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Peter Collier

W. Gordon Collins

Remote Sensing Unit,
University of Aston in Birmingham (U.K.)

THE CLASSIFICATION AND INTERPRETATION OF LAND USE IN THE HUMID TROPICS: AN AIR PHOTO STUDY

Abstract

The paper deals with the problems encountered when attempting a study of the relationship between land use and soil erosion in St. Catherine, Jamaica.

It shows how existing classifications, being based on cover, crop type or usage on the date of photography are unsuited for the purposes of this project. Using the differences between small-scale peasant holdings and the large scale commercial holdings as an example, it shows how a classification is derived and illustrates the kind of problems encountered in carrying out photo-interpretation in the humid tropics.

The classification and interpretation of land use in the Humid Tropics: an air photo study.

Much information has been accumulated over many years of studying the problem of soil erosion (based on the use of test plots and steam sediment load data) in order to evaluate the factors affecting the rate of soil erosion. The research group at the University of Aston considered that remote sensing could be used to obtain sufficient field data to evaluate this problem, which is particularly serious in many of the third world, tropical countries such as Jamaica. One of the problems is that test plot data may not truly reflect what is happening in the field, and that stream sediment testing gives a measure of the average rate of erosion over a whole basin or watershed and therefore provides little or no information about the many and varied individual factors involved.

It was felt that data collected using remote sensing, supported by field checking, might reveal factors not fully considered or appreciated in the use of test plots. To carry out this work an attempt was made to simulate the kind of problems likely to occur in a developing country of limited financial resources; the type of country where the results of this kind of research are most needed. This meant limiting the study to using whatever photography was available of the chosen study area, and to the use of fairly simple and inexpensive equipment for interpretation and data transfer.

Part of the parish of St. Catherine in Jamaica was chosen for this study because work had earlier been carried out in the same parish (Collins, 1972) and the unit had maintained its contact with the Ministry of Agriculture and the University of the West Indies. The most up to date, complete coverage of this area consisted of 1:25,000 scale black and white photography taken in 1968. The study area consists of two interior basins surrounded by hills of limestone, igneous rocks and metamorphosed sediments. Satisfactory topographic and soils maps were available of the whole study area, which meant that it was possible to concentrate on the analysis of the land use and soil erosion as a remote sensing exercise. The study area contains agricultural systems on two very different scales. On the flat or gently sloping alluvial basins there are large-scale plantation systems, while the surrounding hills consist of intensive small-scale peasant cultivation inter-mixed with large-scale food forest holdings.

In the course of studying the land use within the study area it soon became clear that most of the existing tropical land use classifications, and classifications of more general application, would be either misleading or inadequate when applied to this study. The existing classifications are

concerned with the type of crop grown, whether the land is in woodland or pasture, and whether it is in a cycle of crop or land rotation. This approach to land use is summarised in Table 1, the classification compiled for the Jamaican Agricultural Census Unit (JACU) (1973). In almost all the classifications reviewed no account had been taken of the scale of the agricultural activities: a factor which, certainly in Jamaica, has been found to be important in determining the agricultural practices used.

Considerable evidence now exists to indicate that crop and land management are far more important than slope, soil type or rainfall intensity in determining the rate of soil erosion. Hudson (1977) quantifies these various factors:

Variation in the erosivity of the rainfall	5:1
Variation in the erodibility of the soil	5:1
Variation due to slope modification	2:1
Variation due to crop and land management	10,000:1

Lal (1976), Hudson (1977) and Fournier (1967) cite many results from experimental test plots to support these values.

It follows that any attempt to study the relationship of soil erosion with soil type, land use and slope that fails to take account of the variation in management practices is unlikely to obtain reliable and meaningful results. The great difference between the classification of JACU (Table 1) and that of the International Geographical Union (IGU) (Table 2) is that the Jamaican Agricultural Census is concerned solely with what each particular parcel of land was being used for on the day of the census, 1 December 1968, while the IGU surveys are concerned with the 'normal' usage of the land. For the purposes of this research programme the more general approach of the IGU classification to land use was considered more suitable than the JACU classification, as this research programme was investigating whether a relationship existed between land use and soil erosion. It could well be misleading if land use were recorded for only a particular year or a particular day.

The short comings of the JACU classification can be illustrated by considering the classification of land rotation: noted as 4b in the IGU classification. In the humid tropics the system of land rotation normally entails land being cultivated for about three years and then being rested for six or seven years. In areas of rich soil the ratio of cultivation to fallow would be higher, and on poorer soils it would be lower. If we take the average however, at any one time one third of the land will be in cultivation and two thirds will be in fallow. In the IGU classification all

this land would be classified as 4b, but in the JACU classification the land could be classified as any of four different classes; crops in pure stand, crops in mixed stand, fallow or ruinate.

Given that there will be twice as much land being rested as cultivated it would follow that in an area of homogeneous soils and slopes it should be possible to identify more than twice as many soil erosion features on the fallow and ruinate land than on the cultivated land. The problem is, however, that the soil erosion is not caused by the land being rested, but by it being cultivated, thus any correlation between rested land and soil erosion would be meaningless in terms of trying to determine what types of land use are most harmful. Instead of indicating that land is rested because of soil degradation, the statistics would show that the soil is degraded because it is being rested. It is important, therefore, to make sure that the land is always classified according to its most intensive use, since this will usually be the use which causes most soil degradation.

It therefore follows that for this study, a classification similar to that of the IGU is more useful and appropriate than one similar to the JACU classification. Unfortunately although the classification used for this research programme has much in common with that of the IGU it was found that the IGU classification failed to make certain distinctions which were felt to be important. Where the IGU classification was considered to be most deficient was in failing to differentiate between the different scales of continuous or rotation cropping.

During this research programme it became evident that there were marked differences between the methods of cultivation practised on the small-scale peasant farms, with those used on the large-scale, commercial farms, even where both were practising continuous cropping of the same crop. Cultivation techniques are also dependant upon the type of crop being grown, but although this is not taken into account in the IGU classification it would be possible to add a further letter or number to that classification to take account of the major crop types - such as citrus, sugar and coconuts. If, however, this had to be added to a crop-land classification that had already been sub-classified according to cropping system and farm/field size, there would already be a four character classification before allowing for other complications such as the presence of mixed classes and multicropping.

Unfortunately, within the hilly marginal lands of St. Catherine, there are other factors, such as land tenure patterns, which further complicate the interpretation of land use on aerial photographs. Where peasant cultivation adjoins a more extensive area of food forest (areas where

commercial food crops are grown under a canopy of 'natural' woodland) it is often difficult to determine the edges of the peasant holdings. This is due to the tendency of the peasant farmers to grow food crops under a canopy of breadfruit, pimento, star apple and other food trees. On medium scale photography it is not possible to determine whether trees are being grown for their fruits or for timber unless they show a regular pattern characteristic of a plantation or orchard.

The one tree which can be readily recognised on the aerial photographs is the coconut: but this is common to both food forest and peasant holdings. The coconut tree does, however, serve to differentiate between food forest and natural woodland. Such areas pose considerable problems for land use classifications, such as that of Sridas (1966), where only the dominant crop is mapped. In the area of this research programme, where multi-cropping is the rule rather than the exception, it is difficult to decide which criteria are to be used to determine the dominant crop. Economic value, number of plants, area of ground cover or identifiability could all be used to determine the 'dominant' crop type, but none is really satisfactory and, more important, none is capable of being readily applied in an objective way during air photo interpretation.

Another problem is that even if it were possible to determine objectively which is the dominant land use, to map only the dominant usage is to falsify the true nature of the land use, and could well lead to misleading results when an attempt is made to correlate land use and soil erosion. For example coconut grown in pure stand have little or no effect on the rate of natural erosion, but where they are grown in conjunction with vegetables or other crops entailing clean tillage there is a high rate of erosion evidenced by the exposed roots of the coconuts. Exposed root systems are not characteristic of coconuts grown in pure stand.

Collins (1972) in his classification of land use in St. Catherine based on the 1961 aerial photography, classified land use according to crop or natural vegetation. His study comprised the whole of St. Catherine and thus included land uses and vegetation types (salinas, mangrove swamps, etc.) not found in the northern part of the parish. The main deficiency of this classification system, with respect to the present research programme, is that it took no account of farm size which is an important factor in determining the cultivation techniques and practices.

Panton's (1970) land use classification scheme for use in Malaysia, is similar to that of Collins (1972) but includes catagories such as shifting cultivation and annual and diversified crops. Unfortunately again no attempt is made to take account of farm/field size, consequently this

classification is also unsuitable for application in this research programme. The classification of Panton (1970) so resembles that of Collins (1972) that it would seem that the variation between them is more of a function of the different landscapes for which they were intended rather than to any differences in the purpose of the classifications.

The land use or cover classification of the United States Geological Survey (USGS) as given in Anderson et al (1976) (Table 3) was specifically designed for use with remote sensing imagery. Unfortunately this classification, probably because it was originally designed for use in the continental United States, also fails to take account of the different types of agricultural practices which are related to farm/field size. The USGS classification also suffers from the defect that, in being a total land cover system at its first level, it is too general for other than small-scale mapping. By the time it reaches an acceptable level for the scale of mapping envisaged for this project it already involves the use of three character codes before allowing for mixed classes. It was felt that for ease of application no more than four characters should be used to classify a land use - even when dealing with a mixed land use - and that interpretation would be too slow and unwieldy if a more complicated code were used. It was also felt that the analysis would be unnecessarily complicated if there were too many land use variables. The classification employed had to be sufficiently simple to be readily usable, but sufficiently close to reality to make the results of the analysis of any value.

It became evident during the course of this project that there were marked differences between the land use on the large farms and on the small, peasant farms. Although this was indicated during a preliminary study of the area, it was highlighted by an examination of selected statistics (Table 4) from the Jamaican Agricultural Census (1973). In farms of more than 100 acres 97.7% of cropland is in pure stand while in the less than 5 acre class only 45.2% of cropland is in pure stand. In the less than 5 acre class 70% of land is cropped while only 29.5% of the 100 acre plus class is cropped. Fallow formed 4.9% of total land use in the less than 5 acre class but only 0.8% of the 100 acre plus class. The percentages of food forest, grassland and woodland also show marked differences between farm size classes (see Table 4). It is less easy to quantify the differences in the quality of cultivation between the different size classes, but these differences are real and important in terms of their impact on the relative rates of soil degradation. It was with the importance of differentiating between large-scale commercial and small-scale subsistance cropping in mind that the classification (Table 5) was drawn up for subsequent use in this applied research project. No claims are made about the applicability of

this classification for other environments or for other purposes.

A classification should be the orderly arrangement of information for a specific purpose, and the specific purpose of the classification compiled in Table 5 is clearly defined, i.e. the need to identify the relationship of soil erosion with land use and the scale of the agricultural activity.

It is a contradiction in terms to speak of a 'general classification' and our experience shows that these are generally compiled without knowing the use to which they are to be put, or the problems which they are required to solve. It is not surprising therefore to find that these 'general classifications' of land use are rarely of much value in supplying the necessary data to solve most real live problems which by their nature tend to be very specific.

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Table 1 Land Use Classification of the Jamaican Agricultural Census Unit (JACU) (1973)

1) Crops in Pure Stand - subdivided by crop

2) Crops in Mixed Stand - subdivided by crops

3) Food Forest

4) Improved Grassland

5) Unimproved Grassland

6) Fallow

7) Ruinate used as Pasture

8) Woodland

Table 2 Land Use Classification of the International Geographical Union (IGU)

1) Settlement and associated non-agricultural land

2) Horticulture

3) Tree and perennial crops

4) Cropland a. continual and rotation cropping

b. land rotation

5) Improved permanent pasture

6) Grassland and scrub, used as pasture

7) Woodland a. dense, b. open, c. scrub, d. swamp

e. cutover or burnt over forest areas

f. forest with subsidiary cultivation

8) Swamp and marsh

9) Unused land

Table 3 Land cover classification (part) of the United States Geological Survey (after Anderson et al, 1976)

Level I	Level II
2 Agricultural Land	21 Cropland and pasture
	22 Orchards, groves, vineyards, nurseries, and ornamental horticultural areas
	23 Confined feeding operations
	24 Other Agricultural land
3 Rangeland	31 Herbaceous rangeland
	32 Shrub and brush rangeland
	33 Mixed rangeland
4 Forest Land	41 Deciduous forest land
	42 Evergreen forest land
	43 Mixed forest land

Table 4 Land use statistics for St. Catherine, Jamaica (after JACU, 1973)

	Farms of less than 5 acres	Farms of 100 acres plus
Total Acreage	24,595	90,566
% in Pure Stand	31.5	28.8
% in Mixed Stand	38.2	0.7
% in Food Forest	7.7	0.2
% in Grassland	2.4	21.0
% in Fallow	4.9	0.8
% in Woodland	0.7	23.3
% in Ruinate	6.0	16.0

Table 5 Land Use Classification (ASTON) Developed for use in this research Programme

1. Plantation

   a. Sugar)
   b. Citrus) Pure Stand
   c. Banana)
   e. Palm)

   d. Other

   f. Mixed Stand (or use combination of two from above)

2. Cultivation - Subsistance, Horticulture and Market Gardens

   a. Sugar)
   b. Citrus) Pure Stand
   c. Banana)
   d. Palm)

   e. Other

   f. Mixed

3. Grassland and Pasture (including scrub pasture land)

   a. Improved

   b. Unimproved

4. Woodland

5. Food Forest

6. Urban, Industrial and other non-agricultural land use

7. Swamp and Marshland