A PROPOSAL FOR THE CLASSIFICATION OF ANTHROPOGENIC SOILS[1]

B.A. Hartman, J.T. Ammons[2] and N.T. Hartgrove

Abstract. The unique properties of anthropogenic (disturbed) soils have generated a variety of views and proposed taxonomic systems to deal with identification, inventory, and interpretations of these soils. During the soil survey of Knox County, Tennessee, a special study was conducted on two anthropogenic soil profiles. After classifying the two profiles using the three taxonomic methods, it was recognized that no single taxonomic method seemed to be sufficient to properly classify these soils. It was found that current classification schemes for disturbed soils gave different results depending on the system. The objectives of this paper were to combine useable parts from various proposed disturbed soil taxonomy schemes and discuss the implications of a new system made up of combined parts of other proposed systems. *Soil Taxonomy*, anthropogenic soil classification according to Fanning and Fanning, and the proposal for Spolents developed at West Virginia University along with Official Series Descriptions were all evaluated. The result of the study was a new suborder, Anthrents, which could be added to the Entisol order and separated from the other suborders by having at least 3 of the 9 special criteria common to anthropogenic soils. Twenty anthropogenic soil profiles/series using *Soil Taxonomy*, the proposed Spolents, the method of Fanning and Fanning, and the proposed method of classification presented in this paper (Anthrents) were classified to the family level of classification and compared against each other. Using the newest system (proposed in this paper), 16 of the 20 soils were reclassified and the unique soil properties in these soils were readily identified. Amendments should be made to *Soil Taxonomy* to separate anthropogenic soils from other suborders and then structured to convey the unique properties associated with these soils.

Additional Key Words: disturbed soil classification, minesoils, and anthropogenic soils.

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Introduction

The classification and interpretation of anthropogenic soils has received very limited attention in past soil surveys conducted in the state of Tennessee. These soils have been trial mapped at the family level of proposed taxonomy (Ammons and Sencindiver, 1990), but they are generally classified using *Soil Taxonomy* to the subgroup level as Udorthents and are assumed to have properties similar to the in situ soils from which they are created. Most have been mapped as a minesoil series. Strict adherence to classification of anthropogenic soils using *Soil Taxonomy* can lead to misinterpretations in the genesis and does not convey important information about their management (Sencindiver and Ammons, 2000).

In his master's thesis, Hartman (2001), discovered that following the current Soil Taxonomy protocol led to soil taxon that were fairly in descript. Additionally, the author tried using the proposed revisions to *Soil Taxonomy* by Fanning and Fanning (1989) and the proposed Spolent amendment (Sencindiver, 1977; Smith and Sobek, 1978; Sencindiver and Ammons, 2000). Classifying these disturbed soils using all of these various systems were not satisfactory in Hartman's study (2001) in that the various taxon did not completely reveal the true nature and uniqueness of the disturbed soil and its landscape. The objectives of this paper were to combine useable parts from various proposed disturbed soil taxonomy proposals and discuss the implications of a new system made up of combined parts.

Materials and Methods

Using either of the proposed revisions to *Soil Taxonomy* of Fanning and Fanning (1989) or the Spolents amendment (Sencindiver, 1977; Smith and Sobek, 1978; Sencindiver and Ammons, 2000), it is possible to classify anthropogenic soils to a level that begins to reveal their true uniqueness as part of the landscape.

The taxonomic method of Fanning and Fanning (1989) proposed revisions to *Soil Taxonomy* to separate anthropogenic soils from Typic Udorthents subgroup using the unique properties of the anthropogenic soils (Table 1). They introduced new subgroups to the Udorthents for scalped land surfaces with or without lithic contact within 50-centimeters of the surface (Lithic Scalpic/Scalpic), fill materials with little or no manufactured inorganic artifacts (Spolic), and various urban fill materials containing inorganic artifacts (Urbic) and organic wastes of human activity (Garbic) (Sencindiver and Ammons, 2000).

Table 1. Criteria for Proposed Amendments to *Soil Taxonomy*. After Fanning and Fanning (1989).

Typic Udorthents are the Udorthents that:

a. Do not have a layer in the upper 75-cm that has a texture finer than loamy fine sand, that is as much as 18-cm thick, that has a bulk density in the fine earth fraction (at 33 kPa moisture tension) of 95 g/cc or less, and that has either (1) a ratio of measured clay to 1500 kPa water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 1500 kPa water more than 1.5 and more exchange acidity than the sum of the bases plus KCL-extractable aluminum;

b. Are not saturated with water for as long as 1 month within 1.5-m of the surface;

c. Do not have a lithic contact within 50-cm of the surface;

d. Do not have a layer of garbic materials as much as 25-cm thick between the bottom of an Ap horizon, or a depth of 25-cm, whichever is deeper, and a depth of 2-m (proposed);

e. Do not occur on a scalped land surface (proposed);

f. Do not have a layer of spolic materials as much as 25-cm thick between the bottom of an Ap horizon, or a depth of 25-cm, whichever is deeper, and a depth of 1-m in the absence of a layer of urbic materials as much as 25-cm thick in this depth range (proposed);

g. Do not have a layer of urbic materials as much as 25-cm thick between the bottom of an Ap horizon, or a depth of 25-cm, whichever is deeper, and a depth of 1-m (proposed);

h. Have < 50% by volume worm holes, wormcasts, and filled animal burrows between the bottom of the Ap horizon of a depth of 25-cm, whichever is deeper, and either a depth of 1-m or a lithic or paralithic contact if one is present above a depth of 1-m.

Andeptic Udorthents are like Typic Udorthents except for *a*.

Aquic Udorthents are like Typic Udorthents except for *b*.

Lithic Udorthents are like Typic Udorthents except for *c*, or for *c* and *h*, but without *e*.

Lithic Scalpic Udorthents are like Typic Udorthents except for *c* and *e*, with or without *b* (proposed).

Scaplic Udorthents are like Typic Udorthents except for *e* (proposed).

Spolic Udorthents are like Typic Udorthents except for *f*, with or without *b* (proposed).

Spolic Garbic Udorthents are like Typic Udorthents except for *f* and *d* with or without *b* (proposed).
Urbic Udorthents are like Typic Udorthents except for *g*, with or without *b* (proposed).

Classifying soils using the proposed Spolents amendments to *Soil Taxonomy* (Sencindiver, 1977; Smith and Sobek, 1978; Sencindiver and Ammons, 2000) begins with determining if the soil meets the criteria for the Spolents suborder. Sencindiver and Ammons list nine common properties of Spolents: 1) disordered rock fragments; 2) color mottling not associated with horizonization or redoximorphic features; 3) splintered or sharp edges on rock fragments; 4) bridging voids between rock fragments; 5) thin surface horizon generally higher in fines than any other horizon; 6) local pockets of dissimilar material but not parts of former diagnostic horizons; 7) artifacts; 8) carbolithic (black, high C) rock fragments; and 9) irregular distribution of oxidizable C with depth. Once the criteria for the Spolents suborder have been confirmed, the soil is classified to the great group level on the basis of the soil moisture regime. Subgroups of Udispolents are separated on the dominant lithology of the rock fragments present in the profile (Table 2).

Table 3. Proposed Minesoil Subgroups of Udispolents. After Sencindiver and Ammons (2000).

Subgroup modifier	Dominant lithology†
Carbolithic	Black, high C rock‡
Fissile	Thin-bedded shale
Kalkig	Limestone or calcareous mudstone
Matric	< 10% rock fragments
Plattic	Sandstone, predominantly low chroma (gray)
Pyrolithic	Burned carbolithic material‡
Regolithic Plattic	Sandstone, predominantly high chroma (brown)
Schlickig	Non-fissile mudstone
Typic	Mixture of Rock Types

† Unless otherwise noted, subgroups must have at least 10% rock fragments and dominant rock type must make up at least 65% of rock fragments.
‡ 50% or more rock fragments present.

In addition to the Knox County anthropogenic soil profiles (Hartman, 2001), Sencindiver and Ammons (2000) list thirty soil series that have been established for lands mined for coal and 4 additional series for lands disturbed for reasons other than coal mining. The official soil series descriptions were searched using the online Official Soil Series Descriptions. A further search was conducted using the same online information for the soil series characterization data. Of the thirty soils searched, eighteen soil series had sufficient characterization data available to classify the soils using the methods of Fanning and Fanning (1989), the Spolents amendment (Sencindiver, 1977; Smith and Sobek, 1978; Sencindiver and Ammons, 2000) and the proposed method by Hartman (2001). The official taxonomic classifications for the eighteen established soil series to the family level are used as a baseline for comparison with the other classification schemes. In some of the eighteen established soil series, the official soil series descriptions contained the additional classification of the series using the proposed Spolents amendment to *Soil Taxonomy* and are included without modification.

Results and Discussion

Study of the previous systems has led to a new system proposed by Hartman (2001) that combines the classification methods of *Soil Taxonomy* (1999) with the concepts of anthropogenic soil classification by Fanning and Fanning (1989) and the Spolents suborder (Sencindiver, 1977). Table 3 presents a scheme for a proposed Anthrents suborder.

Combining the proposed Spolents suborder (Sencindiver, 1977; Smith and Sobek, 1978; Sencindiver and Ammons, 2000) and the concepts of anthropogenic soil classification by Fanning and Fanning (1989) allows the separation of anthropogenic soils in the Entisol order at the suborder level. A name change in the suborder from Spolents (Sencindiver, 1977; Smith and Sobek, 1978; Sencindiver and Ammons, 2000) to Anthrents will allow the definition of a Spolic (Fanning and Fanning, 1989) subgroup without the appearance of redundancy. Using this new classification method proposed by Hartman (2001), classification as a Anthrent would require meeting a minimum of 3 of the 9 criteria common to anthropogenic soils, i.e. disordered coarse fragments, color mottling not associated with horizonization, frayed edges on coarse fragments, bridging voids, a thin surface horizon high in fines, local pockets of dissimilar material, artifacts, carbolithic coarse fragments, and an irregular distribution of oxidizable organic carbon (Sencindiver, 1977; Smith and Sobek, 1978; Sencindiver and Ammons, 2000).

The great group level is subdivided the same as the Orthents in *Soil Taxonomy* (1999) with great groups subdivided on soil moisture and temperature regimes. The great groups of Anthrents proposed are Cryoanthrents, Torrianthrents, Xeroanthrents, Ustanthrents, and Udianthrents.

At the subgroup level the Fanning and Fanning system given in Table 1 (1989) is used with some modification. From *Soil Taxonomy* (1999) the subgroups of Lithic and Vitrandic from the Udorthents great group are used without modification in the criteria for qualification for these subgroups. Additional subgroups from the work and recommendations of Fanning and Fanning

(1989) of Urbic, Garbic, Spolic, Urbic Garbic, Urbic Spolic, Spolic Garbic, Lithic Scalpic, Scalpic, and Dredgic are included into the subgroups of Anthrents. The Typic subgroup would include those Anthrents that are a mixture of one or all the previously listed subgroups but do not meet the criteria for the specific subgroup.

At the family level of classification, a coarse fragment lithology class has been added for the Anthrents suborder (Table 3). This coarse fragment lithology class is based on the proposed subgroups of Udispolents derived through the work of Sencindiver, 1977; Smith and Sobek, 1978; and Sencindiver and Ammons, 2000. Criteria for the coarse fragment modifier would be the same as given in Table 2 with the change of the Typic to Petric for a mixture of rock types. Each of the twenty soils was then classified to the family level using the system of Fanning and Fanning (1989), the proposed Spolents amendment to *Soil Taxonomy* (Sencindiver, 1977; Smith and Sobek, 1978; Sencindiver and Ammons, 2000), and the method of Hartman (2001).

Of the twenty soils examined, twelve of the soils were changed from their original taxonomic classification at the family level using the method of Fanning and Fanning (1989). Table 4 shows a comparison between the official soil series description at the family level and the subgroup classification of the soils based of the method of Fanning and Fanning (1989). Of the eight unchanged soil series/profiles, two are Inceptisols, one is an Ustorthent and the remaining five are Anthrents. Because the method of Fanning and Fanning separates anthropogenic soils from Typic Udorthents, the unchanged classification of soils is to be expected. However, the method did not recognize eight known anthropogenic soils, four with fill origins and four with mine origins.

Using the proposed Spolents amendment to Soil Taxonomy (Sencindiver, 1977; Smith and Sobek, 1978; Sencindiver and Ammons, 2000) thirteen of the soil classifications at the subgroup level were changed (Table 5). The remaining seven soil series did not contain 3 of the 9 criteria common to Spolents, or were Inceptisols and were therefore not recognized by the method. Of the seven unrecognized series, three had mine origins, one had a fill/waste origin, and three had fill origins. In comparison to the methods of Fanning and Fanning and the proposed Spolents amendment, using this new proposed classification (Hartman, 2001), sixteen of the soil classifications were changed from the classification obtained strictly using *Soil Taxonomy* (Table 6). Since this new proposed method is based as the other two on the concept of separating anthropogenic soils at the Entisol order, it failed to identify two Inceptisols with fill origins, and two Entisols (one fill, one minesoil) that did not have 3 of the 9 criteria necessary to be classified as an Anthrent.

Table 3. Classification Scheme for the proposed Anthrents Suborder. After Hartman (2001).

Order – Entisols

Suborder – Anthrents

- Anthrents are soils that must contain a minimum of 3 of the following criteria:

1. Bridging voids.
2. Disordered coarse fragments.
3. Color mottling not associated with redox or horizonization.
4. Frayed edges on coarse fragments.
5. Thin surface horizon higher in fines than any underlying horizon.
6. Local pockets of dissimilar material.
7. Artifacts, i.e., woody debris, glass, brick, etc..
8. Carbolithic coarse fragments.
9. Irregular distribution of oxidizable organic carbon.

Great Groups – Cryanthrents, Torrianthrents, Xeranthrents, Ustanthrents, and Udianthrents.

Subgroups – example Udianthrents

- Lithic
- Vitrandic
- Urbic
- Garbic
- Spolic
- Urbic Garbic
- Urbic Spolic
- Spolic Garbic
- Lithic Scalpic
- Scalpic
- Dredgic
- Typic

Family – addition of a coarse fragment lithology class

- Carbolithic
- Fissile
- Kalkig
- Matric
- Plattic
- Pyrolithic
- Regolithic Plattic
- Schlickig
- PetricSoil Characterization

Table 4. Comparison of Soil Series Name, Origin, *Soil Taxonomy*, and Classification of Fanning and Fanning.

Soil Series/Name	Origin	Soil Taxonomy	Fanning & Fanning
BETHESDA	mine	Loamy-skeletal, mixed, active, acid, mesic Typic Udorthents	Spolic Udorthents
BIGBROWN	mine	Fine-silty, mixed, non-acid, thermic Typic Ustorthents	No Change from Soil Taxonomy
BRAZILTON	mine	Fine, mixed, nonacid, thermic Mollic Udarents	No Change from Soil Taxonomy
CANARSIE	fill	Coarse-loamy, mixed, nonacid, mesic Typic Udorthents	Spolic Udorthents
CENTRALPARK	fill	Loamy-skeletal, mixed, active, mesic Typic Dystrudepts	No Change from Soil Taxonomy
CEDARCREEK	mine	Loamy-skeletal, mixed, active, acid, mesic Typic Udorthents	Spolic Udorthents
FAIRPOINT	mine	Loamy-skeletal, mixed, active, nonacid, mesic Typic Udorthents	Spolic Udorthents
FIVEBLOCK	mine	Loamy-skeletal, mixed, semiactive, nonacid, mesic, Typic Udorthents	Spolic Udorthents
FORESTHILLS	fill	Coarse-loamy, mixed, active, mesic Typic Dystrudepts	No Change from Soil Taxonomy
GRAYROCK	mine	Fine-silty, mixed, active, nonacid, thermic Typic Udorthents	Spolic Udorthents
GREATKILLS	fill/waste	Loamy-skeletal, mixed, active, nonacid, hyperthermic Typic Udorthents	Urbic Garbic Udorthents
ITMANN	mine	Loamy-skeletal, mixed, semiactive, acid, mesic Typic Udorthents	Spolic Udorthents
JANELEW	mine	Loamy-skeletal, mixed, calcareous, mesic Typic Udorthents	Spolic Udorthents
KAYMINE	mine	Loamy-skeletal, mixed, active, nonacid, mesic Typic Udorthents	Spolic Udorthents
LENZBURG	mine	Fine-loamy, mixed, active, calcareous, mesic Haplic Udarents	No Change from Soil Taxonomy
RAPATEE	mine	Fine-silty, mixed, superactive, nonacid, mesic Mollic Udarents	No Change from Soil Taxonomy
SCHULINE	mine	Fine-loamy, mixed, superactive, calcareous, mesic Alfic Udarents	No Change from Soil Taxonomy
SEWELL	mine	Loamy-skeletal, mixed, semiactive, acid, mesic Typic Udorthents	Spolic Udorthents
KNOX Co., TN 1	fill	Fine, mixed, semiactive, acid, thermic, Typic Udorthents	Spolic Udorthents
KNOX Co., TN 2	fill	Fine-loamy, mixed, semiactive, nonacid, thermic Haplic Udarents	No Change from Soil Taxonomy

Table 5. Comparison of Soil Series Name, Origin, *Soil Taxonomy*, and Classification by the Spolents amendment.

Soil Series/Name	Origin	Soil Taxonomy	Spolents
BETHESDA	mine	Loamy-skeletal, mixed, active, acid, mesic Typic Udorthents	Fissile Udispolents
BIGBROWN	mine	Fine-silty, mixed, non-acid, thermic Typic Ustorthents	No Change from Soil Taxonomy
BRAZILTON	mine	Fine, mixed, nonacid, thermic Mollic Udarents	No Change from Soil Taxonomy
CANARSIE	fill	Coarse-loamy, mixed, nonacid, mesic Typic Udorthents	No Change from Soil Taxonomy
CENTRALPARK	fill	Loamy-skeletal, mixed, active, mesic Typic Dystrudepts	No Change from Soil Taxonomy
CEDARCREEK	mine	Loamy-skeletal, mixed, active, acid, mesic Typic Udorthents	Plattic Udispolents
FAIRPOINT	mine	Loamy-skeletal, mixed, active, nonacid, mesic Typic Udorthents	Regolithic Plattic Udispolents
FIVEBLOCK	mine	Loamy-skeletal, mixed, semiactive, nonacid, mesic, Typic Udorthents	Regolithic Plattic Udispolents
FORESTHILLS	fill	Coarse-loamy, mixed, active, mesic Typic Dystrudepts	No Change from Soil Taxonomy
GRAYROCK	mine	Fine-silty, mixed, active, nonacid, thermic Typic Udorthents	Typic Udispolents
GREATKILLS	fill/waste	Loamy-skeletal, mixed, active, nonacid, hyperthermic Typic Udorthents	No Change from Soil Taxonomy
ITMANN	mine	Loamy-skeletal, mixed, semiactive, acid, mesic Typic Udorthents	Carbolithic Udispolents
JANELEW	mine	Loamy-skeletal, mixed, calcareous, mesic Typic Udorthents	Schicklig Udispolents
KAYMINE	mine	Loamy-skeletal, mixed, active, nonacid, mesic Typic Udorthents	Schicklig Udispolents
LENZBURG	mine	Fine-loamy, mixed, active, calcareous, mesic Haplic Udarents	Typic Udispolents
RAPATEE	mine	Fine-silty, mixed, superactive, nonacid, mesic Mollic Udarents	No Change from Soil Taxonomy
SCHULINE	mine	Fine-loamy, mixed, superactive, calcareous, mesic Alfic Udarents	Matric Udispolents
SEWELL	mine	Loamy-skeletal, mixed, semiactive, acid, mesic Typic Udorthents	Regolithic Plattic Udispolents
KNOX Co., TN 1	fill	Fine, mixed, semiactive, acid, thermic, Typic Udorthents	Matric Udispolents
KNOX Co., TN 2	fill	Fine-loamy, mixed, semiactive, nonacid, thermic Haplic Udarents	Fissile Udispolents

Table 6. Comparison of Soil Series Name, Origin, *Soil Taxonomy*, and Classification by the method of Hartman (2001).

Soil Series/Name	Origin	Soil Taxonomy	Hartman 2001
BETHESDA	mine	Loamy-skeletal, mixed, active, acid, mesic Typic Udorthents	Fissile Spolic Udianthrents
BIGBROWN	mine	Fine-silty, mixed, non-acid, thermic Typic Ustorthents	Fissile Spolic Ustorthents
BRAZILTON	mine	Fine, mixed, nonacid, thermic Mollic Udarents	Fissile Spolic Udianthrents
CANARSIE	fill	Coarse-loamy, mixed, nonacid, mesic Typic Udorthents	No Change from Soil Taxonomy
CENTRALPARK	fill	Loamy-skeletal, mixed, active, mesic Typic Dystrudepts	No Change from Soil Taxonomy
CEDARCREEK	mine	Loamy-skeletal, mixed, active, acid, mesic Typic Udorthents	Plattic Spolic Udianthrents
FAIRPOINT	mine	Loamy-skeletal, mixed, active, nonacid, mesic Typic Udorthents	Regolithic Plattic Spolic Udianthrents
FIVEBLOCK	mine	Loamy-skeletal, mixed, semiactive, nonacid, mesic, Typic Udorthents	Regolithic Plattic Spolic Udianthrents
FORESTHILLS	fill	Coarse-loamy, mixed, active, mesic Typic Dystrudepts	No Change from Soil Taxonomy
GRAYROCK	mine	Fine-silty, mixed, active, nonacid, thermic Typic Udorthents	Typic Spolic Udianthrents
GREATKILLS	fill/waste	Loamy-skeletal, mixed, active, nonacid, hyperthermic Typic Udorthents	Petric Urbic Garbic Udianthrents
ITMANN	mine	Loamy-skeletal, mixed, semiactive, acid, mesic Typic Udorthents	Carbolithic Spolic Udianthrents
JANELEW	mine	Loamy-skeletal, mixed, calcareous, mesic Typic Udorthents	Schicklig Spolic Udianthrents
KAYMINE	mine	Loamy-skeletal, mixed, active, nonacid, mesic Typic Udorthents	Schicklig Spolic Udianthrents
LENZBURG	mine	Fine-loamy, mixed, active, calcareous, mesic Haplic Udarents	Typic Spolic Udianthrents
RAPATEE	mine	Fine-silty, mixed, superactive, nonacid, mesic Mollic Udarents	No Change from Soil Taxonomy
SCHULINE	mine	Fine-loamy, mixed, superactive, calcareous, mesic Alfic Udarents	Matric Spolic Udianthrents
SEWELL	mine	Loamy-skeletal, mixed, semiactive, acid, mesic Typic Udorthents	Regolithic Plattic Spolic Udianthrents
KNOX Co., TN 1	fill	Fine, mixed, semiactive, acid, thermic, Typic Udorthents	Matric Spolic Udianthrents
KNOX Co., TN 2	fill	Fine-loamy, mixed, semiactive, nonacid, thermic Haplic Udarents	Fissile Spolic Udianthrents

Summary

Based on the discussion in this paper, anthropogenic soils should be included in the Entisols order. The central concept of Entisols is those soils with little or no pedogenic development

(Soil Survey Staff, 1999). Anthropogenic soils are Entisols in the fact that when they are re-deposited from an in situ soil and/or other parent material the pedogenic clock is reset to time zero. Any horizonization and diagnostic features present are due to man's influence on how the materials are placed and compacted in the process of creating the anthropogenic soil.

With the data used in this research, it has also been shown that anthropogenic properties are also found as Inceptisols. Common knowledge supports that man has had an impact on the soil all over the globe by mining, excavations and fills, and landfills. Therefore, it can be argued that anthropogenic properties can potentially occur in all soil orders and should not be restricted to Entisols.

Using a combination of these classification systems will allow a broader range of soils to be mapped and inventoried and show the true uniqueness of the disturbed soil as part of the landscape. The authors believe that the best of the past research efforts are brought out in this proposal that it combines the more prominent research efforts from the past. Much of our research interest has been concentrated on minesoils due to large continuous acreages of disturbed soil created by mining activities. This system will allow a broader application of the properties identified in anthropogenic soils to be used in further inventory of such soils, even those with limited acreage.

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