USE OF LAND CAPABILITY CLASSIFICATION SYSTEM IN THE SURFACE MINING CONTROL AND RECLAMATION ACT OF 1977 (PUBLIC LAW 95-87) [1]

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Abstract. The Surface Mining Control and Reclamation Act of 1977 (Public Law 95-87) authorized the Secretary of the Interior to implement a regulatory program to reduce the environmental impacts of coal mining operations. The Secretary of Interior administers this program through the Office of Surface Mining Reclamation and Enforcement (OSM) with assistance from state and other federal agencies as specified in the law. All functions and responsibilities assigned to USDA by Public Law 95-87 were delegated by the Secretary of Agriculture to the Chief of USDA-NRCS, except those that relate to the National Forest Service System Lands and to the USDA-Agriculture Research Service. This paper briefly presents how the Land Capability Classification System can be used in the development of rules, regulations, and guidelines for evaluating the quality of soil reclamation after surface mining for coal. The Land Capability Classification System can provide for compliance with Public Law 95-87. The land capability of the reclaimed soils can be compared to the capability of the pre-mined soils for producing crops.

Additional Key Words: farmland, grandfathering, historically used for cropland, Land Capability Class, Land Capability Subclass, Land Capability Unit, Soil Map Unit, soil component.

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Introduction

The Surface Mining Control and Reclamation Act of 1977 (P. L. 95-87) authorized the Secretary of the Interior to implement a regulatory program to reduce the environmental impacts of mining operations. The Secretary of Interior administers this program through the Office of Surface Mining Reclamation and Enforcement (OSM) with assistance from state and other federal agencies as specified in the law. All functions and responsibilities assigned to USDA by P. L. 95-87 were delegated by the Secretary of Agriculture to the Chief of USDA-NRCS, except those that relate to the National Forest Service System Lands and to the USDA-Agriculture Research Service (USDA-SCS, 1983a). Title V of P. L. 95-87 addresses land areas that have not been surface mined for coal. It describes the reconstruction of a mined soil to recreate soil conditions prior to mining, and bases the success of reclamation upon the soil's pre-mined productivity (30CFR., 2002). The NRCS participates with the State Regulatory Authority (SRA) on answering technical soil questions during the removal, storage, and reclamation of prime farmland historically used as cropland (30 CFR, 2002; USDA-SCS, 1983b; Sinclair, 2004). USDA-NRCS (1999) addresses the activities and conditions requiring specific attention for soil manipulations associated with reclamation of prime farmland. NRCS assists the SRA and mine operators in identifying prime farmland and restoring its productivity after mining (30 CFR, 2002a and b). These activities are in cooperation with SRA and with the assistance of other USDA agencies.

Figure 1 shows the sampling sites used in a study (Sinclair et al., 2004 and 2005) comparing pre- and post-mining land capability classes for several soils in Indiana. Scraper placement was used to reclaim all sites except at the Daviess/001 site, where shovel-truck placement was used during reclamation. The number of years since reclamation is presented in Table 1.

Table 1.The number of years the sites had been reclaimed.

County/Soil	Years Reclaimed
Daviess/001	14
Daviess/002	6
Greene/015	16
Greene/025	17
Pike/001	12
Pike/002	10
Warrick/001	15
Warrick/002	13

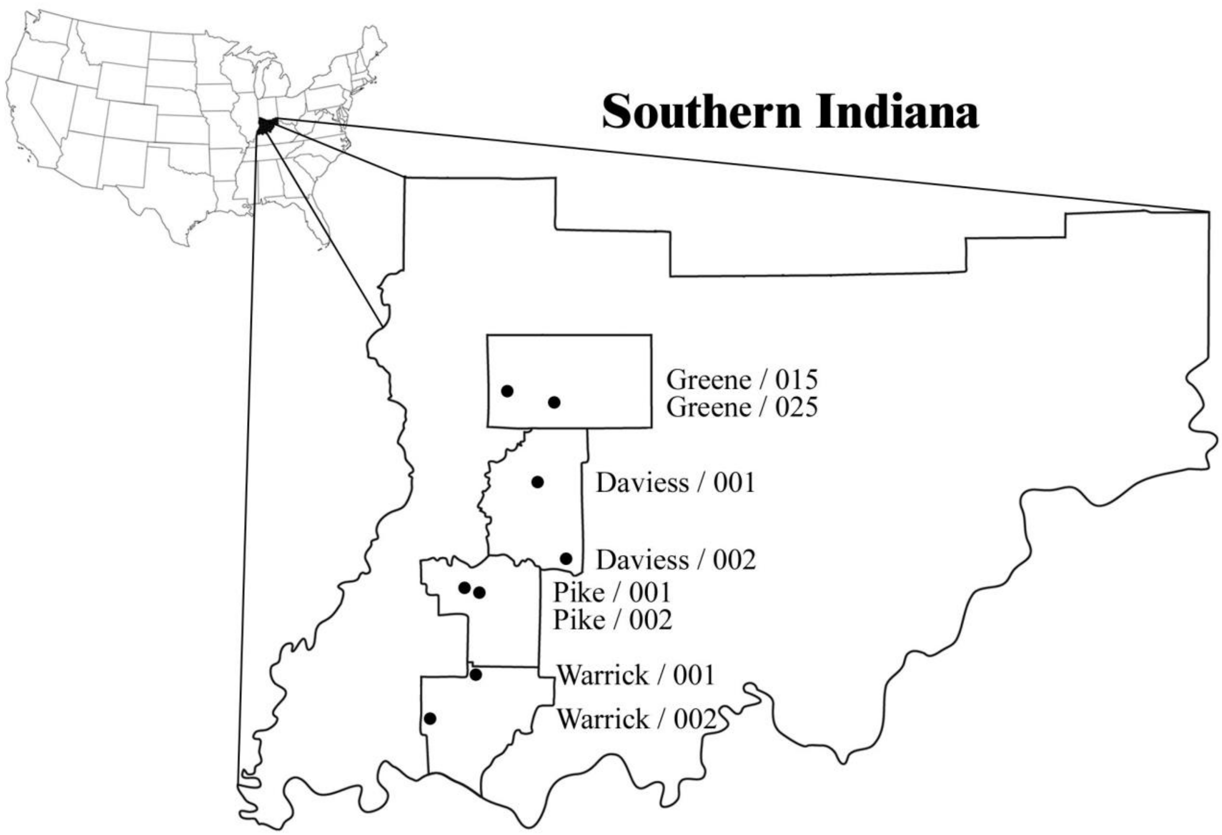

Figure 1. Sampling Sites in Southwestern Indiana.

Land Capability Classification

The Land Capability Classification System is one of many interpretative groupings made for agricultural purposes (Helms, 1977; Hockensmith and Steele, 1943; Klingebiel, 1958; 1963; Neitsch et al., 1997; Klingebiel and Montgomery, 1961; SCS, 1945, 1963; Soil Survey Staff, 1958, 1959). The Soil Conservation Service (SCS) created the Land Capability Classification system (Helms, 1977) during the late 1930's and early 1940's. Some form or adaptation of Land Capability Classification is used throughout the world (Olson, 1974; McCormack et al., 1979; FAO, 1996, 1999). Scientists are continually refining and improving land classification systems (Eswaran et al., 2000; Fischer et al., 2000; Omernik, 1995). As with all interpretative groupings, the land capability classification, at least in the United States, begins with soil components of soil map units (Kellogg, 1951, 1955). Each soil component has a particular set of soil characteristics (chemical and physical soil properties, climate, and landscape features) that make it uniquely different from all other soil components.

The Land Capability Classification consists of soil components, soil map units, land capability classes (LCC), land capability subclasses (LCS), and land capability units (LCU), (Klingebiel and Montgomery, 1961; Soil Survey Staff, 1958). A soil map unit contains one or more soil components (typically soil series) with soil properties that are defined by precise definitions and may or may not have miscellaneous land types, e.g., rock outcrops (USDA-SCS, 1951, 1993). A soil map unit is a portion of the landscape identified as having similar characteristics and qualities. The LCC are groups of soil map units with the same relative degrees of hazards or limitations, based on their soil characteristics, for cropland and pasture uses.

The LCS are groups of LCC's that have the same major conservation problem, e.g., "e" for erosion, "w" for excess water, "s" for root-zone limitations, and "c" for climatic limitations. An LCU is a grouping of one or more LCS's that have similar potentials and continuing limitations or hazards (Soil Survey Staff, 1959). The soil map units in an LCU are sufficiently uniform to (1) produce similar kinds of cultivated crops and pasture plants with similar management practices, (2) require similar conservation treatment and management under the same kind and condition of vegetative cover, and (3) have comparable potential productivity. Odell (1950) explains how the productivity of soils is measured under various environmental conditions. In addition Land Capability Classification has uses other than for agriculture including land use planning and national soil/land inventories (Hockensmith, 1948, 1949; Kellogg, 1968; Klingebiel, 1967; SCS, 1945; Smith, 1983; USDA, 1965 and 2000; USDA-NRCS, 1997).

The land capability classification system (LCC, LCS, and LCU) can be used in the development of guidelines, particularly for the information shown in table 2, for evaluating the quality of soil reclamation after surface mining for coal. This information can help meet the compliance rules and regulations contained in P. L. 95-87 and 30 CFR. The land capability of the reclaimed soils can be compared to the capability of the pre-mined soils. This will test the ability of the reclaimed soils to produce crops relative to the original soil. The remainder of this paper will focus on using LCC to reconstruct a soil so it will meet the requirement in 30 CFR for productivity thus resulting in bond release.

Land Capability Classification and the Surface Mining Control and Reclamation Act

Table 2 lists the soil characteristics and their text criteria and numerical values that are used to assign LCC. The major difference in LCC for pre-mined and reclaimed soils (table 3) was always a result of changes in soil available water capacity (AWC). The importance of AWC in pre-mined and mined soils are discussed by Doll et al., 1984; Merrill et al.,1985, 1998, 2004; Omodt, 1975; Suhl, 2003; Soil Survey Division Staff, 1993; Sencindiver and Ammons, 2000; Fehrenbacher and Snider, 1954; Fehrenbacher and Rust, 1956; Fehrenbacher et al., 1960 and 1967; and Scrivner et al., 1985. Dunker and Barnhisel, 2000 cited McFee et al., 1981 – *"Electrical conductance and water storage capacity were most significantly related to growth and toxic levels of B, Fe, Mn, and Al decreased growth on some materials."* The AWC is the volume of water that should be available to plants if the soil, inclusive of rock fragments, were at field capacity. Field capacity is the amount of water a soil can hold after water has drained by gravity from the large pores. Reductions in AWC are made in the water difference for incomplete root utilization of the total soil volume. Fragipans, bulk density, soil strength, extremely low pH values, high water tables, and other chemical and physical properties can restrict plant rooting and rooting distribution throughout the soil mass. These soil features are either used in calculation of AWC or are surrogates to estimate the AWC for both pre-mined and reclaimed soils. These surrogate properties are important as indicators of plant rooting and AWC of which soil bulk density and soil strength are very important in determining plant rooting and AWC. The amount of available water is measured to the expected maximum depth of root penetration, commonly either 1 or 1.5 m, or a physical or chemical root limitation, whichever is shallower (Soil Survey Division Staff, 1993).

Table 2. Guide for Classifying Soils into Land Capability Classes.

	Land Capability Class - Degree of Limitations, Restrictions, or Hazards							
Soil Properties	I	II	III	IV	V	VI	VII	VIII
Minimum depth to lithic or paralithic (cm)	100	50	50	25	100	50	25	<25
Reaction (pH)	Favorable: easy to modify		Unfavorable: high lime or difficult to modify	Unfavorable: very difficult to modify	Not generally class-determining			Cat clays; unfavorable reaction; impractical to modify
Surface Texture	sl, fsl, vfsl, l, sil, scl, cl, sicl, (non arenic - ls, lfs, fs)	ls, lfs, fs, sic, sc, c (<60% clay) muck, mucky peat	c (≥ 60% clay)	cs	Same criteria as class I	Same criteria as class II	Same criteria as class III	Not class determining
Available Water Capacity (cm)	>22.5	>15-≤ 22.5	>7.5-≤ 15	≤ 7.5	Same criteria as class I	Same criteria as class II	Same criteria as class III	Not class determining
Permeability (water and air)	Moderately slow to moderately rapid	Slow or rapid	Very slow or very rapid	Not class detering	Same criteria as class I	Same criteria as class II	Same criteria as class III	Not class determining
Wetness (drainage class)	Well or moderately well	Moderately well or somewhat poor	Somewhat poor or poor	Poor	Not class determining			
Water table during the growing season (minimum depth in cm)	120 - Does not interfere with crop production	75 - Delays planting or harvesting	45 - Crop selection moderately affected	30 - Crop selection severely affected	Ponding to ≥ 120. Class I after drainage	<30 - Ponding. Class II or III after drainage	<30 - Ponding. Class IV after drainage	<30 - Ponding. Cannot be drained

Table 2. Guide for Classifying Soils into Land Capability Classes (continued).

	Land Capability Class - Degree of Limitations, Restrictions, or Hazards							
Soil Properties	I	II	III	IV	V	VI	VII	VIII
Flooding (overflow)					Frequent - Prevents normal production of crops			
	None during growing season. Crop selection not restricted	Rare-Occasional. Slight crop damage. O to <20% yield reduction or crop selection slightly affected	Occasional. Moderate crop damage. ≥ 20-<35% yield reduction or crop selection moderately affected	Frequent. Severe crop damage. ≥ 35-50% yield reduction or crop selection severely affected	Class I if overcome and protected from flooding	Class II and III if overcome	Class IV if overcome	Tidal Flats
Salinity (mmhos/cmin upper 100 cm)	<2	≥ 2-≤ 4	>4-≤ 8	>8-≤ 16	<2	>16-≤ 30	>30-≤ 40	>40
Sodicity (SAR in upper 100 cm)	<2	<12	<12	<12	<2	<26	≥ 26	Alkali flats
Stones or boulders only on surface	<0.1%	≥ 0.1-<3.0%	≥ 3.0-<15.0%	≥ 3.0-<15.0%	≥ 0.1%	≥ 15.0-<50.0%	≥ 50.0-<90.0%	≥ 90.0%
All rock fragments (surface and control section)	<15%	≥ 15-<35%	≥ 35-<60%	≥ 35-<60%	≥ 15%	Not class determining		
Rock outcrop	<0.1%	≥ 0.1-<2.0%	≥ 2-<10%	≥ 2-<10%	<0.1%	≥ 10-<50%	≥ 50-<90%	≥ 90%
Frost free days	>140	>100-≤ 140	>70-≤ 100	50-≤ 70	Not class determining			
Precipitation Effectiveness (mm)	≥ 1100	≥ 780-<1100	≥ 630-<780	≥ 480-<630	Not class determining	≥ 250-<480	<250	Not class determining
Cumulative days dry in moisture control section	<135 - Udic or Udic Ustic	≥ 135-<180 - Typic Ustic	≥ 180-<220 - Ardic Ustic	≥ 180-<220 - Aridic Ustic	Not class determining	≥ 220-<270 Ustic Ardic	≥ 270 Typic Aridic	≥ 270
Maximum slope: K factor of >32	2	5	8	12	2	25	Not class determining	
Maximum slope: K factor of ≥ 20-≤ 32	3	6	12	18	3	25	Not class determining	
Maximum slope: K factor of <20	4	8	15	25	4	35	Not class determining	
Erosion hazard	None-slight	Moderate	Severe	Very severe	None-slight	Not class determining		

The field and laboratory data reported by Sinclair et al. (2004b, 2005) support that all reclaimed soils in this study had less AWC for plant growth than the soils before mining except for one site (Warrick 002 site). The other soil characteristics listed in Table 2 except AWC supported the LCC in Table 3 (Sinclair et al., 2004b and Sinclair, 2005). To be more specific, the reclaimed soils would all be LCC of I or II if the AWC in the reclaimed soils were higher. A higher AWC would result from a favorable change in bulk density, soil strength, permeability, and structure for growing commodity crops. High bulk density, high soil strength, low permeability, and lack of structure (massive, non granular and non blocky) limit the rooting depth in the reclaimed soils, therefore reducing AWC (O'Neal, 1952; Uhland and O'Neal, 1951; Schoeneberger et al., 2002; Sinclair et al., 2004b, 2005). High bulk densities and soil strength are the major physical soil properties that restrict plant rooting depth and rooting distribution throughout the soil mass, thus reducing the available water capacity to plants (Dunker and Barnhisel, 2000).

Land Capability Classes I, II, and III are considered suitable for cropland and class IV is hayland. LCC of V, VI, VII, and VIII are not considered arable, but can be used for permanent vegetation unless it is a miscellaneous land type. The changes in the land capability classes in Table 3 are due to lower AWC in the reclaimed soils compared to the pre-mined soils. This lower AWC in the reclaimed soils would indicate that the reclaimed soils probably would have lower long-term average yields than the pre-mined soils. Crop production as a measure of prime farmland reclamation success is explained in 30CFR., 2002. Olson (1992) explains the difference in methods and procedures used in the 1977 Surface Mining Control and Reclamation Act and those used by the University of Illinois to determine long term crop yields.

Comments and Conclusion

The Land Capability Classification is one of many interpretative groupings that can be used to evaluate arable and non arable lands for limitations or hazards for producing commodity crops using soil characteristics. The Land Capability Classification can be used to compare the reclaimed soils after surface mining for coal to their pre-mimed condition. The classification system involves soil components, soil map units, land capability classes (LCC), land capability subclasses (LCS), and land capability unit (LCU).

Lack of soil structure (massive or single grained), high bulk density, high soil strength, and slow permeability in subsurface layers limit rooting, thus resulting in lower soil AWC's for the reclaimed soils compared to the pre-mined soil condition. Four of the soils before mining had a LCC of II and after reclamation had a LCC of IV. Three of the soils before mining had a LCC of I or II and after reclamation had a LCC of III. One of the soils had the same LCC before and after mining.

The reclamation process used to reconstruct soils after surface mining for coal is continuingly changing. Reclamation using scraper placement after surface mining for coal is becoming a thing of the past as the more progressive mining companies are using shovel-truck replacement of soil (discussions with other people and personal experiences/observations by author).

The partnership among the coal companies, USDI's Office of Surface Mining, State Regulatory Authority, researchers, and NRCS is improving reclamation technology. The new reclamation technologies being used today by the coal companies to reclaim prime farmland soils will need to be evaluated by studying their morphological properties and sampling them for laboratory characterization (experiences and observations by author).

Table 3. Land capability classes (LCC) assigned by Available Water Capacity (AWC) for reclaimed soils and pre-mined soils (Sinclair et al., 2004b).

County / Soil	AWC of Reclaimed Soils cm	Reclaimed LCC	Pre-mined LCC
Daviess/001	10.9	III	I
Daviess/002	10.6	III	II
Greene/015	6	IV	II
Greene/025	6.8	IV	II
Pike/001	3.4	IV	II
Pike/002	9.9	III	II
Warrick/001	6.6	IV	II
Warrick/002	16.8	II	II

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