Estimation of Soil Map Unit Composition by Electronic Densitometry

Oumar DOUMBIA

Laboratoire de Recherche sur la Désertification (LRD), BP 1704, Bamako, Mali.

Résumé

Cette étude a été menée dans le cadre du programme de Maîtrise de l'auteur au Département d'Agronomie et Pédologie de l'Université d'Etat du Michigan.

L'objectif de l'étude a été de tester la méthode de classification densitométrique d'image à la cartographie de 3 unités complexes de sol de Tuscola County.

La zone d'étude se situe dans la portion de plaine lacustre du comté. Elle se caractérise par un matériau parental limoneux qui a été recouvert par des levées à topographie ondulée constituée de matériaux grossiers. Les unités cartographiques de cette zone identifient 6 complexes de sols composés chacun d'au moins deux types de sols que la cartographie conventionnelle ne peut pas séparer.

La méthodologie d'étude a consisté d'abord à sélectionner deux parcelles représentatives de chaque complexe de sols. Les négatifs des photographies aériennes, noir et blanc, prises à l'échelle 1/15 840 ont été ensuite numérisés par la méthode de classification non supervisée. Un intervalle de valeurs de réflectance pouvait être ainsi défini pour chaque série de sols.

L'estimation de la composition des unités cartographiques a été faite sur le terrain par des observations à la tarière à une grille de 30,5 m de côté. Les sols ont été classés selon la Soil Taxonomy. Les résultats de l'estimation par numérisation et par les observations de terrain ont été comparés à l'estimation faite par l'équipe de cartographie du Service de Conservation des Sols des Etats-Unis.

Les résultats indiquent que :

- l'application de la numérisation est plus efficace sur sol nu ;

- les moyennes de valeur de réflectance d'une série de sol varient d'une parcelle à l'autre, consécutivement à l'utilisation de différents points d'essai de numérisation ;

- il existe une bonne similarité entre les trois méthodes d'estimation.

Abstract

This research paper was submitted to Michigan State University, Department of Crops and Soil Sciences, 1983, in partial fulfilment of the requirements for the degree of Master Of Science.

The objective of the study was to evaluate the use of electronic scanning densitometry to determine the composition of 3 soil complexes in Tuscola County, Michigan, through the use of aerial photographs.

The study area is located in the lake plain portion of Tuscola County with calcareous loam till parent material. This flat plain has been covered by the Wisconsin glacial which left numerous narrow gently sloping ridges. The mapping units of the study area are made of 6 complexes of two or more kinds of soils in such an intricate pattern that it is not practical to map them separately.

Two representative fields of each complex were selected in the county. Large scale (1:15,840) black and white transparency of each field was digitized using a microdensitometer computer EXECOM Image Scanner. An unsupervised classification technique was applied to process the panchromatic image. A range of brightness values could be found for each soil series.

The actual composition of mapping units was made at intensive level by making field observations at about 30,5 m (100 ft) intervals. Soils were classified in the field according to USDA Soil Taxonomy. The densitornetry composition was then compared with both from field results and with the one estimated by Tuscola's soil survey team.

The study results indicate that:

- bare soil is necessary when using electronic scanning densitometry to estimate composition of soil complexes. A distinct range of brightness values was found to separate 4 soil series in 3 complexes. This discrimination was related to drainage characteristic of soils series;
- the mean reflectance values of single soil series varies from one field to another due to the use of different training sites from field to field;
- there was a good agreement between the composition of the map unit determined from densitometry for most of complexes except one. The lack of agreement is probably the result of vegetative interference.

Introduction

The map unit and the scale constitute the most important components of a map. The mapping units are defined as consociations, associations, complexes or undifferentiated groups series. The complex is used on detailed soil surveys when the pattern and proportion of the soils are so somewhat similar in all areas.

Many soil complexes in Michigan have mottled appearance on aerial photographs. Imagery of bare soil collected during the spring months provides the most distinctive patterns. Electronic scanning densitometry can quickly quantify the tones on the aerial photographs. Given the range of density values for each kind of soil, the percent of composition can be determined rapidly for each area. This technique of computer analysis is already useful in many fields. The purpose of this study was to test determination of three soil complexes composition by electronic scanning densitometry.

Objective

The objective of this study was to evaluate the use of electronic scanning densitometry to determine the composition of 3 soil complexes in Tuscola County Michigan, by utilisation of aerial photographs.

Study area

The study area is located in the lake plain portion of Tuscola County with calcareous loam parent material. The flat plain is broken by numerous narrow ridges which are gently sloping.

The first soil survey of this county was made in 1926 by the United States Department of Agriculture (USDA). The legend of this survey has been updated on a 1970 aerial photograph base. Six complexes have been identified. Three of these complexes were considered in this study.

Method

Two representative fields of each complex which showed obvious soil patterns, were selected in the County. The soil taxonomy classification, drainage classification, map name, field number and acreage are given in table 1.

Large scale (1:15,840) black and white transparency of each field was digitized using a microdensitometer computer EXECOM Image Scanner. This computer displays greytone values between 0 for black to 255 for white.

Table 1. Description of the soils series.

Soil series name	Taxonomic classification	Drainage classification	Map unit name	Field number	Acreage (ha)
Avoca	Sandy over loamy mixed, Mesic, Entic Haplaquods	Somewhat poorly drained	Tappan-Londo	2	110.37
					12.44
Guelph	Fine loamy, mixed, Mesic, Glossaboric, Hapludalfs	Well drained	Tappan-Avoca	3	15.55
				4	20.75
Londo	Fine loamy, mixed, calcareous), Mesic, Typic Haplaquolls	Somewhat poorly drained	Guelph-Londo	5	15.55
				6	15.55
Tappan		Poorly drained			

An unsupervised classification technique was applied to process the panchromatic image and to determine brightness values for soil series.

The actual composition of the mapping units was made at intensive level by making field observations at 30,5 m (100 ft) intervals. Soil were classified in the field according to USDA Soil Taxonomy.

The densitometry composition was then compared with both field results and the one estimated by the Tuscola soil survey team.

Results and discussion

For the seek of presentation, the data for only the Tappan-Londo complex is included on this review paper. However the discussion covers all the sampled area.

Soil reflectance values of the three complexes

The display of the Tappan-Londo field 1 is shown in figure 1. To avoid excess of numbers, the cells selected for printout were: every fifth column (cross page) and every fourth row (down page). It was then easier to locate the field observation on the digitized mops. Each number represents an integrated surface area of about 1.2 m^2 (10 ft^2) on the ground. Symbols are used to indicate single soil series or a soil series having similar reflective characteristics.

Table 2 summarizes the variation of the reported soil series brightness values from the Tappan-Londo complex. Some of the numbers appear "abnormally" higher or lower than the surrounding digits, i.e. that the field observation is not correctly located on the precise cell.

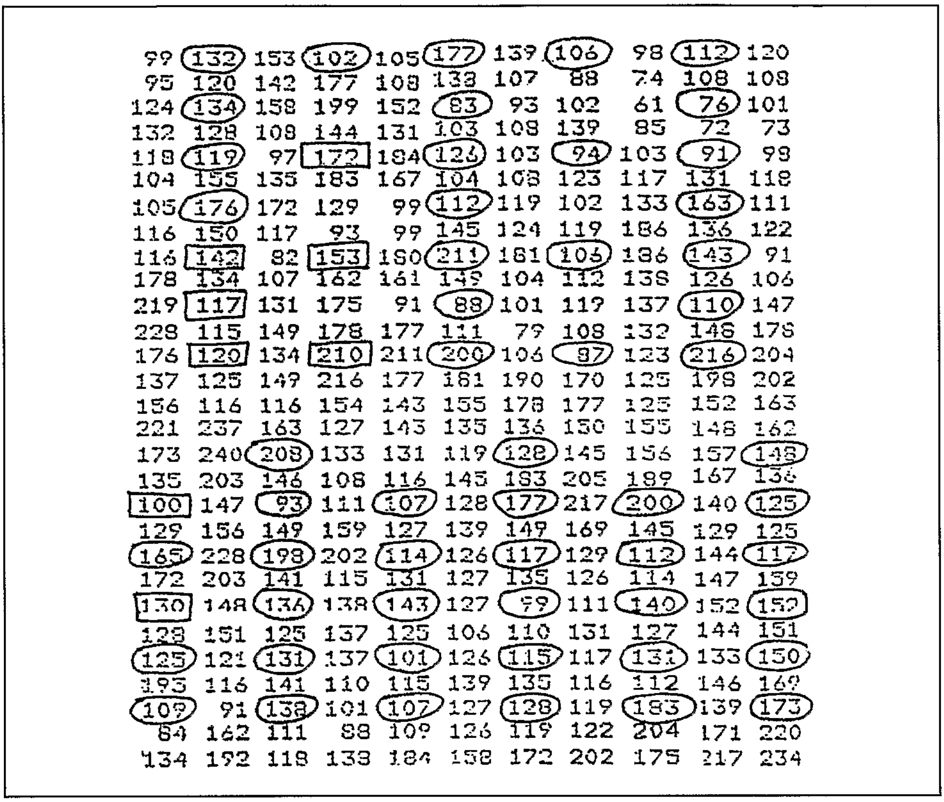

Figure 1. Tappan and Tappan-like soils : ⬭
Londo and Londo-like soils : ▭

The mean and standard deviation of adjusted values were then calculated for each soil series field by field. Avoca has the highest mean value (220) followed by decreasing order Guelph 219, Londo 163 and Tappan 112. This order of the reflectance mean values are well correlated to the soil drainage.

There are significant differences in the mean between soil series in the same complex and in the mean of the same soil series from one complex to another. The differences are accounted to the training stage. Selecting light and dark spots for each individual field, gives different reflectance mean values. To avoid that discrepancy, an alternative technique would have been to select absolute white and absolute black for all the complexes. The mean values of field 6A are lower than those of the others. The standard deviation of all fields are about the same. That suggests that field 6A was vegetated.

Table 2. Variation of soil series reflectance value. First column represents raw data and the second the adjusted values.

	Tappan		Londo	
151-155	1	1	1	1
156-160				
161-165	2			
166-170				
171-175	1		1	2
176-180	3			1
181-185	1			
186-190	1	1		
191-195				
196-200	3			
201-205				
206-210	1	1	1	1
211-215	1			
216-220	1			
Mean	122	112	143	163
Standard deviation	26	18	35	23

Range of reflectance for soil series

From the mean and standard deviation, a range of brightness values is defined for each soil series in each field (table 3). Soil being a continuum in these landscape, the ranges were expanded to fill slight gaps found between these ranges.

Table 3. Range of brightness values for soil series.

	Field number						
Soil series	1	2	2	4	5	6A	6B
Tappan	94-130 (<135)	72-96 (<99)	65-89 (<98)	175-195			
Londo	140-186 (>135)	102-140 (>99)		185-203	132-186 (<191)	116-150 (<150)	126-190 (<192)

Estimation of field composition

The densitometry values are applied to all cells contained in each field. The total number of cells per soil series was determined and then the composition of each soil complex was calculated. A cluster map was derived from that (Fig. 2).

The composition of the three complexes as determined by densitometry, field observations and the Tuscola County soil survey team (SCS) is given in table 4. For Tappan-Londo the slight difference between SCS densitometry and field observation is attributed to sampling method. This study was limited to two fields whereas SCS made observations in the entire map unit.

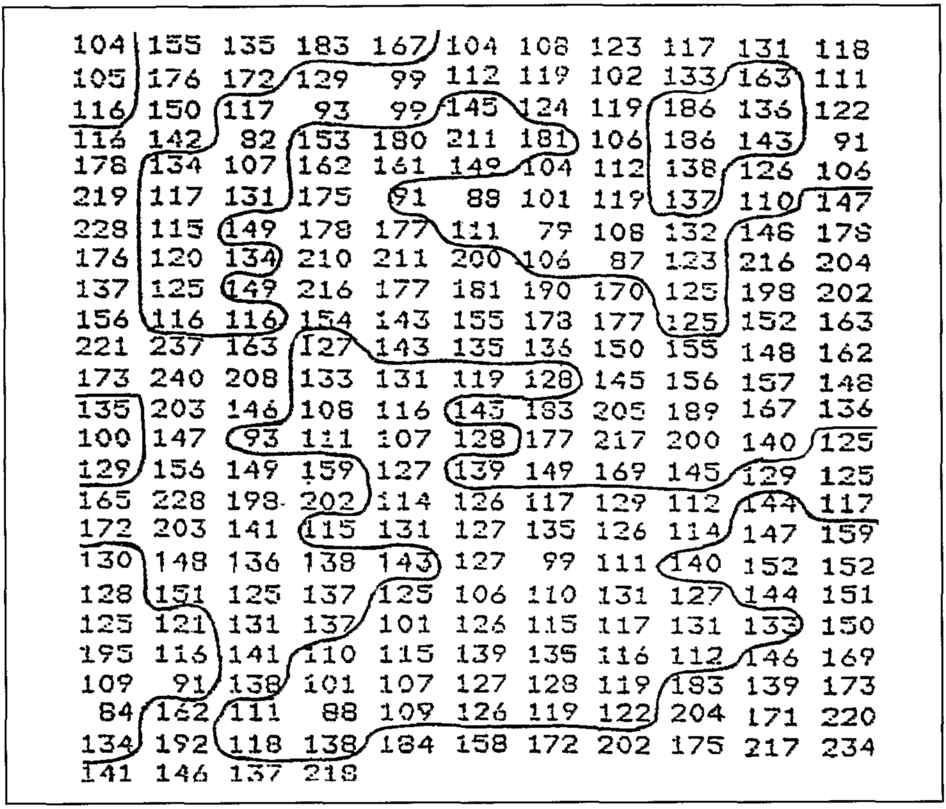

Figure 2. Tappan and Londo clusters in field 1 (Tappan < 135; Londo > 135).

For Guelph-Londo there is an agreement between ground collected data and SCS. On the other hand they are different from densitometry due to the dissimilarity of reflectance patterns between field 5 and 6B.

Table 4. Composition of the three complexes from densitometry, field observations and SCS.

Soil series	Composition (%)		
	Densitometry	Field	SCS
Tappan-Londo			
Tappan	52	55	60
Londo	48	42	40
Tappan-Avoca			
Tappan	36	37	65
Avoca	64	59	35
Londo		3	
Guelph-Londo			
Guelph	60	78	67
Londo	40	22	33

Conclusions

Bare soil is necessary when using electronic scanning densitometry to estimate map unit composition. The presence of vegetation reduces the difference in reflectance.

For bare soil field a distinct range of brightness values was round to separate soil series in the three complexes. The discrimination was related to the drainage characteristic of soil series.

The mean reflectance values of single soil series varies from one field to another, with no significant change in the value of the deviation.

The compositions of map unit from densitometry were similar to those from the field observations. That indicates densitometry can be used as a tool in map unit composition determination.