Pedogenesis Over 40 Years in a Southern Georgia, USA Borrow Pit

Eric C. Brevik, Department of Natural Sciences, Dickinson State University, Dickinson, ND 58601

Introduction

- Soil formation was studied in a borrow pit abandoned for approximately 40 years
- No efforts were made at reclamation, the pit was allowed to revegetate naturally

Materials and Methods

- The pit divided into 3 disturbed zones based on vegetation (lower pit, sparsely vegetated area, and grassy area) and a natural control (control) (Figure 1)
- Soil samples collected using bucket auger or shovel, soil morphology described
- Monitoring wells installed at each of 3 sites in pit, monitored at least once every 2 weeks
- Particle size and pH analysis conducted
- Vegetative cover analyzed using historical air photos and Arcview 3.2
- Bulk density samples of known volume were collected and analyzed
- Total C was analyzed with a Perkin-Elmer 2400 CHNS
- Penetration resistance was measured using a Jornada Impact Penetrometer
- Leaf litter was collected for a one-year period at four locations in each of the four areas of the pit
- A detailed topographic map of the pit was made using a Sokkia laser-based total station
- The pit was dated using Georgia Department of Transportation records

Results

- New soil formation was consistently deeper in the pit bottom and grassy areas with colors attributed to organic materials (5 YR 2/1, 10 YR 4/2) and a stronger grade of soil structure found at greater depths than in the sparsely vegetated area. All three areas investigated within the pit showed much less soil development than was seen in the control area (Table 1).
- Depth to water varied considerably between areas in and around the pit (Figure 2).
- Bulk density values were highest in the sparsely vegetated area (Table 2).
- C content varied considerably by zone and by depth (Figure 3).
- The natural area had the lowest penetration resistance followed by the pit bottom, grassy area, and the sparsely vegetated area (Table 3).
- Leaf litter collections showed that above ground litter additions in the control, pit bottom, and grassy areas were similar, with mean values of between about 400-450 g m^{-2} yr^{-1}, while litter additions in the sparsely vegetated area were significantly less at around 30 g m^{-2} yr^{-1} (Table 4).
- Historical aerial photographs show that the pit went through a period of rapid revegetation in the first roughly 14 years following its abandonment, followed by a continued increase in vegetative cover but at progressively slower rates as time passed (Figure 4).

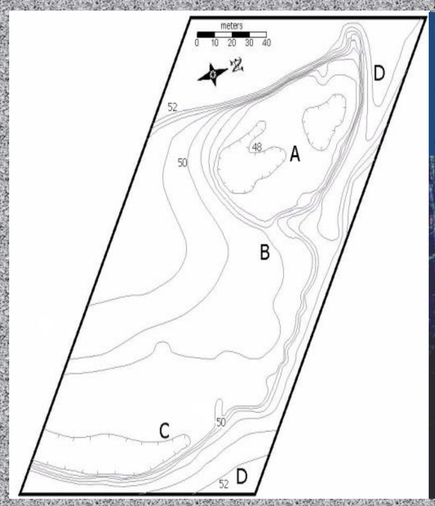
Conclusions

- Pedogenesis can be expected to continue within the borrow pit for several hundred years beyond the 40 years that have already passed.
- Pedogenesis is taking place at a slower rate in the sparsely vegetated portion of the borrow pit. This is attributed to a lack of vegetative growth and the associated reductions in organic carbon additions, which are most likely due to a combination of the high BD and penetration resistance of the surface layer and a limited water supply caused by high BD and local topography within the pit.

Table 1. Generalized soil property descriptions by horizon for each of the areas studied.

Area	Depth interval (cm)	Horizon / Notes
Pit bottom	0-4	O; leaf litter with occasional twigs/limbs
	4-13	AC; weak SBK; ~60% sd, 25% si, 15% cl; pH = 5.2; 5 YR 2.5/1
	>13	C; massive; ~60% sd, 30% si, 10% cl; pH = 5.0; 7.5 YR 5/6, 5/8, and 6/8; 5B 8/2 and 10B 8/2 mottles and coatings on some peds
Sparsely-vegetated	0-6	CA; very little organic coloring; single grained; ~55% sd, 40% si, 5% cl; pH = 5.5; 7.5 YR 4/2 and 5/3
	>6	C; single grained to massive; ~65% sd, 30% si, 5% cl; pH = 5.4; 10 YR 5/4, 6/6, and 7/4
Grassy	0-4	O; leaf litter and dead grass
	4-8	A; moderate medium SBK; ~43% sd, 42% si, 15% cl; pH = 4.5; 5 YR 2.5/1 to 10 YR 4/2; N 8/1 mottles and coatings on some peds
	8-25	AC; moderate medium to weak fine SBK (becoming very fine with depth); ~50% sd, 37% si, 13% cl; pH = 5.1; 5 YR 5/6 to 10 YR 6/6
	>25	C; massive; ~65% sd, 30% si, 5% cl; pH = 5.0; 2.5 Y 8/1 to 5 YR 8/1
Control Area	0-4	O, leaf litter with twigs/limbs
	4-36	A; strong medium SBK; ~89% sd, 9% si, 2% cl; pH = 4.9; 10 YR 4/2
	36-80	BA; strong medium SBK; ~90% sd, 7% si, 3% cl; pH = 5.4; 10 YR 4/3
	80-131	B1; strong medium SBK; ~89% sd, 8% si, 3% cl; pH = 5.0; 10 YR 5/4
	131-168	B2; strong large SBK; ~68% sd, 29% si, 3% cl; pH = 4.8; 10 YR 6/4
	>168	C; single grained; ~93% sd, 5% si, 2% cl; pH = 5.2; 7.5 YR 5/8

SBK - subangular blocky structure sd - sand si - silt cl - clay



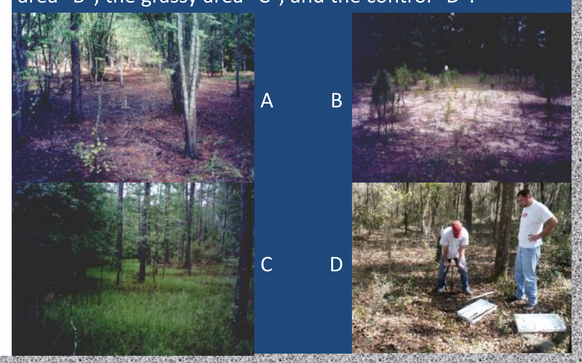


Figure 1. A detailed topographic map of the study area (left) and photos of each area (below). Elevation values shown are m above sea level with a contour interval of 0.5 m. The pit bottom is marked "A", the sparsely-vegetated area "B", the grassy area "C", and the control "D".

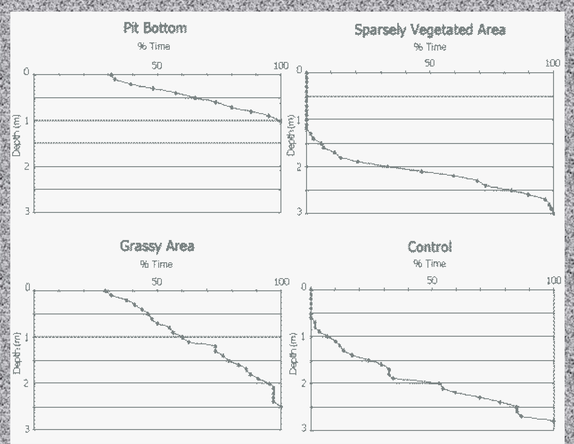


Figure 2. Percentage of time from February 2002 to May 2004 that the water table was at or above a given level at each of the areas in and around the borrow pit. Note that both the pit bottom and grassy area had standing water approximately 30% of the time over this two-year period. The sparsely vegetated area and the control area never experience standing water over this time span.

Table 2. Bulk density in the upper 0.2 m of the soil.

Area	Mean (kg m^{-3})	Std. Dev. (kg m^{-3})	Maximum (kg m^{-3})	Minimum (kg m^{-3})
Pit Bottom	1450	120	1610	1320
Sparsely Vegetated	1740	180	1990	1490
Grassy	1200[a]	330	1560	550
Control	1280[a]	50	1340	1190

Differences between means with the same superscripted letter are not statistically significant

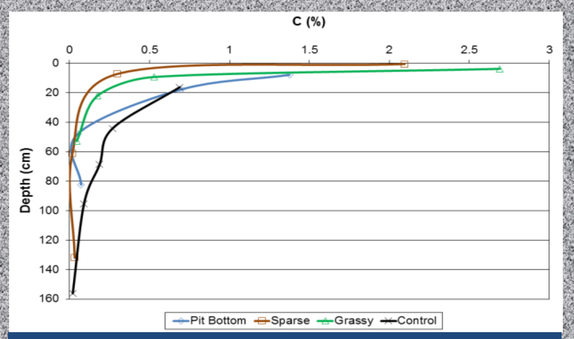


Figure 3. Carbon distribution with depth in and around the borrow pit.

Table 3. Summary statistics for the JIP analysis done at the borrow pit site.

Area	Mean (J/cm)	Std. Dev. (J/cm)	Min. (J/cm)	Max. (J/cm)
Pit bottom	5.29[a]	1.19	3.30	7.09
Sparsely vegetated	24.73[b]	15.37	8.86	70.87
Grassy	7.69[c]	0.71	6.44	8.86
Control	2.18[d]	0.62	1.42	3.22

The differences between means with the same superscripted letter beside them are not statistically significant

Table 4. Summary statistics for leaf litter collections at the different sites in the borrow pit.

Area	Mean (g m^{-2})	Minimum (g m^{-2})	Maximum (g m^{-2})	Std. Dev. (g m^{-2})
Pit bottom	442[a]	325	618	124
Sparsely vegetated	32	19	51	14
Grassy	405[a]	255	550	125
Control	447[a]	259	670	169

Differences between means with the same superscripted letters are not statistically significant

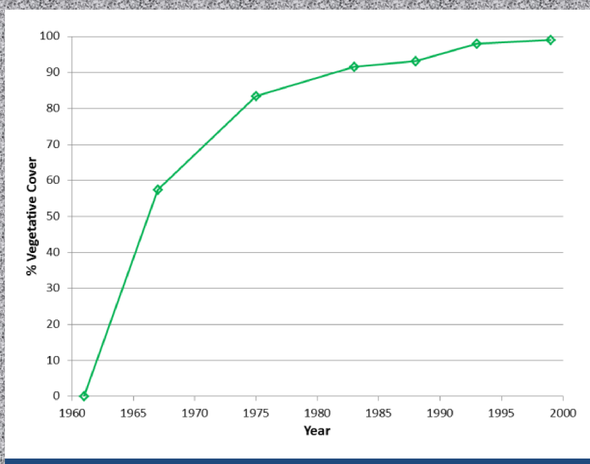


Figure 4. The revegetative history of the borrow pit as documented by historical aerial photographs, showing a rapid initial revegetation followed by a steady but much slower continued revegetation.

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