface conditions.

Taking field observations into account, i.e. relationships between soils and soil surfaces,this document was interpreted for drawing up morphological map units.

In the next step, several derived thematic maps can be obtained, for example : the land resources map (scale : 1/200 000)

INTRODUCTION

This study takes place within the framework of systematic land resources mapping (scale 1/200 000) which is at the present time, carried out by the Direction of the soils (The Tunisian Ministry of Agriculture).

In using Landsat MSS data for the mapping of the two sheets Tatahouine and Zarzis, soil scientists have two objectives:

- -Practice of digital data processing following a previous study using only photographic processes (Escadafal R et Mtimet A, 1981)
- -Effective integration of satellite data in all the stages of soil survey in the hope of economizing some time and means.

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THE LOCAL ENVIRONMENT

In the two areas studied, Tatahouine and Zarzis (Figure 1), rainfall is very low and irregular (P less than 200 mm) Landscapes offer typical patterns of arid regions shaped out of secondary deposit layers with alternation of hard rocks (limestone and dolomite) and softer rocks (marly limestone, gypsiferous marl and little consolidated sandstone.)

The hard rocks form the "Djebels" (mountains) tabular relief broken by cliffs; hills extend in their piedmont and are shaped in softer rocks especially polyphase glacis, coalescent cones and different alluvial formations: fans, terraces etc... More or less sanded sebkhas occupy often endoreic depressions.

The pronounced features of the soils are the ancient pedogenesis and the nature of material. They are in close relationship with geomorphological units. Mention may be made of the most typical ones : soils with calcareous slab or/and crust spread over the hills and the ancient and middle quaternary glacis, soils with outcropping gypsiferous crust, deep soils (sierozems) over the recent quaternary glacis and terraces, salsodic soils (salt-affected soils) in the badly drained depressions, etc...

The natural vegetation is composed of perennial steppe : low ligneous and non-green chamaephytic plants. The plant cover is about 5-15% on the average. In the some places, plant cover can reach 20-30% : halophytic steppes in wet and saline areas, chamaephitic steppes (aristida pungens) over eolian sandy deposits.

In the rainy periods, the surface conditions of some soils allow germination of seeds and growth of plantlets, and consequently, an annual vegetation grows quickly after the rains. Within a few weeks, this vegetal cover disappears.

Grazing is the predominant land use, except for some small areas where rain water is collected either naturally or by man : systems of "Jessours" in piedmont areas (olive, and palm trees, cereals), cereals fields in the small and round depressions ("garaet" or " dayas") and in alluvial fans.

Finally, very open steppe and rare human settlements are the main characteristics of those arid landscapes; Consequently, features are stable over several years.

MATERIALS AND METHODS

MATERIALS

* The Landsat data

The figure (1) shows the scene 205,37 and the two sheets of Tatahouine and Zarzis (scale 1/200 000)

Among the available views of the scene 205-37, we selected two dates:

-April 4th,1981, end of autumn, before the dry season, when vegetation reaches its maximun.

-September 29th, 1978, end of dry season when the soil is the barest.

Above all, the sun inclination is very similar for the two dates (approximately 45°) so illumination conditions are comparable.

It is important because in arid regions, spectral brightness depends essentially on the characters of the soil surfaces, particularly roughness in connection with the shadow effect of nongreen steppe vegetation (Graetz and Gentle 1982) and with coarse elements.(Escadafal, 1984).

* The ancillary data

In addition to the topographic maps (scale 1/100 000) for the two areas, the team was provided with many but fragmentary, heterogeneous documents (different scales, ages and quality): geological maps, vegetation maps, soil maps (particularly the sheet of Zarzis), aerial photographs, etc...)

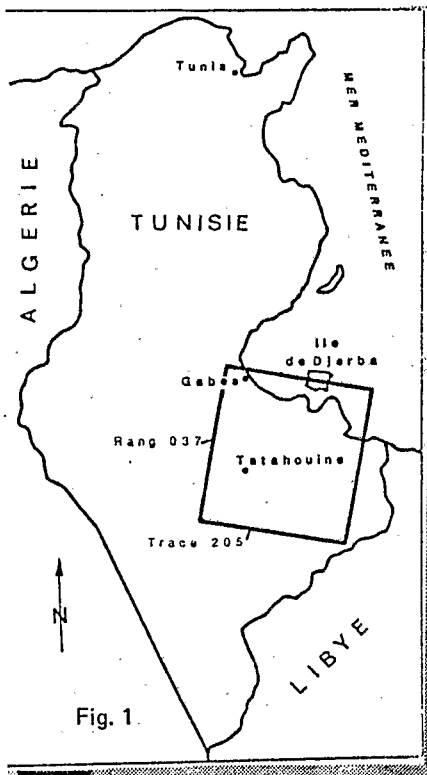
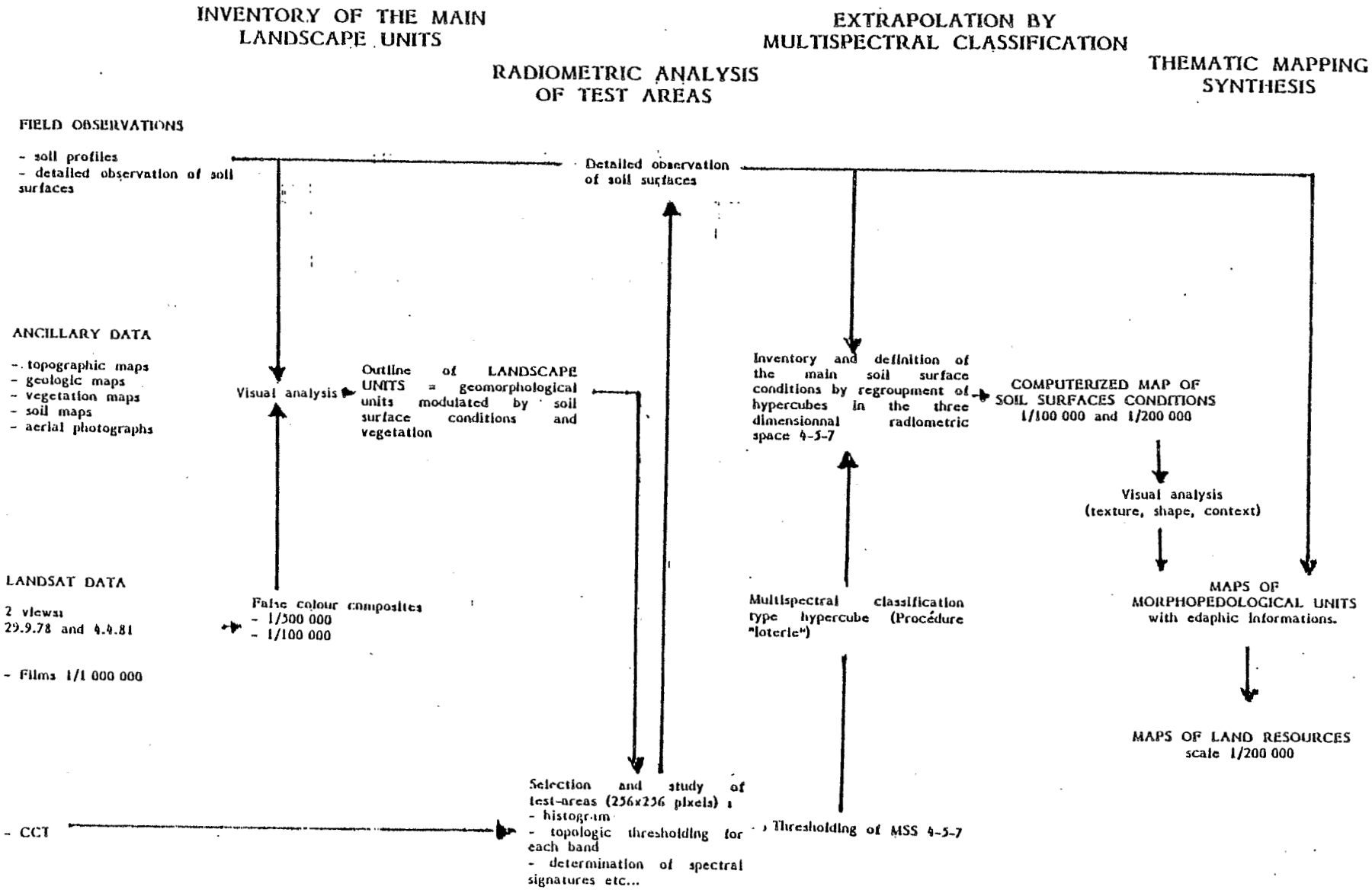


Fig. 1

Figure 2 : Study area

Figure 2 : METHODOLOGICAL APPROACH



METHODS

* Field observation has been carried out mainly by using the classical methods: soil profiles, auger, etc... In addition, it is necessary to emphasize the more detailed observation of the soil surfaces with a specific methodology developed by one of us (Escadafal, 1981).
* Photochemical processing of Landsat data enabled to obtain false colour composites to be obtained at the scales of 1/500 000 and 1/100 000 (diazoic films) generated from negative films (1/1 000 000)
* Digital processing of Landsat data has been carried out at the "Atelier de Télédétection" of ORSTOM in Bondy, France) by using : MINI 6 computer, interactive colour video console (Pericolor 1000), colorplot (Printronix) and plotting table (Benson).
* The methodological approach: (Figure 2)

-closely combines field and laboratory work
-uses interactive digital data processing with an effective and easy to handle multispectral classification.

The whole approach includes four stages :

STAGE 1 Inventory of the main landscape units

In this preliminary step, the outline of mapping landscape units is carried out by analysing existing data, making rapid reconnaissances along well chosen transects and making a visual analysis of false color composites. In arid regions landscape units are in relationship with geomorphological units modulated by soil surface conditions and vegetation.

This essential stage leads us:

-to take into account detailed observations of soil surface in order to characterize units which can be located in the field and on the false colour composites.
-to select test areas in order to start the second stage

STAGE 2: Radiometric analysis of test areas

Each of them, including 256x256 pixels, is recorded on floppy discs and processed on Pericolor 1000 off line.

-various histograms
-topologic thresholding for each band.
-determination of spectral signatures of more or less homogeneous units which can be located on the false colour composites and studied in the field. They constitute the main soil surface conditions.

The radiometric analysis of the four bands leads us to take MSS 4 into account in spite of its poor quality (stripping). It allows discrimination of soil surfaces according to their colour. It also allows improvement of soil-vegetation information provided by MSS 5 and 7. MSS 6 which is highly correlated with MSS 7, will not be used in the subsequent classification.

At the end of this second stage we can threshold the three bands 4,5,7. , each class which is given by the previous analysis corresponds to significant thresholds in order to identify the different soil surface conditions.

STAGE 3: Extrapolation by multispectral classification

In the space of the three bands the set of data occurs as a cluster of points where the soil surface conditions are located in different areas. Therefore, we try to divide this cluster into three-dimensional classes ("lots" or "hypercubes") combining these three bands (procedure "loterie", ORSTOM, 1978) This classification is applied to all the regions studied, for instance the Tatahouine sheet.

Inventory and definition of the main soil surface conditions are made. Each of them form a set of hypercubes in the space of MSS 4,5,7 data. Among these hypercubes we distinguish the modal "lots" or "nucleus" and the surrounding ones called "perimodaux". By increasing the number of hypercubes and consequently the thickness of threshold in this space, it is possible to specify the

radiometric content of the theme "soil surface conditions"

Using the interactive process allows us to change the thresholds and to evaluate their validity. Several multispectral classifications are made through successive tests. Following new field controls we select the most discriminatiing and stable classification in order to draw the computerized map of soil surface conditions at a scale of 1/200 000 or 1/100 000. This map shows the relationship between brightness and characters of soil surfaces and gives a spatial representation of soil surface conditions in the whole region at the date of the satellite flight.

Therefore we draw up a map for each area, Tatahouine and Zarzis, and for each view studied (September 29th, 1978- April 4th, 1981).

STAGE 4: Thematic mapping synthesis

Taking into account field observations, i.e. the relationships between the soil surface conditions and soils themselves, the previous documents are interpreted (visual analysis) in order to draw up "maps of morphopedological units". Some exemples taken in the Tatahouine area allow us to show some aspects of the interpretation.

These two maps of morphopedological units (Tatahouine and Zarzis) are useful to make a derived thematic mapping, for example : The land resources map at a scale of 1/200 000.

RESULTS

The effective statement of the most important results (that is, the cartographic documents which have beeen built up during the study), is not possible in the context of this communication : These are to be published soon.

Only two sets of results will be emphasized, the former concerning the methodology employed, the latter, some comments about the Tatahouine sheet.

Methodological aspect:

A real integration of the MSS Land sat data has been achieved at every stage of the mapping:

-prospecting preparation

-during the prospecting, with, in particular, the detailed observation of soil surface, added to classical methods.

-at the end of prospecting the computerized soil surface conditions map, which has been drawn up through field observations, contitutes the "background" of the morphopedological unit map.

The unceasing backwards and forwards running made by the field soil scientists between field and laboratory has led them to have an effective share in digital data processing. A correct mastery of different processes has been given by the "four stages" approach and the simplcity of the multispectral classification. Therefore important information has been obtained, concerning:

-the relationships between the spectral brightness and the characteristics of the soil surfaces (Escadafal R., 1983, Escadafal R. and Pouget M., to be published)

-the relationships between the soil surface conditions and soils themselves.

Brief commentories on the region of Tatahouine give some evidence of it.

The sheet Tatahouine

The computerized map of the 4.4.1981 view shows 16 types of soil surface conditions (Table 1). The two-dimensional histogram (Figure 3) shows:

-the thresholding of the MSS 4 and 5 channels into classes.

-the projection of the "nuclei" of the "soil surface conditions" themes on the plan of MSS 4 and 5.

Let us emphasize that the multispectral classifications made during successive tests have shown that it has been possible to discriminate between all the themes and that each of them holds a constant and well defined position in the three-dimensional space of the MSS 4-5-7. This is true for the two dates studied, and then, some stability over time can be checked.

TABLE I : LEGEND OF THE COMPUTERIZED MAP OF SOIL SURFACE CONDITIONS
Sheet of Tataouine, Scale 1/100 000

N°	SOIL SURFACE CONDITIONS	GEOMORPHOLOGICAL UNITS
1	Shaded surfaces	Steeply sloping mountains (N-W exposure)
2	Stony surfaces	Steeply sloping mountains
3	Stony surfaces Dense vegetal cover: steppe with Aristida pungens	Rolling mountains Fields of nebkhas over terraces and alluvial fans
4	Stony surfaces	High piedmonts,hills with calcareous crust
5	Stony and gravelly surfaces Dense halophytic vegetation	Hills with calcareous crust, upper glacis Humid sebkhas
6	Gravelly surfaces	Hills and glacis with calcareous crust
7	Light cover of eolian sand	Hills and glacis with calcareous crust, sandy or loamy glacis
8	Light cover of eolian sand and micronebkhas	Glacis with calcareous crust, sandy or loamy glacis,alluvial fans
9	Loamy surfaces with gravels and coarse sand (West zone) Outcropping gypsiferous crust with discontinuous loamy cover (East zone)	Loamy or sandy glacis Hills and glacis
10	Loamy and crusty surfaces (West zone) Outcropping gypsiferous crust with discontinuous loamy cover (East zone)	Loamy glacis and alluvial fans Glacis and ancient terraces (Oued Ferch)
11	Light cover of eolian and coarse sands	Ancient terrace (Oued Dekouk)
12	Fine eolian sand	Fields of sandy dunes
13	Light surfaces Gravels and coarse sands (West zone) Outcropping gypsiferous crust (East zone)	Alluvial fans Glacis,dried sebkhas
14	Light surfaces Eolian sand Outcropping gypsiferous locally sanded crust	Fields of sandy dunes Glacis,ancient terraces and dried sebkhas
15	Specular reflection areas	Cliffs (S-E exposure) sides of sandy dunes facing the sun
16	Bright surfaces with saline efflorescences	Dried and uncovered sebkhas

OBSERVATION : Cultivated areas ("jessours" and "dayas") which are well located in radiometric analysis (April 4,1981) are not mentioned at this scale.

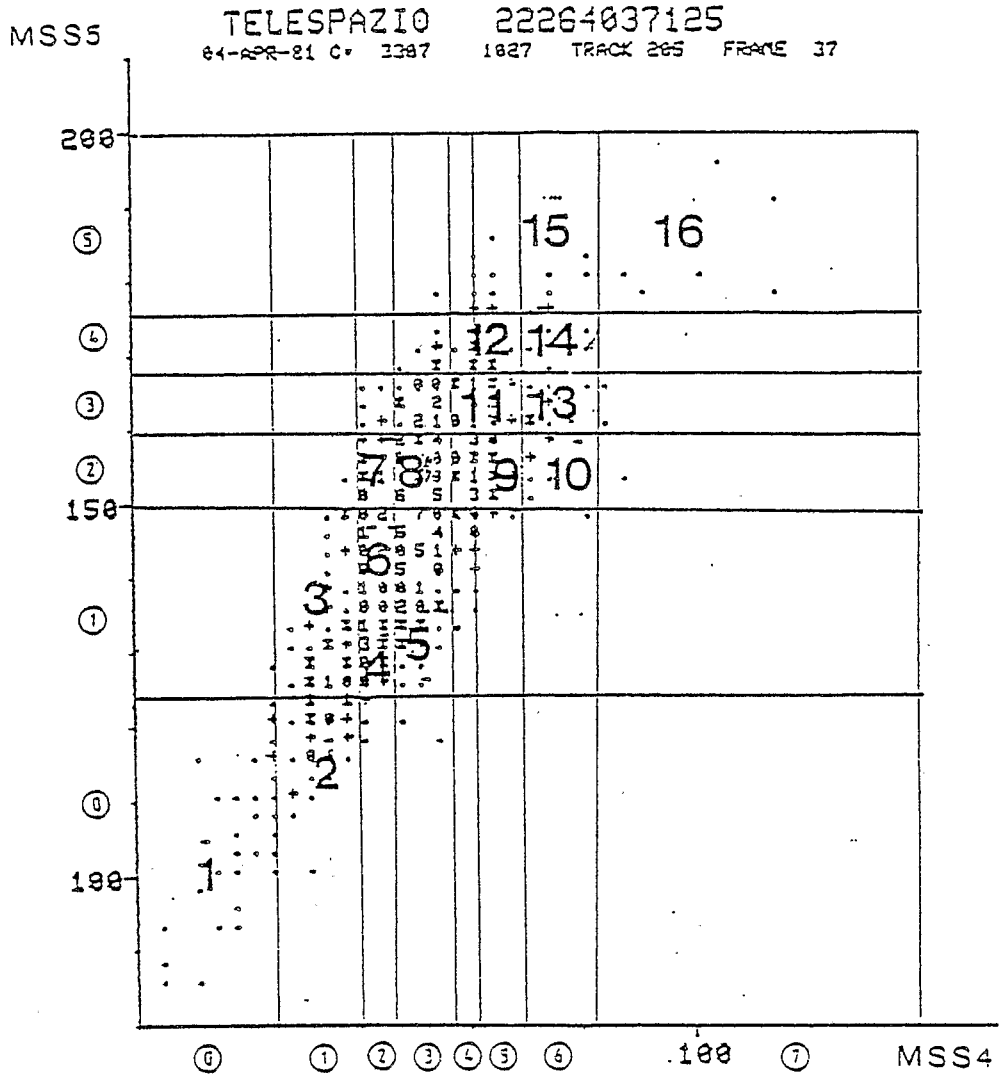


Figure 3 : Two-dimensional histogram MSS 4 - MSS 5. Projection of the "nuclei" of the "soil surface conditions" themes on the plan of MSS 4 and MSS 5.

Thresholds of MSS 4,5,7.

CLASS	MSS 4	MSS 5	MSS 7
0	0- 63	0-125	0-129
1	64- 69	126-150	130-143
2	70- 73	151-159	144-151
3	74- 78	160-167	152-156
4	79- 80	168-173	157-159
5	81- 84	174-255	160-164
6	85- 91		165-171
7	92-255		172-255

It is not surprising, in so far as spectral brightness values are in connection with some stable characteristics of the soil surface : roughness (stoniness, crusting, shadow effect), colour and texture, etc...The same does not hold true for those themes occupying very limited area, which are dominated by an "active" vegetation (for example: cereals in "dayas" and "jessours"). The examination of the legend (appendix I) leads to the following commentaries:

- -many surface types are clearly distinguished by their radiometric classification (1,2,4,6,7 etc)
- -for others (3,5,9,10 etc...) some radiometric convergences prevented us from differentiating some units which are, however, very different. The example of the 9 is very significant since it includes coarse sandy and loamy surfaces (deep soils of the West zone), and gypsiferous crust (sterile soils of the East zone)
- -on the other hand, 6 and 7 can be distinguished by a light cover of eolian sand, when most often, they are in fact, similar soils (soils with calcareous crust)

These brief commentories emphasize that field observations are necessary to interpret, but also to establish maps of soil surface conditions.

CONCLUSION

For the Tatahouine and Zarzis sheets, Landsat data has been a valuable help in the mapping of land resources. They enabled time and means to be saved for prospections. However, one must be aware of the fact this saving has been widely used to process digital data.

Anyway, these maps of soil surface conditions constitute a new approach to arid regions, not only concerning the inventory of land resources, but also the monitoring of these fragile ecosystems.

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