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Soil Quality, Forests, and Water Resources of Stripmines

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ABSTRACT

Surface mining for coal excavates deep pits that are refilled at the bottom with large rocks and in the root zone with a loose mixture of soil and shattered mineral-rich shales, sandstones, and/or limestones from above the coal. If not overlaid with massive fragic or claypan subsoils compacted by excessive grading the mineral fragments near the surface rapidly weather to become nuggets of nutrients and moisture for plant growth on well-aerated soils. Creatively-reclaimed soils have historically grown outstanding trees on productive forested lands. Regulations mandated by the Illinois Department of Natural Resources for unrealized agricultural land uses have resulted in extensive deforestation with other values of stripmined lands reduced especially in southeastern Illinois. The replaced fine-textured layered soil materials excessively graded and compacted at great cost limit soil water entry and penetration and have commonly been abandoned to grasses and invasives. Mineral riches above the coal are buried and wasted. A vital loss is the potential for abundant clean water that once was stored in mine pits underground and in deep lakes that are now required to be largely filled. Southeastern Illinois needs a long-term scientific reclamation agenda based on its environmental, economic, and cultural potential. Misdirected provisions of federal and state stripmine laws and counter-productive regulations urgently need to be reviewed and remedied.

Key words: environmental services, plant nutrients, Public Law 95-87, reclamation, reforestation, surface coal mining, sustainability, tree growth

INTRODUCTION

The focus of this paper is the coal lands east of the geological Du Quoin monocline in Jackson, Saline and Williamson counties of southeastern Illinois. Pre-mining soils are largely order Alfisols and Subgroup Typic Fragiudalfs (Miles and Weiss, 1978) including infertile fragipan and claypan soils. Farmlands commonly have little remaining agricultural topsoil with some physical and chemical properties of the unmined subsoils inherently limiting when replaced for crop production. Both before mining and more so when replaced and commonly compacted the subsoils are glue-like when wet, brick-like when dry, and limit water entry, aeration, rooting, and plant growth.

During the first four decades of surface mining in Illinois most mined lands were left relatively unaltered. Tree seedlings commonly planted after mining grew well, with exceptions, and early forested lands have now been logged. With later moderate grading

of mine banks pasture and livestock became important. Other land uses included crops, lakes, orchards, parks, housing, landfills, wildlife, roads, fairgrounds, airports, and shopping malls. Federal and state agencies and universities in cooperation with coal industry associations developed high-quality reclamation practices for sustainable soil, plant, and water resources. Ways were found to speed up the natural revegetation of infrequent "moonscapes" and remedy acid stream drainage that resulted from early lack of knowledge or understanding of geochemistry, and from carelessness in placing sulfide-rich minerals at or near the surface (Ashby et al., 1979). Tree species successful on initially barren stripmines are valuable for reclaiming other barren areas and may be adapted for reclaiming brownfields, parkways, or other adverse urban sites.

After earlier state laws Public Law 97-87 (U.S. Congress, 1977) with nine subdivisions or Titles placed stripmine reclamation operations under federal government control. Other agencies conducting reclamation research and demonstration were later eliminated or reclamation research reduced. States were given authority to administer P.L. 95-87, in Illinois the now Department of Natural Resources (IDNR). Both federal and state agencies published numerous detailed reclamation regulations.

PRE-REGULATION SOIL QUALITY AND WATER RESOURCES

Surface mining for coal created productive soils and abundant water resources, with exceptions discussed later. The deep plowing in stripmining broke up the pans of unproductive soils and replaced them with loose mixtures of soil particles and rock fragments called geological topsoil or spoil (Committee on Soil as a Resource in Relation to Surface Mining for Coal, 1981). The rock fragments or nuggets of sedimentary shales, sandstones, and limestones from deeper in the coal overburden when exposed at the surface to oxidation, wetting and drying, microbial and root penetration, and animal activities release nutrients. Commonly renewed are essential potassium and from shales phosphorus (Underwood and Smeck, 2002; Brantley, 2008). Vigorous alfalfa (*Medicago sativa*) growth on a nugget-enriched rooting medium versus poor growth on adjacent replaced soil was attributed by visiting Polish scientists to available boron. Rock fragments also become nuggets for soil moisture (Limstrom, 1960; Hansen and Blevins, 1979; Schafer et al., 1979) and greatly increase essential soil aeration. Black walnut (*Juglans nigra*) rooted much more deeply and widely on spoil than on replaced soils (Josiah, 1986). Soil loosening and the mineral riches of rock nuggets as slow-release fertilizer pellets could be of greater long-term value than the coal mined (Ashby et al., 1984; Ashby, 1996).

"Water is a product of the land" (Colman, 1953). Pre-regulation minelands with loose spoil had high rates of water infiltration and of percolation to deep storage. Low places in contact with stored pit water became wetlands, ponds, or streams. With little post-mining human disturbance native plants and animals moved into the forested habitats as natural areas.

Water from rainfall/snow melt impounded underground deep within mine pits had neither siltation nor evaporative losses and typically extended to a deep, long, and narrow lake at the end of the pit with no further coal overburden excavated to fill it. Aerial photos of 347 ha (858 ac) in Saline County mined and leveled by dragline pullback of spoil banks in the 1950s had 28 ha of lakes fed by much more water stored underground. A later mining

permit application for the same mine proposed having at no cost to society seven lakes on 156 ha. Stripmine lakes and ponds with clear water have been used extensively by hunters, fishermen, and boaters, for recreation and education, and for consumptive domestic and agricultural needs. The original Pyramid State Park mined pre-law in Perry County is a recreational mecca with untold megaliters of clear water underground and in numerous lakes. Mined land with lakes is commonly the highest-price real estate in an area (Christy et al., 1979).

PRE-REGULATION VEGETATION RESOURCES

For decades before government control of the coal industry experienced reclamation specialists voluntarily planted numerous tree species on mine soils with some early failures and increasing later success (Limstrom, 1960; Ashby, 1996). Plantings in Saline County of 47-year-old tuliptree (*Liriodendron tulipifera*) and sweetgum (*Liquidambar styraciflua*) each averaged 28 m tall with diameters breast height (DBH) of 36 and 30 cm. Thriving white (*Quercus alba*) and red/Shumard oaks (*Q. rubra*/*Q. shumardii*) 55 years old averaged 26 and 33 m tall with 23 and 35 cm DBH. Planted forest stands on fertile, well-drained post-mining soils soon developed volunteer mesic tree and ground cover occasionally with ladies'-tresses (*Spiranthes spp*.) and other orchids related to the availability of propagules (Ashby et al., 1981; Ashby, 2009). Ants, earthworms, root nodules, and mycorrhizae are typically found on forested mined lands. Pioneer settlers valued land by kind of trees. Today forests are valued for clean water and air, flood protection, soil building, carbon sequestration, timber and other forest products, habitats for native plants and animals, recreation, and education.

POST-REGULATION SOIL, WATER, AND VEGETATION

IDNR reclamation regulations required mining permits and bonding for site preparation and revegetation to meet performance standards in 5 or more years. Formerly integrated reclamation operations were increasingly contracted out with loss of coal company/industry control and downsized numbers of reclamation specialists.

Under TITLE IV - "Abandoned Mine Reclamation" poorly-vegetated pre-law mined lands with off-site environmental damage became a management priority regardless of ownership. Reclamation with massive grading and pasture-type reclamation practices resulted in negligible survival of typically-planted tree seedlings and staggering over-all costs. Many more Abandoned Mine Land (AML) sites could be vegetated by working with nature, preserving flora already established, and supporting research for site-adapted trees, shrubs, and herbs to increase plant cover and soil organic matter that ameliorates toxic and drought conditions. The ecological amplitude and value of plants is commonly not recognized or utilized. Acid-tolerant river birch (*Betula nigra*), pin oak (*Q. palustris*), and sweetgum that establish naturally get bulldozed. Many smaller AML sites with scant off-site damage need little grading or "reclamation" and have significant long-term value for research and environmental education, historical relevance, innovative forestry, recreation, natural areas, and fossil collecting.

TITLE V - "Control of the Environmental Impacts of Surface Coal Mining" eliminated later "moonscapes" by mandating identification and deep burial or flooding of potentially

harmful spoil materials during mining. Post-mining lands are intensively graded to Approximate Original Contour and commonly compacted hindering water entry, aeration, rooting, and revegetation and negating reclamation goals. IDNR rather than reclaiming typically replaces to 1.2 m depth soil types described in county soil reports and classified for engineering and biological uses by the USDA Natural Resources Conservation Service. Productivity indexes otherwise developed for pre-mining southern Illinois soils are among the lowest in the state for crop and less so for timber yield (Fehrenbacher et al., 1978). IDNR disregards biological properties of the root zone, an important federal reclamation criterion, and uniquely and perversely replaces poorly-productive soils with deleterious fragic materials that reform as pans and elsewhere are deeply buried. Federal provisions for soil quality have not prevailed. Similar adverse effects of government control of reclamation under P.L. 95-87 have been reported for Appalachia (Palmer et al., 2010).

Crop production with at least two years of acceptable corn (*Zea mays*) yields became an Illinois reclamation requirement for performance bond release. Unacceptably low yields soon made necessary further unsustainable deep soil ripping, exceptionally high levels of fertilization, and specially bred corn varieties. After a performance bond is released coal companies in southeastern Illinois commonly have left idle the replaced fragipan lands.

Water resources have been greatly limited by IDNR with minimal recharge and percolation to deep storage of the massive replaced surface soils. Water storage capacity of stripmine lakes has further greatly been reduced by faulty federal and state requirements for partial refilling, reportedly related to unique mining problems in Appalachia. Both the inner and outer highwalls at the open end of a mine pit must be graded to gentle slopes with both the mined and unmined adjacent land shoved into the future lake basin. Thousands of kiloliters of lake water storage capacity are needlessly lost (Chugh and Grandt, 1981). Such a shallow lake cannot be replenished by water stored in voids between the large rocks replaced deep in the pit. Filling-in water bodies violates the spirit if not the requirements of the National Environmental Policy Act and the Clean Water Act and denies future generations vital water resources that are increasingly needed.

TITLE VII Section 711 “Experimental Practices” authorizes, with environmental safeguards, innovative research studies. A cooperative grading study by a reclamation-conscious coal company and my research group was spurned with no reason by IDNR. A second experimental practices proposal was rejected with “You can’t grow corn on spoil” despite numerous examples of corn grown on spoil in northern and central Illinois and in other states (Grandt, 1978; Nielsen and Miller, 1980). Before IDNR banned forestry and required costly uncertain corn production for bond release there had been no reason for coal companies with forestry equipment and expertise to become farmers. We cooperated with local agronomists and for four years experimentally grew corn on graded spoil mined in 1971 formerly a 20-ha hayland in Saline County. Variability in yields was traced to soil patches with re-sprouting alfalfa, nitrogen and moisture limitations related to uneven soil compaction in grading, and especially potassium fixation by shrinking clays as the soil dried. We made mistakes, had lots of visitors and professional advice and encouragement, and no visitors came from IDNR. Letters from a local agricultural supplier and farmers gave support. Farm operations on nugget-enriched friable soils with large rocks deeply buried can readily be carried out with modern equipment. In 1980, the

first and a severe drought summer with no later comparisons our corn yield exceeded that of an unmined reference field planted by a local farmer. In numerous soil pits corn rooted much less deeply than alfalfa. Unlike soil and water benefits with reclaimed forests, corn fields are relatively barren for most of the year and tend to decrease rather than build organic matter and natural soil fertility and not to conserve water or enhance ecosystem values.

DISCUSSION

Potential benefits from productive, sustainable stripmine reclamation relate directly to national and world needs. Leadership of the Soil and Water Conservation Society has emphasized the increasing importance of improving the quality of soil resources (Towery, 2009). Deforestation is widely and recently was strongly condemned at the international Copenhagen conference (Kintisch, 2009). Regulatory authorities in Appalachia encourage building soils and safeguarding water supplies under a new forestry reclamation approach (Burger et al., 2009) that could readily be fulfilled in Illinois. The USDA Forest Service (2009) considers clean water the most vital of the ecosystem services provided by our forests. Reforestation of stripmines interspersed with farming areas would allocate land uses in an efficient way (Fischer et al., 2008).

Fields of soil study are genesis, classification, and as a medium for plant growth. Important findings from numerous studies of soil genesis/development after natural disturbances (Jenny, 1980) and on stripmines (Thomas and Jansen, 1985; Sencindiver and Ammons, 2000) seem to be ignored by IDNR. USDA soil scientists found deep prime soils in 1979 under thriving forest stands planted in 1938 (Personal communication). Productive soils if needed for other purposes are available after timber harvests. “Collapse - how societies choose to succeed or fail” (Diamond, 2005) has worldwide examples from earlier centuries of use of rocks and reforestation to renew/build soils and sustain societies. Blackbourn (2006) documents pitfalls in management of natural resources from unwise government control.

Land uses with replaced fragipan and other degraded soils mandated by government in mining permits commonly are not sustained after release of performance bonds. Reclamation expenditures of eight to ten million dollars in the 1980s, now likely much higher, for a typical 120-ha mining reclamation operation have been a flush of wealth for local businesses and governments with scant long-term benefits. Soils replaced for presumed and unfulfilled crop production have failed to support adequate growth or even survival of many tree species (Ashby and Kolar, 1998). More sustainable environmental and economic reclamation practices both short- and long-term are needed for crop and pasture production, forest habitats and products, improved soil, air, and water quality, and new kinds of biomass production for energy independence instead of growing costly corn for ethanol production with no energy gain. Coal companies are willing to contribute use of land, personnel, and other resources for reclamation research while our regulatory authority has seemingly been hostile to environmental quality.

Public Law 95-87 requires restoring capability at least equivalent to pre-mining. Noncompliant Illinois regulations state that forested land is to be reclaimed as woody or herbaceous cover including weeds on replaced soils. Such changes in land use are masked as

simply changes in vegetation to accommodate IDNR's failed soil reclamation practices. Southern Illinois was formerly about 40% forested and I have not found data on how many thousands of hectares have been deforested. Extensive "reclaimed" lands between Harrisburg and Marion north of Illinois route 13 previously forested now have broomsedge (*Andropogon virginicus*), other grasses, autumn olive (*Elaeagnus umbellata*), and other invasives. Near-by pre-law lands south of Illinois route 13 have forests with the best or near-best growth of white and red oak, tuliptree, and black walnut in upland areas of the region (Ashby, 1996).

Water readily available from lands suitably reclaimed after surface mining for coal is an important option overlooked for future water needs of numerous upland Illinois localities with scant natural surface or usable ground water (Hood, 1981). Community water systems built by earlier generations typically rely on "borrowed" stream water from distant areas impounded in shallow man-made lakes that fill with sediment at about 1% a year. What replacement water supplies will be politically or economically available when today's lakes become unusable is not known. Few sites for new impoundments are likely to be available. In recent years irrigation to offset declining crop yields has increased greatly in the Midwest.

A public outraged by increased costs for electricity generated using coal ignores significant coal industry costs of federal tonnage fees and of compliance with numerous cosmetic and often fruitless mandates for segregating, replacing, grading, and ripping degraded soils that are commonly later abandoned. Untold thousands of gallons of fossil fuels with consequent CO_2 emissions would not be needed with more environmentally responsible reclamation requirements. The costly soil replacement agenda of the politically-dominant central Illinois agricultural community implemented by IDNR has too often brought about the end rather than the beginning of productive sustainable post-mining land uses in southeastern Illinois. Texas implements P.L. 95-87 with diverse and effective stripmine reclamation regulations for multiple uses. Illinois should do no less. Direct and effective federal control may be the answer.

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