Overview of InSAR technology for monitoring subsidence over undermined areas[1]

Z. Agioutantis and J. Robertson[2]

Abstract: Interferometric Synthetic Aperture Radar (InSAR) has experienced a surge in the past decade due to advancements in technology and the proliferation of SAR-capable satellite instrumentation. Numerous processing methodologies have been developed that stem from InSAR, such as DInSAR and PSInSAR. Using one or more of these methods, one can detect ground surface movements (subsidence) at different order of magnitude, i.e. feet or millimeters. Although traditional surveying techniques are widely used to detect these movements to extreme accuracy, they prove to be costly and time consuming. InSAR based methods offer a lower cost technique to not only detect, but also continuously monitor ground deformation in subsidence prone areas, especially since InSAR imagery is freely available from the European Space Agency (ESA). In this presentation, the advantages and disadvantages of the different InSAR techniques for detecting and monitoring subsidence will be discussed. Examples will be given from abandoned mining areas.

Additional Key Words: Abandoned mines, active mines, ground movements, satellite imagery.

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1. Oral paper presented at the 2018 National Meeting of the American Society of Mining and Reclamation, St. Louis, MO: The Gateway to Land Reclamation, June 3 - 7, 2018. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.

2. Zach Agioutantis, Professor, Department of Mining Engineering, University of Kentucky, Lexington, KY 40506; Joe Robertson, Geotechnical Investigator, Illinois Mine Subsidence Insurance Fund, Caseyville, IL, 62232.

Reclamation Bond Optimization using 3d-dig Plus[1]

J. Anderson[2]

Abstract: Annual Reclamation Bonds are a critical process to ensure that mining operations can be effectively reclaimed if the site or company ceases operation. Calculation of the reclamation bond can occupy one or a team of engineers in a multi month project during bond estimation. From final mine design to calculation of productivities, multiple different types of workflows are utilized. 3D-Dig is a mine simulation software that can quickly simulate Dragline, Truck/Shovel, Dozer, Environment Reshaping, and blasting. By using 3d-dig an engineer can design a final surface, calculate fleet productivities, and get an accurate total cost of excavation and fleet operating costs. The simple functionality of 3d-dig can speed up the process of the bond design and calculation, and run alternative scenarios. Using 3d-dig can help to ensure an accurate and realistic bond estimate, which could save time and money in both the estimation and actual total bond cost.

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1. Oral paper presented at the 2018 National Meeting of the American Society of Mining and Reclamation, St. Louis, MO: The Gateway to Land Reclamation, June 3 - 7, 2018. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.

2. Jake Anderson is a geologist in Vulcan Technical Services. He graduated with a bachelor's degree in Geology from the University of Nebraska at Omaha. Before joining Maptek, Jake worked for Kiewit Mining Group and assisted with geologic exploration and reclamation bonds.

Individual Tree and Stand-Level Carbon and Nutrient Contents Across One Rotation of Loblolly Pine Plantations on a Reclaimed Surface Mine[1]

H.Z. Angel[2], J.S. Priest, J.P. Stovall, B.P. Oswald, Y. Weng, and H.M. Williams

Abstract: Loblolly pine (*Pinus taeda* L.) trees growing on reclaimed mined land in east Texas exhibit similar productivity compared to unmined land. However, rates at which carbon (C) and nutrients in aboveground components aggrade, are correlated to stem growth rates, or differ from forests on undisturbed land have not been documented. Numerous studies have previously assessed loblolly pine aboveground biomass, C, and nutrient contents; however, similar data is limited for loblolly pine on mined land. We investigated C, N, Ca, Mg, K, and P contents for first-rotation loblolly pine growing on reclaimed mined land in east Texas over a 32-year period using a chronosequence approach. At the individual tree level, we evaluated elemental content in aboveground biomass components using tree size, age, and site index as predictor variables. At the stand-level, we then scaled individual tree C and nutrients and fit a model to determine the sensitivity of aboveground elemental contents to stand age and site index. Generally, aboveground C and nutrients in loblolly pine on mined land either exceeded or followed similar trends to data for unmined plantations derived from the literature. DBH and height were the best predictors of individual tree C and nutrient contents for the stem biomass component ($R^2 \geq$ 0.7343 and 0.6095, respectively) followed by stand age ($R^2 \geq 0.5147$). Foliage produced weaker relationships across all predictor variables compared to stem, though still significant ($P \leq 0.05$). The model for estimating stand-level C and nutrients using stand age provided a good fit, indicating that contents aggrade over time predictably.

Additional Key Words: aboveground biomass, nitrogen, potassium, phosphorus, calcium, magnesium.

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1. Poster presented at the 2018 National Meeting of the American Society of Mining and Reclamation, St. Louis, MO: The Gateway to Land Reclamation, June 3 - 7, 2018. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.

2. Hannah Z. Angel (student), Graduate Research Assistant; Jeremy S. Priest, Graduate Research Assistant; Jeremy P. Stovall, Professor; Brian P. Oswald, Professor; Yuhui Weng, Professor; and Hans M. Williams, Dean, Arthur Temple College of Forestry and Agriculture, Stephen F. Austin State University, Nacogdoches, TX 75962.

Rehabilitation of the Reitz #1 Passive Treatment System[1]

G. Bailey*, A. Ferko, R. Fife, R. Siwy, C. West, A. Rovder, W. Strosnider, C. Denholm, and J. LaBar[2]

The Shade Creek Watershed Association (SCWA) contacted Stream Restoration Incorporated to rehabilitate the Reitz #1 passive water treatment system near Central City, PA. The bioreactor was emitting a sulfidic odor that was causing nearby residents to complain. It was noted that the bioreactor was no longer working as designed, but instead functioning partially as a surface flow wetland. Faculty and students from Saint Francis University worked with SCWA to evaluate the system and develop a plan for rehabilitation. During seven weeks of work in the context of a sophomore level environmental engineering class, the odor coming from the bioreactor was decreased by increasing the flow through the bioreactor. Other activities included leveling rock baffles to remove preferential flow patterns and removing iron deposits on the Agri Drain stop logs. An island was built in the middle of the bioreactor, using compost, native plants, and logs fastened in place with rebar, to introduce vegetation and improve waterfowl habitat. Furthermore, the substrate in the bioreactor and the vertical flow pond was fluffed using pickaxes, shovels and rakes in order to disrupt preferential flow patterns. Through the completion of these tasks, the group was able to cost-effectively optimize overall system performance. The project was an ideal example of industry-academic partnership for student development, non-profit assistance and, water quality improvement.

Additional Key Words*:* Vertical flow pond, bioreactor, operation and maintenance.

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1. Poster paper presented at the 2018 National Meeting of the American Society of Mining and Reclamation, St. Louis, MO: The Gateway to Land Reclamation, June 2 – 7, 2018. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821
2. Grace Bailey, Andrew Ferko, Ryan Fife, Ashley Rovder, Ryan Siwy, Colton West, Undergraduate Students at Saint Francis University; Dr. William Strosnider, Associate Professor, Saint Francis University Environmental Engineering Department, Loretto, PA; Clifford Denholm, Environmental Scientist, Stream Restoration Incorporated, Mars, PA; Dr. Julie LaBar, Post-Doctoral Fellow, Saint Francis University Environmental Engineering Department, Loretto PA.

The Influence Herbaceous Vegetation on Ectomycorrhizal Root Colonization and Nutrient Uptake[1]

J. M. Bauman, M. Fergus, and J.A. Franklin[2]

Abstract: Ectomycorrhizal (ECM) fungi are the primary symbionts important for the growth and establishment of many forest tree taxa used in forest restoration on coal-mined sites. Encouraging functional ECM symbiosis in restoration projects has resulted in improved seedling establishment, lower metal accumulation, and a positive correlation with tree growth. What is less understood is the compatibility of herbaceous vegetation planted with hardwood trees. Some non-native plant species used for mine reclamation may inhibit both nutrient acquisition and ECM colonization of tree seedlings in the early years of establishment. The objective of this study is to investigate the ECM root colonization, nutrient concentrations, and heavy metal accumulation on a single seven-year-old hardwood host (*Castanea dentata*) under three unique restoration conditions in eastern Tennessee: 1) trees planted with non-native, aggressive plant species, Chinese lespedeza (*Lespedeza cuneata*), 2) trees planted with a mix of native herbaceous species with Chinese lespedeza, and 3) trees planted with only native herbaceous species. ECM fungi present on roots was identified by DNA sequencing and correlated to root colonization, nutrient acquisition, heavy metal accumulation, and groundcover community composition. Trees growing within the monoculture of Chinese lespedeza were larger and did not show signs of nutrient deficiency. Types of groundcover did not impact ECM root colonization, however, there were significant differences regarding fungal community composition (P=0.0004) with certain ECM species associated with a higher level of organic matter, while some were linked to nutrient availability. Foliar analysis did not detect heavy metal accumulation in trees. Fungal species such as *Cortinarius* and *Scleroderma* were associated with an increase in foliar concentrations of nitrogen (P= 0.02) and aluminum (P=0.01). Results will inform future protocols regarding herbaceous species interactions with fungal symbionts of certain hardwood trees in mine restoration.

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2. Jenise M. Bauman, Professor, Huxley College of the Environment, Western Washington University, Poulsbo, WA, 98370, Martha Fergus, Student, Western Washington University, Bellingham, WA 98225, and Jennifer A. Franklin, Professor, University of Tennessee, Knoxville, TN 37996.

Reliance, Wyoming Mine Subsidence Mitigation Project[1]

D.L. Beahm[2], R.S. Reed, C.R. Gerrard

Abstract: The Reliance Subsidence Mitigation Project was sponsored by the Wyoming Abandoned Mine Lands Program (AML). BRS Engineering and Western Engineers & Geologists collaborated on the project beginning in 2015. The project is located along eastern portions of Reliance, Wyoming approximately 3 miles north of Rock Springs in Sweetwater County, Wyoming[3]. Underground coal mining in Reliance began in 1910 at the No. 1 and No. 3 mines followed by the No. 7.5 in 1913, No. 7 1936, and No. 11mine in 1941. The eastern portion of Reliance is underlain successively by the No.1, No. 7, No. 7.5, and No. 11 mines, with the depth to the No. 1 mine workings as shallow as 40 feet from the ground surface. In 1926 a mine fire erupted in the No. 1 mine and in 1933 the No. 1 mine was closed. The Wyoming AML program closed mine portals in the area beginning in the late 1980's and in 2007 AML began reclaiming mine subsidence features, which were expressed at the surface and began monitoring the No. 1 mine fire, which was also expressing itself at the surface. In 2015 investigative drilling showed that mine subsidence and the No.1 mine fire was encroaching on residents in the eastern portions of Reliance. Mitigation of hazards relating to the mine subsidence and mine fire were immediately initiated in the most critical areas using pressurized void-fill grouting. The initial work was then followed by phased construction proceeding west in 2016 and 2017. In 2017 verification coring of the site was completed which demonstrated the grouting had stabilized the mine voids and extinguished the mine fire where it was impacting the Reliance residents. The presentation addresses the general history of the project; challenges faced during investigation and mitigation, and documents the success of the project.

Additional Keywords: Coal Mine Fire, Underground Mine Subsidence, Void-Fill Pressure Grouting, Wyoming Abandoned Mine Lands Program.

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1. Oral paper presented at the 2018 National Meeting of the American Society of Mining and Reclamation, St. Louis, MO: The Gateway to Land Reclamation, June 3 - 7, 2018.
2. Doug Beahm, PE, PG, Principal Engineer, BRS Engineering, 1130 Major Ave., Riverton, Wyoming 82501; Ryan Reed, PE, Project Engineer, BRS Engineering, 1130 Major Ave., Riverton, Wyoming, 82501; Rob Gerrard, PE, Principal Engineer, Western Engineers and Geologists, 1329 Ninth St, Rock Springs, WY 82901.
3. Work reported here was conducted near 41° 40′ 16″ N, 109° 10′ 59″ W.

Investigations of Acidic Discharges from the Historic Mining of the Davis and Dekoven Coal Beds in Southern Illinois[1]

P.T. Behum[2] and A. Mick[2]

Abstract: Historic surface mining of the Davis and Dekoven Coal members of the Carbondale Formation in the Southern Illinois portion of the Illinois Coal Basin has produced numerous discharges of particularly problematic acid mine drainage (AMD). AMD associated with these seams has been characterized by high loadings of acidity, aluminum, iron, and sulfate as the result of leaching of acid-forming materials associated primarily with the inter-burden material separating the two seams. This paper summarizes the findings of a series of site investigations under the Illinois Abandoned Mined Lands (AML) Program. The investigations studied the geochemistry and quantified the contaminant loading of these discharges in order provide the basis for future remediation which may include passive treatment. In a previous paper, the authors presented the geochemistry of AMD discharges at the Palzo AML mine site in Williamson County, Illinois. Information presented in this study will detail the geochemistry of discharges at two nearby surface mines in Saline County, Saxon/Walnut Grove and Will Scarlet, which also surface mined the Davis and Dekoven seams prior to Federal Surface Mining Control and Reclamation Act (SMCRA) of 1977. Extensive land reclamation has been attempted for each sites under the Illinois AML Program; however, significant AMD discharges remain which, if left unabated, may impact the South Fork of the Saline River. Construction of low-pH iron oxidation cells and sulfate-reducing bioreactors are currently the only viable alternatives for passive remediation of these discharges due to the low pH of high aluminum, iron and acidity (>40 mg/L, >60 mg/L, and >450 mg/L CCE, respectively). The use of a steel slag leach bed exists as another possible passive treatment alternative, but could be limited in these locations due to the economics of an excessively long slag haul and the lack of a viable fresh water leachate source. Passive treatment of Davis and Dekoven seam discharges have not been attempted by Illinois to date. This paper presents conceptual passive treatment designs for several case example AML discharges investigated at these sites in the event that funding becomes available at some future date[3].

Additional Key Words: low-pH iron oxidation, sulfate-reducing bioreactors, acid-forming materials.

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2. Paul T. Behum, S. Hydrologist, Office of Surface Mining Reclamation and Enforcement, Alton, IL 62002; Angie Mick, Environmental Protection Specialist, Illinois Department of Natural Resources Office of Mines and Minerals, Springfield, IL 62702.

3. Work reported here on the two case example sites was conducted near 37° 39’29” N; -88° 33’29” W and 37° 38’ 30” N; -88° 41’ 45” W.

Investigation Acidic Discharges at the Monahan Abandoned Mine Lands Site, Kansas[1]

P.T. Behum, M. Spence, J. Arruda, R. Johnson, and C. Kiser[2]

Abstract: Pittsburg State University Monahan Outdoor Education Center is located at the site of several pre-SMCRA coal mining and processing facility. The 80-acre site is located in Crawford County, approximately 1 mile north and 1.5 miles east of Cherokee, Kansas in the southern part of the state's historic coal mining area. Mining at the Monahan AML Site included: 1) underground mining of the Weir-Pittsburg coal bed (Commercial Fuels Co. #2 Mine -1910's-1920's); 2) surface mining of the Mineral coal bed in (Commercial Fuels Co # 10 Mine -1930's - 1940's); and 3) processing of coal from various Commercial Fuels Co. mines with on-site coarse (gob) and fine (slurry) coal waste disposal (1920's -1940's). Over 40 years later the Abandoned Mine Land (AML) Fund provided support for a site investigation and surface mine reclamation by U.S. Dept. of Agriculture, SCS (now NCRDS; 1981-1985). Reclamation of the site focused on eliminate hazards (burning coal waste) and remediation by land reclamation of severe environmental problems [acid mine drainage (AMD) and offsite sedimentation]. However, a significant amount of oxygen-bearing water and ferric iron apparently continues to infiltrate into the pile allowing continued oxidation of pyrite, which is abundant in the coarse refuse. A series of AMD seeps have coalesced to form a barren northern slope of reclaimed gob pile, which will continue to erode unless measures are taken within the next few years to collect the AMD in a subsurface drain system and re-establish vegetation. This paper describes the result of a series of post-reclamation site investigations initiated by Pittsburg State University which more recently updated by the Kansas Dept. of Health and Environment (KDH&E) with support from students and technical staff of the college and Office of Surface Mining's Mid-Continent Region. This information will form the basis for proposed remediation of the Monahan site AMD though additional land reclamation and the application of passive treatment of the Monahan Gob Pile AMD. This paper will present the current plans, which inched use of low-pH iron oxidation. Although a high aluminum and acidity of AMD which seeps from the gob pile suggests that the construction of a sulfate-reducing bioreactor is necessary, there are concerns of the potential for periodic amounts of hydrogen sulfide gas will provide a hazard at a public use area. The current remediation plan includes the use of low-pH iron oxidation and dilution water to lower iron, aluminum, and acidity to levels that are more appropriate for traditional limestone-based VFP, which will be followed by oxidation pond and aerobic wetland for metal precipitation.

Additional Key Words: low-pH iron oxidation, sulfate-reducing bioreactors, acid-forming materials.

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2. Paul T. Behum, Ph.D., Sr. Hydrologist and Chris Kiser, Mining Engineer, Office of Surface Mining Reclamation and Enforcement, Alton, IL 62002; Marlene Spence and Randy Johnson, The Surface Mining Section of the Kansas Dept. of Health and Environment, Pittsburg, KS; and Joseph Arruda, Ph.D., Professor of Biology, Pittsburg State University.

Integrating Geochemical Characterization and Field Procedures in Construction to Mitigate Potentially Acid-Generating Materials in Northern Minnesota, USA[1]

Mehgan Blair, Irvin Mossberger, and Jason Richter[2]

Abstract: Highway 169 in northern Minnesota, USA, recently underwent rerouting after years of serious vehicular accidents. The new highway alignment cuts through significant exposures of the Soudan Iron Formation, which contains potentially acid-generating (PAG) rock. PAG rock was identified as a potential environmental issue during planning, and subsequent investigation and consideration led to the development of a thorough mitigation plan. Both the plan and its execution in the field during construction drew heavily on geochemical and geological characterization methods originating from mining environmental studies. The goal of the plan was to minimize fragmentation, exposure and oxidation, and leaching of PAG rock, while still using the material as the primary fill making up the road core, and developing the road cuts necessary to improve the visibility for highway drivers. The requirements of the mitigation plan needed to be tailored to site restrictions including work within a narrow road corridor, very rapid blasting and rock placement schedules, and heavy equipment capabilities. Local sources of neutralizing amendment materials were identified, and site-specific lime amendment and mixing and blending techniques were developed and used to achieve the mitigation design criteria and to overcome the limitations of the construction equipment. In addition, because of the recognition of PAG unconsolidated soils in the area, field-specific techniques were used to screen the potential for these materials to generate acid. Placement of final geomembrane cover materials took place sequentially during construction, and long-term groundwater monitoring is ongoing. Lessons from this project are currently helping inform the development of a guidance document on acid rock drainage for transportation projects in Minnesota.

Keywords: acid rock drainage, water quality, transportation.

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2. Mehgan Blair, Senior Geologist, Project Manager, Barr Engineering Company, Duluth, MN 55802; Irvin Mossberger, Senior Geologist, Barr Engineering Company; Jason Richter, Chief Engineering Geologist, MnDOT Materials and Road Research, Maplewood, MN 55109.

Planning and Implementation of the 2017 AML Pilot Program in Pennsylvania[1]

B.J. Bradley[2], E.E. Cavazza, and J.J. Stefanko

The Consolidated Appropriations Act of 2017, (Public Law 115-31), authorized the federal Office of Surface Mining Reclamation and Enforcement (OSMRE) to provide funding for Fiscal Year (FY) 2017 for the Abandoned Mine Land (AML) Reclamation Economic Development Pilot Program (AML Pilot Program). For FY2017, the AML Pilot Program is providing grants to the six Appalachian states with the highest amount of unfunded high-Priority coal AML problems based on OSMRE's AML inventory data as of September 30, 2016. Kentucky, Pennsylvania (PA), and West Virginia are each receiving $25 million, while Alabama, Ohio, and Virginia are each receiving $10 million. The purpose of the funding is to accelerate the remediation of AML sites with economic and community development end uses. The intent of the AML Pilot Program is to explore and implement strategies to return legacy coal sites to productive uses. This is the second year that AML Pilot Program funding has been authorized by Congress. PA received $30 million in AML Pilot Program funding in FY 2016.

As a requirement of the AML Pilot Program, state AML programs, in consultation with state and local economic and community development authorities, are required to develop a list of eligible projects in Appalachian counties that demonstrate a nexus with AML cleanup and economic and community development. From over two dozen AML Pilot project proposals received and evaluated, PA is targeting 12 AML sites encompassing a wide variety of project types with a variety of possible economic or community development benefits and partners. PA is again allocating all of the AML Pilot Program funds for the construction of SMCRA Title IV eligible AML and AMD problems. The project partners will then work to fund and complete non-AML economic development aspects of the projects. PA's 2017 AML Pilot Grant was approved on November 1, 2017 and has a three-year period of performance.

This presentation will discuss the planned reclamation and anticipated benefits for each of the 12 AML Pilot Projects as well as the status of each including any issues which could impact their successful implementation.

Additional Key Words: Abandoned Mine Lands (AML), Economic Development

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1. Oral paper presented at the 2018 National Meeting of the American Society of Mining and Reclamation, St. Louis, MO: Reclaiming the West, June 2-7, 2018. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.

2. Brian J. Bradley, P.G., Assistant Bureau Director and Eric E. Cavazza, P.E., Director, Pennsylvania Department of Environmental Protection, Bureau of Abandoned Mine Reclamation, Harrisburg, PA 17106; John J. Stefanko, Deputy Secretary, Office of Active and Abandoned Mining Operations, Pennsylvania Department of Environmental Protection, Harrisburg, PA 17101.

Restoring an Oak Savanna in the Upper Mississippi Valley Zinc-Lead District[1]

Dan Brumm[2]*, Cody Zink[2]* and Yari Johnson[2]

Abstract: By 1829, southwestern Wisconsin was producing over 5,000 tons of lead each year. Prior to this mining boom, the Upper Mississippi Valley zinc-lead district was mostly oak savanna with a few scattered prairies and forested areas. Oak savannas are now one of the rarest plant communities in the upper Midwest with less than 500 acres remaining. The primary goal of this project is to restore a small, 3-acre oak savanna community on a remnant savanna hillside on the campus of the University Wisconsin-Platteville. As a secondary goal, the restored oak savanna will serve as a demonstration project for the region. Prior to restoration efforts, which began in late winter 2017, the site was heavily invaded by hybridized bush honeysuckle (*Lonicera x bella*). The honeysuckle formed a monoculture in the understory and prevented oak regeneration. Furthermore, due to fire suppression, the overstory canopy was dominated by immature black walnut trees (*Juglans nigra*). To complete the restoration, a plot was established approximately one acre in size containing a cluster of oak trees (*Quercus macrocarpa* and *Q. alba*), as well as a canopy of black walnut and a bush honeysuckle understory. Both black walnut and bush honeysuckle were cut and stumps were treated with a mixed solution of 5.4% picloram and 20.9% 2,4-dichlorophenoxyacetic acid (Tordon RTU) in the one-acre area while the remaining two acres serve as a control. Bare soil left after removing the bush honeysuckle was frost seeded with native plants. Preliminary vegetation surveys show that understory species richness increased in the treated area.

Additional Key Words: Invasive and fire suppression.

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2. Dan Brumm and Cody Zink, Reclamation, Environment and Conservation students at the University of Wisconsin-Platteville; Yari Johnson, Assistant Professor in the School of Agriculture at The University of Wisconsin-Platteville; Platteville, WI 53818.
3. The site is located at 42° 42’ 38” N: 90° 29’ 22” On University of Wisconsin-Platteville property.

Soil stockpile seed viability is affected by depth and current surface vegetation[1]

Jennifer Buss[2], and Brad Pinno

Abstract: Stockpiled soil will be used to operationally reclaim approximately half of the area disturbed by oil sands mining in northern Alberta, Canada in the next few decades. However, there are concerns regarding the viability of native seeds in stockpiles relative to directly-placed reclamation soil. To test the germination of seeds from a four-year-old soil stockpile, we took samples at different depths up to 90cm and on three separate surface vegetation treatments (sweet clover, perennial sow thistle, and wheat grass). These samples were placed in a greenhouse on top of potting soil to allow any seeds to germinate for nine weeks. The highest species richness and total plant abundance were found at the surface of the stockpile, with 61% of species and 80% of seedlings occurring at the 0-10cm depth. However, viable seeds were found below the surface, with the 80-90cm depth making up 3% of all seedlings and 9% of species richness. Approximately 75% of the species found in these soil samples were native species, including the most abundant species, *Potentilla norvegica* (rough cinquefoil). Some other abundant native species include *Agropyron trachycaulum* (slender wheat grass), *Agrostis scabra* (ticklegrass), and *Achillea millefolium* (common yarrow). The 3 most abundant non-native species were perennial sow thistle (*Sonchus arvensis*), sweet clover (*Melilotus spp.*), and scentless chamomile (*Matricaria perforata)*. Vegetation type affected the abundance of seedlings, with the seed bank reflecting the current vegetation at the surface of the stockpile, but not at the lower depths. Using soil stockpiles for final land reclamation in the future may be problematic because of the low number of viable seeds below the surface and the effect of current vegetation on the surface. Also, although native species may be present in a stockpile, competition with fast growing grasses and non-native species, could prevent their establishment.

Additional Key Words: seed bank, species abundance, species richness, germination.

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1. Oral paper presented at the 2018 National Meeting of the American Society of Mining and Reclamation, St. Louis, MO: The Gateway to Land Reclamation, June 2 - 7, 2018.

2. Jennifer Buss, MSc student, University of Alberta, Alberta, Canada; Brad Pinno, Assistant Professor - Silviculture, University of Alberta, Alberta, Canada.

Development of Soil Physicochemical Properties of Reclaimed Croplands in a Large Opencast Mining Area on the Loess Plateau[1]

Y.G. Cao[2]

Abstract: In this study, we collected soils from 11 plots of the reclaimed cropland at a large-scale opencast coal mining area, analyzed their profile properties, and compared these properties with the properties of undamaged croplands and un-reclaimed lands. These properties were compared using comparative analysis, variance analysis, correlation analysis, and principal component analysis to reveal the underlying rules of variation with reclamation years. The results indicate that the soil profile properties of the reclaimed cropland vary significantly with differences in depth, particularly at depths of 30 cm, 40 cm, and 50 cm. In addition to soil organic matter and soil total potassium, the most significant differences among the three types of croplands are soil fertility followed by soil physical indicators. There are positive correlations between soil bulk density and soil pH ($p<0.01$), between soil field moisture capacity and total phosphorus ($p<0.05$), between soil organic matter and total nitrogen ($p<0.01$), between soil organic matter and soil available potassium ($p<0.01$) and between soil organic matter and soil total phosphorus ($p<0.01$). The primary factors affecting the properties of soil in reclamation croplands are soil physical and chemical indicators for those croplands that have been reclaimed for 2 years and organic matter and soil nutrients for those croplands that have been reclaimed for 13 years and 18 years, as well as undamaged cropland. The distribution of the physical soil profile and chemical properties of the croplands that have been reclaimed for 13 and 18 years are highly consistent with the properties of the undamaged croplands.

Additional Key Words: land reclamation; soil reconstruction; soil quality

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1. Oral paper presented at the 2018 National Meeting of the American Society of Mining and Reclamation, St. Louis, MO: The Gateway to Land Reclamation, June 3-7, 2018. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.

2. Yingui Cao, Associate professor, School of Land Science and Technology, China University of Geosciences, Beijing, P. R. China 100083.

Implementation of the 2016 AML Pilot Program in Pennsylvania: Successes, Challenges, and Lessons Learned[1]

E.E. Cavazza[2], B. J. Bradley, and J.J. Stefanko

The Abandoned Mine Land (AML) Pilot Program, authorized by Congress under the Consolidated Appropriations Act (signed by President Obama on December 18, 2015), provided $30 million of US Treasury Funds to Pennsylvania's (PA) AML Program for federal fiscal year FY2016. Language contained in the authorizing bill specifies that the funding be used "for the reclamation of abandoned mine lands in conjunction with economic and community development and reuse goals. State AML programs, in consultation with state economic and community development authorities, shall develop a list of eligible AML projects in Appalachian counties that have a nexus to economic and community development, and select qualifying AML projects that have the potential to create long-term economic benefits."

The purpose of the AML Pilot Program is to both explore ways to return legacy abandoned coal sites to productive reuse and to inform Congress of the programmatic impacts of changes to the underlying federal law (the Surface Mining Control and Reclamation Act (SMCRA)) such as those included in the proposed RECLAIM Act which would accelerate distributions from the federal AML Trust Fund for similar economic revitalization and community development projects associated with the reclamation of AML sites.

Since this is a pilot program, PA selected 14 AML sites encompassing a wide variety of project types with a variety of possible economic or community development benefits and partners. PA is allocating all of the AML Pilot Program funds for the construction of SMCRA Title IV eligible AML and AMD problems. The project partners will then work to fund and complete non-AML economic development aspects of the projects. PA's 2016 AML Pilot Grant was approved on June 1, 2016 and has a three-year period of performance. This presentation will discuss the planned reclamation and anticipated benefits for each of the 14 AML Pilot Projects as well as the current status of each including project implementation successes, challenges, and lessons learned.

Additional Key Words: Abandoned Mine Lands (AML), Economic Development

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1. Oral paper presented at the 2018 National Meeting of the American Society of Mining and Reclamation, St. Louis, MO: Reclaiming the West, June 2-7, 2018. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.

2. Eric E. Cavazza, P.E., Director and Brian J. Bradley, P.G., Assistant Bureau Director, Pennsylvania Department of Environmental Protection, Bureau of Abandoned Mine Reclamation, Harrisburg, PA 17106; John J. Stefanko, Deputy Secretary, Office of Active and Abandoned Mining Operations, Pennsylvania Department of Environmental Protection, Harrisburg, PA 17101.

Retrofitting a Lime Doser with Automatic Siphon and MixWell System[1]

T.P. Danehy[2], C.A. Neely, R.M. Mahony, D.W. Petry

Abstract: An existing tipping-bucket lime doser active treatment system was retrofitted with and automatic dosing siphon and MixWell system, including a trompe-powered airlift mixing tank (A-Mixer), to decrease maintenance and increase treatment efficiency. An acidic (~300 mg/L hot acidity), metal-laden (12 mg/L Fe, 2 mg/L Mn, 21 mg/L Al) discharge from an abandoned coal mine with flows ranging from 0.2 to 24.1 L/sec (3 – 382 gal/min) was captured in a forebay and directed to a lime doser where calcium oxide is added at the top of a mixing channel leading to a series of two settling ponds and a wetland. The variable flow required frequent site visits to meet treatment goals and avoid undertreatment or overtreatment. Poor lime dissolution achieved in the mixing channel resulted in accumulation of unreacted lime in the settling ponds. A steady flow rate was established using a Fluid Dynamic Siphons Model 523 automatic dosing siphon to initiate periodic flush events that drain the forebay. The outlet of the siphon is plumbed to the center pipe of a MixWell with a nozzle that restricts the flow to 8.8 L/sec (144 gal/min), which is roughly the 88th percentile flow of the raw discharge. A small portion of the siphon discharge is drawn off prior to the MixWell and directed to the tipping-bucket lime dispenser that feeds lime to a sluice. The calcium oxide drops from the sluice into the top of the MixWell chamber. The lime-water mixture is then conveyed through a section of the existing mixing channel to the A-Mixer. The effluent of the A-Mixer tank flows through a 100 mm (4 inch) trompe that generates compressed air to run the airlift. Overall system performance has been enhanced through reduced maintenance needed to reach treatment goals and increased lime utilization efficiency.

Additional Key Words: Acid mine drainage, passive mixing, active treatment,

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2. Timothy P. Danehy, QEP, Principal and co-inventor of the MixWell (US Patent 9416027B2), Cody A. “Buck” Neely, Environmental Engineer, Ryan M. Mahony, Environmental Scientist, BioMost, Inc., Mars, PA 16046: David W. Petry, Restoration Program Manager, Friends of the Cheat, Kingwood. WV 26537.

Proactive Management of Imperiled Species to Avoid Federal Listing: Monarch Butterfly Habitat Enhancement on Mined Lands[1]

K. L. Dodson[2]

Abstract: The eastern population of the monarch butterfly has declined by 80% within the past 20 years leading several non-profit organizations to petition the USFWS to list the species for protection under the Endangered Species Act. Utilizing a proactive pre-listing approach to conservation of the species, a Mid-America Monarch Conservation Strategy is being developed that involves multiple stakeholders and sectors (e.g. utility corridors, road rights-of-ways, agriculture, private lands, reclaimed mined lands). Efforts are focused on voluntary habitat restoration/enhancement and promotion of land management best practices to avoid federal listing and subsequent regulatory requirements. Federal listing of a species with such a broad range across coal mining states could have a significant impact on permitting and reclamation requirements and a potential economic impact for permittees. The Illinois Department of Natural Resources/Land Reclamation Division participated in the regional strategy by drafting a chapter section focused on non-rights-of-way energy infrastructure. Information was gathered through discussions with OSMRE and by polling states with abandoned mined lands and regulatory programs located in the eastern core monarch population range. The chapter section presents current habitat enhancement initiatives on mined lands, outlines strategies for improvement of current efforts, explores the limitations unique to mined land reclamation, and details the potential scale restoration efforts on mined lands could contribute to the pre-listing approach to monarch butterfly conservation. Based on information obtained from nine responding states, at minimum half a million acres across the Midwest are bonded with post-mining land uses conducive to monarch butterfly and native pollinator habitat restoration. Educational outreach to permittees, consideration of pollinator seed mixes that adequately control erosion, development of BMPs specific to mined lands, and fostering partnerships that provide incentives for the voluntary adoption of higher priced seed mixes are necessary to move a mined lands monarch butterfly conservation initiative forward.

Additional Key Words: habitat restoration incentives, Mid-America Monarch Conservation Strategy, pollinator habitat, pre-listing approach to conservation.

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Peat Based Sorption Media – Passive Treatment of Trace Metals Without a Stink[1]

P. Eger, P. Jones, and D. Green[2]

Abstract: Mine drainage has been treated passively with biochemical reactors and wetlands for over 20 years but each approach has shortcomings. Both require contact times over 24 hours which requires large footprints, particularly for constructed wetlands. Biochemical reactors can remove trace metals from both acid and neutral mine drainage but often produce excess sulfide which can generate hydrogen sulfide. At a minimum, hydrogen sulfide can cause odor problems, but can also create hazardous conditions, particularly in confined or low-lying areas. BCRs also release elevated nutrients and organics during the start up phase. This water, if not properly managed, can cause downstream water quality problems. Wetlands can successfully remove trace metals from neutral mine drainage but in addition to the need for a large area, performance often decreases in the winter when water tends to channelize and the rate of biological reactions slow down. Peat sorption media is a granular engineered product made from natural reed sedge peat. It is lightweight, has a hydraulic conductivity similar to coarse sand, and can remove up to 1 -15% metal. The high permeability allows it to effectively treat 1 gpm/ft^2 with minimal head and the lightweight and granular nature of the material allows easy construction and media replacement. Other than a small amount of color in the initial pore volumes, there is no release of nutrients or organics. A pilot test was conducted at a base metal mine in North America. Three gravity flow biocells were constructed using 55 gallon barrels and operated at hydraulic residence times varying from 15 to 60 minutes. A small column was run concurrently so that removal could be evaluated as a function of depth and a removal capacity for the media could be estimated. The input mine water was circumneutral with average total metal concentrations of 2100 µg/l lead, 115 µg/l zinc and 0.8 µg/l cadmium; average dissolved concentrations were 150 µg/l lead, 70 µg/l zinc and 0.2 µg/l cadmium. Only the dissolved lead generally exceeded permit limits. Mine water was successfully treated for about 9 months. Lead removal varied from greater than 99% at the beginning of the study to over 80% when the test was stopped. Estimated lead removal capacity of the peat sorption media was greater than 0.5% lead

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The Use of GPS Treatment Data and ArcGIS tools to Evaluate Herbicide Treatment Effectiveness on a Reclaimed Coal Mine[1]

W. Erickson[2], Darrell Inskeep, and Matt Clark

Abstract: A coal mine located in the southwestern United States has been reclaimed and is working towards final bond release. Noxious weed management has been performed at various levels of intensity during the life of the mine. Since 2010 the mine has contracted noxious weed herbicide treatments, with emphasis on larger, higher density infestations. In 2017 mine management and the SMCRA regulatory agencies called for a quantitative evaluation of the effectiveness of herbicide treatments. Herbicide treatments have been recorded with environmental grade GPS units. Precipitation records and herbicide treatment data were used to quantitatively evaluate treatment effectiveness. This evaluation used Fishnets from ArcToolbox to perform a Grid Pattern Analysis to characterize treatment data. Mining area boundaries were used to establish Fishnet grids. Fishnets were sized at 929 square meters. A join was completed between Fishnets and herbicide data using the Spatial Join geoprocessing tool that resulted in a summary attribute field in a new Fishnet layer. This attribute field summarized the number of Herbicide Treatment Locations within each Fishnet. Fishnets with "0" treatment locations were deleted. The remaining Fishnets each contained one or more recorded herbicide treatment locations. Fishnets were then symbolized using quantitative values into three classes (low, medium and high) to graphically display density of noxious weed herbicide treatments. Data was exported to Excel for quantitative analyses. This process was repeated for each treatment year and mining area used in the comparison analyses. This GIS modeling resulted in an efficient method for quantitatively characterizing and graphically visualizing the effectiveness of noxious weed herbicide treatments. The analyses indicate that herbicide treatment of noxious weed infestations has been effective.

Additional Key Words: Southwest United States, Invasive Species, Fishnets, MS Excel.

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2. Wayne Erickson, Principal Environmental Scientist, Habitat Management, Inc., Englewood, CO 80112; Darrell Inskeep, GIS Director, Habitat Management, Inc. Farmington, New Mexico; and Matt Clark, Licensed Commercial Pesticide Applicator, Habitat Management, Inc., Englewood, CO, 80112.

Geomorphic Reclamation and Landscape Heterogeneity: Results of Vegetation Analysis and Implications for Wildlife[1]

Kurt Fleisher[2], Kristina M. Hufford[2], Peter D. Stahl

Abstract: Severe land disturbance is a consequence of surface mining operations. These disturbances damage the environment by causing pollution, by destroying habitats, by diminishing land aesthetics, and by creating hazards, which threaten public and private property. In Wyoming, anthropogenic disturbances caused by infrastructure development for resource extraction contribute to habitat loss for wildlife species such as Greater Sage-grouse (*Centrocercus urophasianus*) and pronghorn (*Antilocapra americana*). Changes in the plant community have the potential to alter an ecosystem via changes in structure and function, with a corresponding loss of habitat quality. Reclamation serves to mitigate the effects of mining by reconstructing the landscape to its former status. The traditional reclamation method results in terrestrial rebuild that is characterized by uniformity in slope in which topsoil is spread across the manufactured landscape. In contrast, geomorphic reclamation intends to mimic heterogeneous landforms that are not susceptible to severe erosional processes. The geomorphic design incorporates drainages, slopes, and aspects that naturally blend into the surrounding environment. Two surface mines in western Wyoming present an opportunity to compare reclamation methods and study the environmental outcomes of the geomorphic technique. We assessed differences in plant community recovery across reclamation types and undisturbed rangeland, with particular interest in the consequences for wildlife habitat and vegetation density, composition, and diversity. Data include nadir image analyses that allow for an efficient landscape-level assessment of vegetation functional groups between traditional and geomorphic sites; and BLM Assessment Inventory and Monitoring (AIM) vegetation transects that describe plant community characteristics, such as canopy cover, vegetation height, and species data at a finer scale. Initial results indicate that vegetation at both traditional and geomorphic reclamation sites differs significantly from nearby undisturbed rangeland. We will discuss results and describe similarities and differences between geomorphic and traditional reclamation methods for resulting plant community diversity and habitat quality indices.

Additional Key Words: restoration ecology, mine reclamation, plant community

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Hickory and Oak Growth Over 10 Years in Response to Initial Fertilization[1]

J.A. Franklin *[2] and D.S. Buckley

Abstract. Planted ground covers can compete strongly with planted tree seedlings, hindering reforestation efforts. Fertilization may benefit both trees and ground cover, but its effects on the balance of these competitive interactions are unclear. A 3x3 factorial experiment with 3 levels of fertilizer application and 3 seeding rates was established in 2006 to test for differences in tree seedling growth and survival, and for differences in ground cover establishment and composition. Treatments were applied by hydroseeding a mixture of native warm-season grasses, annual ryegrass and Korean lespedeza at around 6, 30, or 60 kg/ha, along with 10:20:20 water soluble fertilizer at rates of 1, 224, or 448 kg/ha. Bare-root, 1-0 tree seedlings of scarlet oak, white oak, black walnut, and mockernut hickory, along with mockernut hickory seed, were planted on an 8x8 foot spacing. Tree growth and survival, and ground cover establishment have been monitored. After seven years, white oak survival was consistently good across plots with an overall average of 69% and hickory was consistently poor across plots with less than 5% survival. Survival of scarlet oak and black walnut was highly variable, averaging 46% and 33%. After 10 years the plots had reached canopy closure. Survival was similar to the previous sampling period; white oak survival was 71%, scarlet oak was 51%, and black walnut was 36%. More hickory was recorded in 2016 than had been previously, with survival rates of 10% for hickory planted as seed and 6% for hickory planted as seedling. White oak diameter averaged 49 mm in plots with the highest fertilization rate, compared to 43 mm in plots receiving less fertilizer.

Additional keywords: hardwoods, Quercus, Carya.

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3. Work reported here was conducted near 36° 29’ 34” N; 84° 17’ 05” W.

Using groundcover to Outcompete Tall Fescue (*Festuca arundinacea*) without outcompeting tree seedlings on a legacy mine site[1]

M. Aldrovandi*[2] and J.A. Franklin

Abstract. The purpose of this study was to determine which of nine ground cover species would outcompete tall fescue (*Festuca arundinacea*) without outcompeting tree seedlings on a legacy mine site. Horseshoe Mountain, a former mine site reclaimed in the 1990s, located in Claiborne County, Tennessee was ripped in fall 2016. Prior to ripping, autumn olive (*Elaeagnus umbellata*) and other invasives were removed using a chainsaw and herbicide. The site was planted in February 2017 with 49% shortleaf pine (*Pinus echinata*); 13% chinkapin oak (*Quercus muehlenbergii*); 9% American chestnut (*Castanea dentata*); 7% each of black oak (*Quercus velutina*), northern red oak (*Quercus rubra*), and southern red oak (*Quercus falcata*); plus woody wildlife species totaling 158 stems per ha. Fifty permanent plots were installed in May 2017. Ground cover treatments were applied to 20 trees per plot. A 1m² hoop was placed over trees; 9 different species of groundcover seeds were dispersed within the hoop. It was hypothesized that ground cover species that do not have shallow root systems with extensive surface area will be less competitive with tree seedlings than species that have shallow root systems with extensive surface area. Of the 9 ground cover species planted, 3 species showed good establishment. Sunn hemp (*Crotalaria juncea*) produced an average of 16.7g dry weight/m2, ragweed (*Ambrosia artemisifolia*) produced an average of 13.7g dry weight/m2, and sorghum (*Sorghum bicolor*) produced an average of 10.0g dry weight/m2. Competition will be further determined by tree growth (RCD and height), transpiration rate, and chlorophyll content.

Additional keywords: mining, groundcover, competition, *Festuca*.

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2. Matthew Aldrovandi is a Master's Candidate in the Department of Forestry, Wildlife and Fisheries, University of Tennessee, 274 Ellington Plant Science, Knoxville, TN, 37996. (865) 974-8659, maldrova@vols.utk.edu. Jennifer A. Franklin is a Professor in the Department of Forestry, Wildlife and Fisheries, University of Tennessee, 274 Ellington Plant Science, Knoxville, TN, 37996. (865) 974-2724, fax (865) 974-4714, jafranklin@utk.edu
3. Work reported here was conducted near 36° 31' 21" N; 83° 55' 17" W.

Mine reclamation using bioenergy crops: An investigation into plant-microbe interactions of switchgrass (*Panicum virgatum*)[1]

Brianna L. Mayfield[2] and Zachary B. Freedman

Abstract: Bioenergy crop production has recently increased, initiating demand to find alternative growing land. One attractive option is the use of marginal soils, such as reclaimed minelands, for bioenergy crop agriculture. Switchgrass (*Panicum virgatum*) is a promising bioenergy crop that can be grown on marginal lands due to its robust growth in various soil types and climates. However, little is known regarding plant-microbe interactions among switchgrass systems within reclaimed minelands. Investigating the mineralization and acquisition of critical nutrients, i.e. carbon (C), nitrogen (N), and phosphorus (P) will provide insight into reclamation impacts on plant-microbe interactions in marginal soils. Data were obtained from two switchgrass cultivars grown on high- and low-quality reclaimed mine sites (Hampshire and Hobet, respectively) in West Virginia[3]. Switchgrass yields at Hampshire were nearly an order of magnitude higher than Hobet (8.4 Mg ha^{-1} vs 1.0 Mg ha^{-1}). Within Hampshire, the Cave-in-Rock cultivar yield was approximately 2-fold greater than that of Shawnee (12.9 Mg ha^{-1} vs. 7.6 Mg ha^{-1}). Here, we illuminate plant-microbial interactions that may account for this drastic shift in cultivar yield by combining enzymatic activity analyses with shotgun metagenomics. Hampshire showed significant increases in extracellular enzymes associated with mineralization and acquisition of critical nutrients as compared to Hobet. A significant site × cultivar interaction was found for acid phosphatase activity, indicating differences in the genomic capacity of the soil microbiome to cycle P between sites and cultivars. Metagenomic analyses showed significant differences in C- and P- associated gene abundances, but showed no difference in N-associated or "housekeeping" genes. Further, genes associated with phosphonate metabolism had significantly greater abundance in Hampshire versus Hobet (+1350%; $p<0.01$) and a significant site × cultivar interaction was found ($p<0.01$). Together, these data suggest microbial community differences that potentially affect nutrient cycling capabilities and switchgrass biomass yield between both Hampshire and Hobet.

Additional Key Words: shotgun metagenomics, marginal land use.

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2. Brianna L. Mayfield, Graduate Student, Plant and Soil Sciences, West Virginia University, Morgantown, WV 26506; Zachary B. Freedman, Assistant Professor, Plant and Soil Sciences, West Virginia University, Morgantown, WV 26506.
3. Work reported here was conducted near 39° 24' N; 79° 06' W (Hampshire) and 38° 06' N; 81° 36' W (Hobet).

Sloping Sand Filtration Bed for Mineral Sand Plant Effluent Clarification[1]

J. Gusek[2], J. Renner, and D. Settles

Abstract: The Southern Ionics Minerals, LLC (SIM) mine and mill in southeast Georgia recover heavy mineral sands rich in zircon and titanium minerals. The sand ore contains a naturally-occurring, low-density organic humate fraction that is dissolved and suspended in the process water. Process water can be treated to settle humates, but settled humates are notoriously difficult to de-water and cause long-term pond management challenges. Thus, a low-cost efficient process was needed to remove and dewater humate particles from a process stream with a typical flow rate of about 380 m^3-d^{-1} and a concentration of 400 ppm TSS. Flocculating and coagulating reagents facilitated settling but the process solution still required clarification. Slow sand bed filtration and other solid-liquid separation methods (e.g., settling ponds, nanofiltration, and commercial sand filters) were considered and rejected due to excessive costs and maintenance concerns associated with repeated back-flushing and handling settled humates. A 50-year-old "passive" de-watering technology looked promising: the metal mining industry used sub-aerial deposition methods similar to slow sand bed filtration to manage very fine-grained tailings (minus 74 µm). The process is described in more detail in the on-line GARD Guide. Following the design principles for sub-aerial tailings management, the design team devised a series of bench tests that SIM personnel conducted at the mill site. The team called the process the "sloping sand bed" (SSB). Positive results from a series of batch and continuous flow tests supported SIM's decision to construct a full scale 0.57 ha SSB to handle an average discharge of 0.26 m^3-min^{-1} containing just 0.05% suspended humate. A full scale SSB was constructed over the summer of 2017; it began to receive humate-laden feed from the mill in October 2017. It is functioning as designed and its discharge meets SIM's water quality goals.

Additional Key Words: sub-aerial tailings deposition methods

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3. Work reported here was conducted near 31°25'1.52"N; 82° 6'5.79"W.

Lion Mining Borehole Project: Drilling a Flowing Artesian Water Well into a Mine Pool[1]

D.A. Guy[2], T.P. Danehy, C.A. Neely, S.L. Busler, M.H. Dunn

Mine discharges in the coal regions do not always issue at locations with sufficient area to facilitate the construction of treatment systems. Obstructions such as highways, dwellings, streams, or unworkable topography often necessitate the construction of a system in areas far removed from the initial point of issue. This was the case of the Lion Mining Grove #1 Mine where a 200 mm (8 inch) water well was drilled to a depth of 180 m (600 feet) into a flooded underground coal mine in 2003. The flowing artesian well was situated adjacent to a newly constructed active system to avoid the need for pumping of the 50 L/sec (800 gal/min) alkaline-iron discharge. The mining company subsequently closed, and the Pennsylvania Department of Environmental Protection (DEP) assumed operation of the well and treatment system in 2006. Leaks developed around the top of the well and several measures were taken to prevent a major uncontrolled discharge. DEP replaced the active system with a wetland-based passive treatment system in 2011 but corrosion of the mild-steel casing and related appurtenances continued to raise concerns. DEP assembled a project team and installed a new well in 2016 using stainless steel casing and plugged the original well. This case study will discuss design and construction aspects and obstacles overcome during the Lion Mining Borehole Project from the planning process, through drilling and new well construction, and the decommissioning of a failing flowing artesian water well.

Additional Key Words: Mine drainage treatment, well plugging and abandonment.

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2. Daniel A. Guy, PG, Timothy P. Danehy, QEP, Principal, Cody A. “Buck” Neely, PE, Shaun L. Busler, GISP, Margaret H. Dunn, PG, BioMost, Inc., Mars, PA 16046.

Soil Water Quality of Reforested Mine Site Twelve Years after Reclamation[1]

A. Hass*, T. Geberehiwot, D. Hall, J.G. Skousen, and R. Cantrell[2]

Abstract: Forestry reclamation approach (FRA) shown to improve success of reforestation of mine sites in Appalachia by alleviating soil compaction and selection of proper topsoil replacement materials conducive to root growth. Material selection and management practices also expect to affect soil water quality and composition. This study evaluate the effect of FRA practices, namely the use of oxidized vs reduced sandstone spoils as topsoil replacement material, and loose vs compacted placement thereof on soil water quality of a WV mine site[3] 12 years after reclamation. Two large experimental plots (ca. 2.8 hectare each) established in 2005 using brown sandstone or gray sandstone spoils as topsoil replacement material. Each plot was further split into two subplots where the material was compacted or loosely placed. Shallow wells and zero-tension pan lysimeters (30 to 80 cm deep) installed near three random locations within each treatment plot (spoil type x placement practice) during early spring of 2017 to collect and monitor water quality. Water samples were collected weekly from June to mid-November, 2017 and analyzed for elemental and ionic composition, total alkalinity, total and organic and inorganic carbon, as well as dissolve oxygen, pH, temperature, and redox potential. Initial results showed levels of alkali and alkaline earth metals within the range of benchmark reference values for surface water in WV (0.8 – 1.9 times the reference levels) while that of Fe, Mn were much higher (878, and 604 times the reference levels of 0.019, and 0.016 mg L-1, respectively). Levels of heavy metals were elevated as well (1.8, 23, and 37 times the reference levels of 0.0076, 0.0027, and 0.0008 mg L-1, for Ni, Zn, and Cu, respectively). Overall, redox processes and seasonal variation therein seemed to govern metal solubility, nitrogen speciation, and pH of the reclaimed mine site soil solution 12 years after reclamation.

Additional Key Words: redox potential, spoil, brown sandstone, Forestry Reclamation Approach

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3. Work reported here was conducted near 38° 02’ 42” N; 81° 30’ 30” W.

Using novel geophysical techniques to relate surface coal mining fill characteristics to effluent stream water quality[1]

K.L. Little, J. Buckwalter, C. Zipper, T. Burbey, and E.T. Hester[2]

Abstract: Surface coal mining has altered Appalachian landscapes, affecting water quality and aquatic ecology. Valley fills created from excess overburden are prominent features of many mined landscapes. Increased total dissolved solids (TDS), as measured by its surrogate specific conductance (SC), is a significant water quality concern related to the exposure of fresh mineral surfaces to weathering in valley fills. Specific conductance levels in waters draining Appalachian mined areas are highly variable, yet the causes for this variability are not well known. Here we sought to improve understanding of such variability by connecting it to valley fill characteristics such as age and construction method. We used electrical resistivity imaging (ERI) to investigate the geologic structure of four valley fills in two dimensions. We combined ERI with artificial rainfall to investigate the location and residence time of hydrologic preferential flowpaths through the fills. Finally, we used borings, tracer tests, and SC measurements in effluent streams to corroborate the ERI results and improve understanding of relationships between fill characteristics and SC. We found that ERI is able to successfully distinguish fills constructed using conventional loose-dump and experimental controlled-material compacted-lift construction methods. Conventional fills had greater ranges of resistivity in the subsurface indicating a wider range of substrate types. Conventional fills also showed more accumulation of water within the fill during artificial rainfall, possibly indicating greater quick/deep preferential flowpaths than in the experimental fill. Bore logs confirm the ERI structural interpretations. Tracer tests indicate that accumulations of water within the fills during rainfall may only flush out later during larger storm events. ERI results indicate that flow within valley fills is highly preferential with most infiltrating water interacting with only a small subset of the fill volume. ERI appears to be a robust non-invasive technique that provides reliable information on valley fill structure and hydrology, and experimental compacted-lift valley fill construction produces significantly altered hydrologic response, which in turn affects downstream SC.

Additional Key Words: Geophysical Inverse Modeling, Stormflow, Preferential Flow, Conductivity

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2. K.L. Little and E.T. Hester, Civil and Environmental Engineering; J. Buckwalter and C. Zipper, Crop and Soil Environmental Sciences; T. Burbey, Geosciences, Virginia Polytechnic and State University (Virginia Tech), Blacksburg, VA, 24060

Correlating Surface Water Quality and Spectral Reflectance with small Unmanned Aerial System (sUAS)-Collected Imagery[1]

B. K. Holzbauer-Schweitzer* and R. W. Nairn[2]

Abstract: Remote sensing is the science or art of obtaining information about an object on Earth's surface without encountering it. Every object has a unique spectral signature, which is determined by measuring the amount of solar energy reflected off the surface of the object (spectral reflectance). This information can be used to examine vegetation health, surface water quality, and land cover characteristics. The purpose of this project was to correlate the spectral reflectance of surface waters in passive treatment systems (PTS) to the measured *in-situ* water quality at the time of flight, with the goal of developing statistical models capable of predicting *in-situ* surface water quality thus minimizing the need for laborious and costly surface water quality sampling and analyses. The specific sUAS utilized for this research was the Aerial Technologies International (ATI) AgBot, paired with the MicaSense RedEdge Multispectral sensor. This sUAS can operate autonomously and capture extremely high-resolution (centimeter scale) multispectral imagery at five discrete bandwidths within the electromagnetic spectrum. As part of a larger project, the sUAS was used to evaluate surface water quality in two PTS located in the Tri-State Lead-Zinc Mining District: Mayer Ranch and Southeast Commerce Passive Treatment Systems (MRPTS and SECPTS), respectively. Thus far, the correlation coefficients (R) for interpolated water quality (e.g., aluminum, iron and lead concentrations) and spectral reflectance ranged from -0.49 to 0.61. Linear models produced regression coefficients (R^2) of 0.31, 0.13, and 0.23 for aluminum, iron, and lead, respectively. These relationships represent preliminary results and will be improved as future work is completed. Future work for this study includes examining varying pixel window size (e.g., how many pixels are represented by a single surface water sample), determining an appropriate time window, performing a more extensive *in-situ* sampling event, and investigating the correlation within all components of the PTS.

Additional Key Words: Remote Sensing, Passive Treatment Systems, Statistical Models, Interpolation

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2. Brandon K Holzbauer-Schweitzer, Graduate Research Assistant (student) and Robert W. Nairn, Professor, Center for Restoration of Ecosystems and Watersheds, School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK 73019.

Innovation of Filling Reclamation with Multi-Layered Soil Profile[1]

Zhenqi Hu [2]

Abstract: Filling reclamation is an effective way to increase the amount of farmland. The existing reclamation technology adopts one-time filling measures, which leads to classic two-layer soil profile pattern with "soil layer + filling material layer." As covering soil is insufficient, the productivity of reclaimed farmland is usually low. This paper put forward a multi-layered soil profile pattern with inter-layers of filling materials. Taking filling reclamation of subsidence land with Yellow River Sediments as an example, this study analyzes the principles and methods of inter-layers reclamation. The results show that: (1) Adding a soil layer as inter-layer in filling material layer could improve the moisture and nutrition situations of filling material, overcome the disadvantages of two-layer soil profile pattern with "soil layer+ filling material layer", and increase the quality of reclaimed farmland. (2) An alternate multilayered multi-filling method for soil reconstruction with reclaimed mining subsidence was proposed. The continuous construction technology of multilayered soil profile reconstruction is realized through alternate filling process, multiple filling, and soil backfilling. (3) Practices were carried out in Qiuji mine of Shandong province. Multi-layered soil profile pattern has certain influence on wheat output. The wheat outputs of some profile patterns are higher than that of the control group.

Additional Key Words: filling reclamation; mining subsidence land; soil reconstruction; soil water; filling technique; soil profile.

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2. Zhenqi Hu, Professor, Institute of Land Reclamation and Ecological Restoration, China University of Mining and Technology-Beijing, Beijing, China, 100083.

Stormwater Management for a Large Open-Cast Coalmine: A Case Study And Proposed Solutions[1]

J. Hugo, N. Mcknight, L. Madison, D. Madl, E. Baker, A. Rovder, S. Shoemaker, R. Siwy, S. Long, and W. Strosnider[2]

Abstract: Stringent discharge limits are faced be a large open-cast coal mine located in a semi-arid temperate coastal region that receives the vast majority of its rainfall in a few intense stormy periods per year. In order to most consistently achieve compliance, characteristics of the water quality and quantity as well as mine the mine site were diagnosed. Then solutions were presented. These solutions include infiltration basins, infiltration berms on the overburden pile, revegetation with deep-rooted trees and grasses, a sedimentation vortex system, improved streambank armoring, gabion baskets, check dams, and most importantly an infiltration basin with a floating decanter and an outflow control structure. These solutions are proposed to be applied together but due to cost, some management practices many not be included in the final applied solution set.

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1. Poster to be presented at 2018 National Meeting of the American Society of Mining and reclamation. Needs More!
2. Work completed under William Strosnider, Professor, Environmental Engineering, Saint Francis University, Loretto, PA.

An assessment of long-wall mining subsidence on internationally important floodplain meadows: I. Plant communities and their response to increase in wetness[1]

P. R. Benyon[2] and R. N. Humphries

Abstract: The floodplain meadows of the River Derwent are of international importance and designated as a Special Area of Conservation for their floristic composition and a Special Protection Area for the over wintering and breeding wetland bird assemblages they support. The meadows of the Lower Derwent Valley are of particular importance as they have the most extensive *Alopecurus pratensis – Sanguisorba officinalis* (MG4) type of mesotrophic grassland in the UK and one of the most extensive of the type in Europe. The maintenance of their conservation status is dependent on the degree and duration of waterlogging events. Long-wall mining induced subsidence differentially lowers the ground surface and is known to alter hydrological regime of the floodplain and its floristics. This first paper defines the plant communities present, including MG4, their susceptibility and response to increases in wetness using both experimental and observational techniques with the aim of informing assessments of the impact of long-wall mining.

Additional Key Words: MG4 grassland, inundation grasslands, Lower Derwent Valley

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2. Paul R. Benyon, Dunkirk, Nottingham NG7 5JE, UK; R Neil Humphries, Blakemere Consultants Ltd, Dorchester DT1 3RZ, UK.

An assessment of long-wall mining subsidence on internationally important floodplain meadows: II. A model for the prediction and quantification of impact and mitigation[1]

R. N. Humphries[2] and P. R. Benyon

Abstract: The floodplain meadows of the River Derwent are legally protected as a Special Area of Conservation and their wetland bird assemblages of a Special Protect ion Area. Consequently, following the designations, further mining activity under the Lower Derwent Valley floodplain and the future of the Selby Mine Complex was dependent on either there being no significant impact of long-wall mining on the extent and type of floristic composition or that mitigation was possible by either controlling water levels or their replacement elsewhere. This second paper considers the nature of the subsidence-induced changes in hydrology and distribution of plant communities, and in particular on *Alopecurus pratensis – Sanguisorba officinalis* (MG4) mesotrophic grassland. A regression model is developed which enables the quantification of the extent and degree potential impact and mitigation required. The model is able to determine and quantify the mitigation by either defining the water-level control necessary to maintain the floristic composition or the extent of the affected communities to be recreated as compensation.

Additional Key Words: MG4 grassland, inundation grasslands, Lower Derwent Valley

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1. Oral paper presented at the 2018 National Meeting of the American Society of Mining and Reclamation, St Louis, MO: The Gateway to Land Reclamation, June 2 – 7, 2018. Published by ASMR, 1305 Weathervane Dr., Champaign, IL 61821.
2. R Neil Humphries, Blakemere Consultants Ltd, Dorchester DT1 3RZ, UK; Paul R. Benyon, Dunkirk, Nottingham NG7 5JE, UK.

The Deployment and Risks Associated with Different Types and Combinations of Earth Moving Equipment in the Restoration of Functional Soil Profiles: An updating of the UK Guidance[1]

R. N. Humphries[2], P. Close, and J Thorne

Abstract: Practical guidance for the handling soils by different earth-moving machines was published by the UK's Ministry of Agriculture, Fisheries and Food in 2000. The guidance comprised detailed recipes for achieving the best and consistent outcomes for three types/combinations of equipment used for the stripping, storage and replacement of soils. It was in a form which could be understood and used by professionals and machine operators alike, and has been widely used across the minerals industry for almost twenty years. During this time there has been significant changes in the preference for the type of earth moving equipment used by the minerals industry and general acceptance that certain combinations are preferable for certain land uses and quality than others. In recognition of the positive contribution the guidance has made to the sustainable working of minerals, the industry through its professional body, the Institute of Quarrying, and Natural England, the agency acting for the UK Government's Department of the Environment, Framing and Rural Affairs on land use and minerals policy for England and Wales, got together in 2017 to publish an updated version by 2019 which covers the changes in the most commonly used earth moving equipment and advances in site practices.
This paper will examine aspects of the contextual deployment of current combinations of earth moving machines in mine site development and closure in relation to planning policy, and the inherent risks and limitations on the practices available for the restoration of land use and quality.

Additional Key Words: excavator, bulldozer, dump-truck.

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2. R. Neil Humphries, Blakemere Consultants Ltd, Dorchester DT1 3RZ, UK; Peter Close, Government Advice Team, Natural England, Newcastle upon Tyne NE4 7YH; James Thorne, Chief Executive, Institute of Quarrying, Nottingham NG9 6RZ, UK.

Aspen sprouting response to above ground disturbance on a reclaimed boreal oil sands site in Alberta, Canada[1]

S.A. Jean*, B.D. Pinno, and S.E. Nielsen[2]

Abstract: Reclamation of an oil sands mine requires the re-establishment of a self-sustaining ecosystem, consisting of native species. Aspen (*Populus tremuloides* Michx.) are an important early successional species in the boreal region. After an above ground disturbance, aspen commonly regenerate via root suckering and stump sprouts, herein defined as sprouting. Abundant sprouting is important for successful re-establishment of aspen stands, and is seen after forest fires and harvesting. However, we do not know how abundant sprouting would be on recently reclaimed oil sand sites if they were affected by a disturbance. To determine the sprouting response of aspen growing on a reclamation site to an above ground disturbance we cut individual trees 2.5 cm from the ground in May of 2017. Trees were selected across the two soil types used on the reclamation site: forest floor-mineral mix and peat-mineral mix; as well as across three height classes: 100-199.9 cm, 200-299.9 cm, and >300 cm. In August of 2017, we returned to each cut tree to assess the type (sucker vs. stump sprout) and abundance of regeneration. Soil type had a significant effect on the amount of sprouting, with trees on peat-mineral mix producing 13 suckers and 10 stump sprouts on average per tree, while trees on forest floor-mineral mix produced 8 suckers and 3 stump sprouts on average. Taller trees tended to produce more suckers; however, height did not have an effect on the number of stump sprouts produced. Competitive effects on sprouting were also assessed, with higher amounts of competition, especially from grasses, hampering sprouting response. This could be a factor when comparing soil types, as forest floor-mineral mix tends to have much higher ground cover compared to the peat-mineral mix. Overall, the use of peat-mineral mix soil is more beneficial for facilitating aspen sprouting post-disturbance on a reclamation site.

Key Words: *Populus tremuloides*, root suckering, sprouting, forest regeneration, land reclamation, resiliency

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1. Oral paper presented at the 2018 National Meeting of the American Society of Mining and Reclamation, St. Louis, MO: The Gateway to Land Reclamation, June 2 - 7, 2018. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.
2. Stephanie A. Jean, M.Sc. student; Bradley D. Pinno, Professor; Scott E. Nielsen, Professor, Department of Renewable Resources, University of Alberta, Edmonton, Alberta, Canada.

Seeding Techniques to Promote Woody Plant Establishment in the Northern Great Plains[1]

G.L. Johnson[2]*

Abstract: The majority of the grassland areas in south central Montana include woody plants such as Wyoming big sagebrush and Winterfat. Establishing woody plants in reclamation can be challenging because of the direct competition with desirable and undesirable grasses. Additionally, reclamation requirements include establishing an adequate amount of native grasses to control erosion, control weeds, and provide adequate ground cover for wildlife and livestock. The Spring Creek Mine[3] (SCM) uses different soil substrates and segregated seeding techniques to promote an ecological environment where woody plants can establish. SCM has successfully used the seeding techniques since 2013 and has successfully used different substrates since 1997. SCM received the 2017 Office of Surface Mining Excellence in Reclamation award for success using these techniques. The poster will detail reclamation techniques used to promote an ecological environment for woody plant establishment. Using different soil substrates and segregated seeding techniques can usually be implemented by making simple changes to revegetation methods. The result can be improved ecological diversity providing important forage for wildlife and livestock.

Additional Key Words: soil substrates, vegetation competition, reclamation

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2. Gabe L. Johnson*, Environmental Engineer, Cloud Peak Energy Spring Creek Mine, Decker, MT, 59025.
3. Work reported here was conducted near 45°12’ N, 106°91’ W.

Case Study to Assess the Costs of the Appalachian Regional Reforestation Initiative's (ARRI) Forest Reclamation Approach[1]

J.W. Johnson[2], M.G. Jacobson, and E. Oliver

Abstract: Conventional methods of reclamation in the Appalachian region have been shown to inhibit the growth of forest trees on post surface-mined land. Unsuitable topsoil substitutes, high rates of soil compaction, as well as the use of fast-growing groundcovers create unfavorable conditions for tree growth. The ARRI has developed a process known as the Forestry Reclamation Approach (FRA) to address these problems and promote the restoration of healthy forests. The FRA emphasizes the placement of at least four feet of uncompacted rooting medium, slow-growing groundcovers, and the use of professional tree-planting techniques. Despite the obvious ecological advantages of the FRA, there is no single source presenting a complete economic analysis of the technique compared to conventional reclamation practices. A case study is currently being conducted to compare costs of the two reclamation approaches in Pennsylvania, where mining occurs mainly on previously-forested land. Real-time cost analyses on several active mines will assess appropriate spoil materials, grading, and seeding/planting. Active mine data from Pennsylvania will be paired with a compilation of regional industry data from representive Southern, Central, and Northern mining operations. Data will illustrate material handling, grading, soil amendment requirements, groundcover establishment, tree planting, and maintenance of sediment control structures. Preliminary results will be presented and implications discussed. The importance of this work is to show landowners and operators that they have options, other than conventional reclamation, that result in productive long-term benefits and the restoration of sustainable native forests.

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2. Jacob W. Johnson, PhD Candidate, Forest Resources, Department of Ecosystem Science and Management, Pennsylvania State University, State College, PA 16803; Michael G. Jacobson, Professor, Forest Resources, Department of Ecosystem Science and Management, Pennsylvania State University, State College, PA 16803; and Eric Oliver, Mineral Resources Program Specialist, Department of Environmental Protection, Philipsburg, PA 16866.

What is the best time of year to use prescribed fire to control invasive shrubs? A case study from the Upper Midwest[1]

Yari Ben Johnson[2], Daniel Brumm, & Kelly Weede

Abstract: The control of invasive woody species presents one of the greatest challenges for restoration and revegetation of fire-dependent ecosystems. While the vast majority of prescribed burning occurs in the early spring, there is evidence that burning during other times of the year can offer more effective control of undesirable species. This project investigated how seasonality, fire temperature, and fire residence time interact to influence stem damage and resprouting of invasive woody shrub species that are often targeted by prescribed fire treatments in in the Upper Midwest. Common buckthorn (*Rhamnus cathartica*) and honeysuckle (*Lonicera* spp.) are exotic invasive species that frequently degrade revegetated mine land, forest understories, edges, and grasslands in the Upper Midwest. Prescribed fire was simulated using a propane torch system designed for treating invasive plants. Invasive plant stems were burned for either short (15-second) or long (30-second) durations and hot (>246° C) or moderate (125-175° C) temperatures over four different seasons (spring, early growing season, late growing season, and fall). Each treatment regime and a control were randomly assigned to 20 invasive plants (for a total n = 340) in a prairie restoration on the campus of the University of Wisconsin-Platteville. These fire residence times and temperatures were derived from temperature profiles of prescribed fires conducted in the spring of 2016 in southern Wisconsin. Top-kill and resprouting were subsequently determined for each plant one-month following treatment. Initial results show that late-growing season burns (late-October through early November) are best for controlling invasive shrubs compared to burning at other times of the year. Season of burn predicted more top-kill than temperature or residence time. Based on these results, practitioners who want to control invasive shrubs in the Upper Midwest should focus their efforts on fall prescribed burns.

Additional Key Words: season of burn, revegetation.

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2. Yari Ben Johnson, Assistant Professor and Director, Reclamation, Environment & Conservation program, University of Wisconsin-Platteville, Platteville, WI 53818.; Daniel Brumm, student, Reclamation, Environment & Conservation program, University of Wisconsin-Platteville, Platteville, WI 53818; Kelly Weede, student, Reclamation, Environment & Conservation program, University of Wisconsin-Platteville, Platteville, WI 53818.

Restoration of the Soil Microbiome Following Mine Land Reclamation[1]

J.L. Kane[2], Z.B. Freedman, J. Skousen, and E.M. Morrissey

Abstract: Federal law requires coal companies to restore a previously-mined site to equal or better condition as it was prior to the initiation of mining activities. In West Virginia alone, more than 500,000 acres of land have been reclaimed in the past 40 years. However, in many cases, even after reclamation standards have been met, poor soil quality still limits the potential for profitable post-mining land uses. One crucial knowledge-gap in mine land reclamation is how reclamation practices impact the assembly and recovery of the soil microbial community. Elucidating microbial community assembly processes in these lands is important, because the soil microbiome contributes to critical ecosystem services, for example, carbon (C), nitrogen (N), and phosphorous (P) cycling and storage. To address this knowledge gap, soil samples were taken at four sites in northern West Virginia which were reclaimed from strip mining activities 2, 10, 15, and 32 years ago; all four sites are within a 15-mile radius, experience a similar climate, and have similar soil types and reclamation strategies. It is hypothesized that, with increased time since reclamation, microbial activity, and diversity will increase, thus increasing soil quality. With increased time since reclamation, the soil microbiome displayed an increase in extracellular enzyme activity associated with labile C compound mineralization (β-glucosidase; + 61.6%, $P < 0.05$) and N mineralization (N-acetyl-β-D-glucosaminidase; + 121.4%, $P < 0.05$), and a decrease in enzyme activity associated with complex C compound mineralization (peroxidase and phenol oxidase; - 71.5% and - 54.8%, respectively; $P < 0.05$). The soil microbiome also increased in biomass (+ 53%; $P < 0.05$) over time. Together, these data suggest the importance of labile C and organic N, as well as the lesser-importance of recalcitrant C to the recovery of the soil microbiome and thus, soil health following mine land reclamation.

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2. Jennifer L. Kane, Graduate Student, Zachary B. Freedman, Assistant Professor, Jeffrey Skousen, Professor, and Ember M. Morrissey, Assistant Professor, Plant and Soil Sciences, West Virginia University, Morgantown, WV 26506.

A Suite of Options at Tar Creek[1]

Tim Kent[2], Craig Kreman, and Summer King

Abstract: The Quapaw Tribe of Oklahoma was the first tribe in the nation to assume the lead over an EPA Superfund site. The Tar Creek Superfund Site is in Northeast Oklahoma[3], and is a former lead and zinc mine. Closed in the 1960′s, Tar Creek was listed on the National Priorities List in 1983. Since that time, more than 35 teragrams of mine tailings have been identified, and the 100 square kilometer site is undergoing active remediation. A suite of options has been developed for use at Tar Creek, where top soil is scarce. These include the use of soil amendments with short- and long-term performance measures, utilizing ecological-risk cleanup goals, and GIS mapping utilizing kriging, in addition to the traditional excavation approach. Working with landowners, EPA, and state officials, the Tribe determines the best approach on a site-by-site basis, so that the remediated site can be returned to productive use.

Additional Key Words: CERCLA, Tri-State Mining District.

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2. Tim Kent, Environmental Director; Craig A. Kreman, Assistant Environmental Director/Environmental Engineer; Summer R. King, Environmental Scientist, Quapaw Tribe of Oklahoma, Quapaw, OK 74363.
3. Work reported here was conducted near 36° 58′ 21″ N; 94° 49′ 52″ W.

Loblolly Pine Survival and Growth on a Reclaimed Mineral Sands Mine in Southeastern Virginia[1]

S.K. Klopf*, W.L. Daniels, and D.M. Evans[2]

Abstract: Mineral sands mining for zircon and ilmenite in southeastern Virginia results in compacted soils with low fertility and low pH. Loblolly pine (*Pinus taeda*) is a common timber species planted in the southeastern USA that is well-adapted to sandy, infertile, somewhat poorly drained soils. Loblolly pine plantations generally require minimal inputs by landowners and may be a preferred post-mining land use for many. In 2013, we initiated a study on a recently reclaimed mineral sands mine to assess the effects of fertilizer amendment (F), weed control (WC), and fertilizer plus weed control (WCF) treatments on loblolly pine growth and survival. Bare root seedlings were planted in January 2013 and treatments were actively managed during the first two growing seasons. Fertilizer treatments were applied in March 2013 and June 2014 with 56 kg/ha N as urea, 12 kg/ha N as DAP, 28 kg/ha P_2O_5 as DAP, and 56 kg/ha K_2O as potash. Fertilized trees also received 114 kg/ha granulated trace minerals in June 2014. In March and June 2013, and June 2014, 1.5 m circle was sprayed with 1% glyphosate around trees in weed control treatments. After five growing seasons, overall mean survival was 74.4%. Survival was highest in the C treatment (92.9%) and lowest in the F treatment (53.0%) ($p=0.013$). Trees in the WCF treatment had the greatest mean height (332.6 ± 7.0 cm) and ground line diameter (GLD, 9.23 ± 0.21) after five growing seasons. WCF trees also had the greatest total height and GLD growth. Overall growth rates were lower than regional undisturbed soils over the first two growing seasons but by year three, growth rates were similar to expected natural stand growth rates. Our findings show that the combination of weed control and fertilizer was the most effective treatment for loblolly pine growth in this reclamation environment.

Additional Key Words: Silviculture

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[2] Sara K. Klopf, Research Associate, Crop and Soil Environmental Sciences, Virginia Tech, Blacksburg, VA 24061; W. Lee Daniels, Professor Crop and Soil Environmental Sciences, Virginia Tech, Blacksburg, VA 24061; and D.M. Evans, Center for the Environment, Plymouth State University, Plymouth, NH 03264.

Survival, Growth, and Blight Incidence of Chestnuts on an FRA-Reclaimed Coal Mine in Southwestern Virginia[1]

S.K. Klopf*, C.E. Zipper, and J. Holliday [2]

Abstract: Until the rapid spread of a fungal blight in the early 1900s, the American chestnut (*Castanea dentata*) was the dominant hardwood species in Appalachia. Organizations such as the American Chestnut Foundation have been crossing American and Chinese chestnuts (*Castanea mollissima*) to produce blight-resistant trees, but field-testing is necessary to assess their efficacy. Reclaimed coalmines in need of reforestation in Appalachia provide thousands of acres within the range of American chestnut for field-testing. The Forestry Reclamation Approach (FRA) has improved reforestation success on coalmines, but chestnuts often do not establish well and it is unclear why. In 2008, a mix of American, Chinese, and hybrid chestnuts were planted on an FRA-reclaimed coal mine in southwestern Virginia to quantify survival, growth, and blight incidence in response to annual rye (AR), tree compatible (TC), and conventional (CON) seeding treatments. In 2016, we revisited these research plots to quantify chestnut performance in response to seeding treatments and site characteristics including soil pH, vegetation competition, slope (%), and downhill aspect. Survival was highest among the Chinese chestnuts (72.7%) ($p<0.001$). Survival was higher within the AR seeding treatment (51.2%) than the CON treatment (36.7%) ($p=0.005$). Several site variables affected chestnut performance. Downhill aspect was a strong driver of both ground-line diameter ($p<0.001$) and height ($p<0.001$). Trees at southerly aspects grew more compared to easterly aspects, though larger trees had more blight symptoms. We suspect the higher blight incidence was a function of; 1) larger trees being more likely to exhibit blight symptoms and 2) higher tree density resulting in faster spread of disease. Several site variables such as soil pH and aspect were auto-correlated and limited the conclusions that we could make. Therefore, additional studies are needed to specifically investigate the effects of site variables such as soil pH and aspect on chestnut performance.

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[1] Oral paper presented at the 2018 National Meeting of the American Society of Mining and Reclamation, St. Louis, MO: ***The Gateway to Land Reclamation*** June 3 - 7, 2018. Published by ASMR, 1305 Weathervane Dr. Champaign, IL 61821.

[2] Sara K. Klopf, Research Associate, Crop and Soil Environmental Sciences, Virginia Tech, Blacksburg, VA 24061; J. Holliday, Professor of Forest Resources and Environmental Conservation, Virginia Tech, Blacksburg, VA 24061; C.E. Zipper, Professor Crop and Soil Environmental Sciences, Virginia Tech, Blacksburg, VA 24061.

Surveyor in the Sky: Using Very High-Resolution Drone-Collected Data to Monitor Ecological Restoration[1]

G. J. Koenemann, T.J. Minnick, A. Langton, and R. Alward[2]

Abstract: We are implementing ecological restoration monitoring using multi-spectral remote sensing on a drone platform. Lands disturbed by oil and gas operations must be restored and meet several performance-based standards, including vegetation monitoring and reporting at regular intervals. Rigorous quantitative monitoring, using conventional methods, can be expensive since it entails high-skill, labor-intensive procedure that must be deployed during a limited growing season. We estimated vegetation cover and species composition on seven reclaimed well pads and two reference sites in Rio Blanco County, Colorado, using standard line-point-intercept techniques. We compared these results to those obtained using a 5-band multi-spectral camera with sub-meter resolution flown over each of these nine sites. Pixel-based supervised classification of the resulting multi-spectral imagery allowed us to accurately estimate the herbaceous, shrub, and tree composition of these well pads compared to the LPI method (achieving R^2 values of0.9). We could also reliably identify several woody species including *Juniperus osteosperma, Pinus edulis, Artemisia tridentata* spp. *wyomingensis* from the imagery. Additional species that we could distinguish, with lower accuracy, included *Ericamaria nauseosa* and *Gutierrezia sarothrae*. We will apply this classification to the regions beyond the small plots assessed using LPI to determine its capability to monitor larger restoration areas. Further analyses of these areas will include object based image analysis (OBIA) and will potentially increase the accuracy of the remote sensing-based classification. Our results indicate that remote sensing techniques can provide land managers with an effective but more cost-efficient alternative to ground-based monitoring. A further strength of this type of monitoring effort is the ability to scale-up to the landscape-level rather than being restricted to the small areas that can be assessed using standard field methods.

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1. Oral research paper presented at the 2018 National Meeting of the American Society of Mining and Reclamation, St. Louis, MO: The Gateway to Land Reclamation, June 2 - 7, 2018.

2. Grayson J. Koenemann, Student, Colorado Mesa University, Grand Junction, CO, 81503; Tamera J. Minnick, Professor, Colorado Mesa University, Grand Junction, CO, 81501; Alicia Langton, Environmental Consultant, EcoloGIS, Grand Junction, CO, 81501; and Richard Alward, Professor, Colorado Mesa University, Grand Junction, CO, 81501.

Treatment Success in a Heavily Mined Watershed in Ohio[1]

N.A. Kruse Daniels, Amy L. Mackey, Jen R. Bowman[2]

Abstract: Little Raccoon Creek is the largest tributary to Raccoon Creek in southern Ohio and, historically, it was the most severely impacted part of the watershed. After pre-regulation mining of over 20,000 acres, Little Raccoon Creek supported little aquatic life and was previously designated as Limited Resource Water by the Ohio Environmental Protection Agency. Since 2000, treatment and reclamation projects have been installed on four of the key acid producing tributaries. Treatment projects have included successive alkalinity producing beds, steel slag leach beds, limestone leach beds, and land reclamation. Over $14 million has been spend in Raccoon Creek Watershed on treatment and reclamation projects, much of that in Little Raccoon Creek. Several treatment projects have now been abandoned after analyzing the relative impact of each and deciding how to best invest future maintenance dollars. In a recent evaluation, not only are there biological communities in Little Raccoon Creek, most of the mainstem of the Little Raccoon Creek meets and exceeds state standards for macroinvertebrate and fish communities. The cumulative result of treating the extensive acid producing material and consistent evaluation and reevaluation of treatment success with active partnership between Raccoon Creek Partnership, Ohio University, and the Ohio Department of Natural Resources has led to a series of successful projects and a successful application of watershed-scale water quality management[3].

Additional Key Words: acid mine drainage, passive treatment, biological recovery, land reclamation

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2. Natalie A. Kruse Daniels, Voinovich School of Leadership and Public Affairs, Ohio University, Athens, Ohio, 45701.
3. Work reported here was conducted near 39°04'05.8"N 82°31'29.8"W.

Seasonal Trends in Water Quality in a Treated Acid Mine Drainage Impaired Stream[1]

N.A. Kruse Daniels and Z. Martin[2]

Abstract: While mine water treatment has been broadly successful in improving water quality in mining impaired watersheds in Ohio, the biological communities suggest that there are factors limiting recovery. To investigate the long term water quality, we collected three seasons of semi-continuous water quality monitoring data 2.3 miles and 8 miles downstream of a lime doser in a heavily studied watershed, Hewett Fork, Raccoon Creek, Ohio. There is a long dataset of grab samples and fish and macroinvertebrate data and a USGS gage station just downstream of the confluence of Hewett Fork and Raccoon Creek that can be used to compare with continuous monitoring data. Downstream of the doser, biological recovery begins after about 2.3 miles and reaches state benchmarks 8 miles downstream. At the upstream end of the recovery zone, large fluctuations in water quality occur throughout the year. Specific conductivity tends to be lower in the early spring when snowmelt and early-season rainfall events dilute the acid mine drainage and the regional water table remains high, potentially cutting off reactive material from oxygen. It increases throughout the summer with the highest values during flushing events in the fall. pH tends to be circum-neutral during base flow with either alkaline or acidic flushing events causing increases or decreases in pH. At the downstream end of the recovery zone where biology meets targets, these storm-related fluctuations in water quality are much smaller, although the mean values are not much better than those further upstream. This shows not only the value of seasonal sampling and storm sampling, but also of continuous monitoring downstream of treatment systems.

Additional Key Words: continuous monitoring, doser, active treatment, stream recovery.

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1. Oral paper presented at the 2018 National Meeting of the American Society of Mining and Reclamation, St. Louis, MO: The Gateway to Land Reclamation, June 3 - 7, 2018. Published by ASMR; 1305 Weathervane Dr., Champaign, IL61821.
2. Natalie A. Kruse Daniels, Voinovich School of Leadership and Public Affairs, Ohio University, Athens, Ohio, 45701.
3. Work reported here was conducted near 39°20'49.1"N 82°15'15.9"W.

Statistical modeling of mine pool formation in underground coal mines of Ohio[1]

Lindsey Schafer, Dina L. Lopez, Natalie Kruse, Jen Bowman, Frederick Twumasi, Robert Delach, Nora Sullivan, Rebecca Steinberg, Zachary Matthews[2]

Mining has occurred in Ohio for over two hundred years and has resulted in hundreds of flooded or partially flooded mines releasing acid mine drainage. Present mining regulations in Ohio prevent the approval of a mining permit if it is predicted that the future mine will potentially create a pollutional discharge. However, there is not a consistent methodology that mining companies and regulators use to determine, with some degree of uncertainty, if a mine will develop a pool or not. This work is part of a larger project that aims to create a tool that can predict with some certainty if a mine pool will form in a future coalmine, and if it does, where it could discharge. Mines that have been recently exploited in Ohio are being investigated. Data such as stratigraphy, pre- and post-mining potentiometric heads of wells within the mining area and precipitation was collected from public sources and are being investigated. Using the statistical program, Unscramble, multivariate statistical analysis such as step-wise multivariable regression, principle component analysis regression, and partial least square regression discriminant analysis is performed on these variables for multiple mines. This analysis will result in a regression equation that allows for the prediction of mine pool formation using potentiometric heads, hydrological parameters, and stratigraphy and topography of the mined area. Preliminary statistical analysis has shown that the amount of shale in the overburden is positively correlated with post-mining potentiometric head. This indicates that as the amount of shale in the overburden increases, the hydraulic conductivity decreases which decreases the vertical flow of water allowing it to accumulate in the overburden. The equations relating elevation of the water within the mined area and the variables cited above will be used to predict the formation or not of mine pool in future mines within some uncertainty.

Additional Key Words:

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1. Oral paper presented at the 2018 National Meeting of the American Society of Mining and Reclamation, St. Louis, MO: The Gateway to Land Reclamation, June 3 - 7, 2018. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.
2. Insert author info eg.: Allen J. Smith, Professor, Plant and Soil Sciences, University of Kentucky, Lexington, KY 40546; Barbara C. Jones, Ecotoxicologist and Certified Associate Wildlife Biologist, Altec, Georgetown, KY, 40552; and Charles D. Doe, General Electric, Cincinnati, OH, 42345.
3. Insert location, if possible eg.: Work reported here was conducted near 40° 06’ 07” N; 88° 14’ 59” W

Data Management for OSM Mine Pool Project at Ohio University: Lessons Learned[1]

Rebecca Steinberg*, Zachary Matthews, Dina L. Lopez, Natalie Kruse, Jen Bowman, Frederick Twumasi, Lindsey Schafer, Nora Sullivan, Robert Delach[2]

Abstract: The OU Voinovich School GIS Team is working to develop a method to collect, extract, and organize data to be used in creating a GIS tool for predicting mine pool formation. The team has collected and organized large amounts of mine permit data from Ohio Department of Natural Resources (ODNR) Division of Mineral Resource Management. Other publicly available data necessary was collected in cooperation with ODNR Water Resources, ODNR Geological Survey, industry collaborators, US Office of Surface Mining, and others. A process for data extraction, organization, and management was developed to efficiently work with such a large range of data for use in ArcMap, ArcGIS Online, QGIS, Box, and Microsoft Excel. Data extracted from well and borehole records included coordinates, static water levels, coal elevation, and strata percentages. Challenges encountered collecting data involved receiving thousands of pages of raw data in PDF and not easily manipulated formats, inconsistencies in data reporting, ambitious data delivery deadlines, and locating relevant publicly available data. Obstacles to tracking data entry included a need to develop uniform collection mechanisms, multiple data entry personnel, and assuring accuracy. A status-tracking sheet recorded different stages of the data management process, allowed for prioritization of permits to facilitate efficient use of data entry time, eased communication between team members, and allowed the process to move more smoothly. Sharing lessons learned can help others avoid some of the pitfalls and dead ends encountered by the team. Recommendations and tools for processes developed for data extraction, quality control/quality assurance, standardized Excel sheets, shapefile creation, and status tracking will be detailed.[3]

Additional Keywords: Have any?

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2. Info on authors
3. Lat and Lon of study, if appropriate.

Modelling and parameter sensitivity of mine pool formation in the Meigs Mine, Ohio

Frederick Twumasi, Dina L. Lopez, Natalie Kruse, Jen Bowman, Lindsey Schafer, Robert Barber-Delach, Nora Sullivan, Rebecca Steinberg, Zachary Mathews

Abstract: Hydrogeological modeling of the partially flooded Meigs mine in southern Ohio is underway to determine the sensitivity of the pre and post-mining water elevation within the mined area and possible discharge of water to the environment to different parameters such as pre-mining water elevations, stratigraphy, and recharge to the mine. Variables such as surface elevation, coordinates, rock types, coal elevation, depth from surface, and strata thickness of boreholes distributed in the Meigs mine were used in building the model. The modeled area was selected based on the hydrological boundaries of the surrounding watershed to the mine. Contacts maps were generated out of the various contact elevation of the boreholes using Surfer software and imported into Modflow for model building. Wells located in three aquifers were reported by the Meigs mine permits and the water wells in the county database; maps of potentiometric elevation in the wells of each aquifer were constructed. Correlation of the water potentiometric maps for each aquifer were compared with the elevation of the upper contact of the formation hosting the aquifer which shows that areas of the aquifer that have the highest elevation have the lower potentiometric head and the areas with lower elevation having the highest potentiometric head. This is consistent with groundwater flow in the direction of the Ohio River. The pre-mining model calibration is underway and shows that the rocks of the cyclothems have higher hydraulic permeability than the values expected for the kind of rocks. The calibrated pre-mining model will be used to model coal extraction and mine pool formation. With this work we expect to identify the determining factors and the formation of mine pools and use it to create an empirical model for mine pool formation.

Additional Keywords:

1.
2.
3.

Selection Criteria for Sedimentation Ponds that may be Transitioned to Permanent Impoundments for a Reclaimed Surface Mine in the Southwest USA[1]

K. Kutter[2] and M. Siemsglusz

Abstract: An important aspect of post-mining closure activities is the determination of suitable sedimentation ponds that can be converted to permanent impoundments for a grazing and wild-life-habitat post-mining land use. During the final reclamation at a large surface coal mine in the arid southwest USA there were many sedimentation ponds that had been in place to facilitate mining activities that were desired for retention by the post-mining land user. Before a sediment pond could be converted to a permanent impoundment, an evaluation was conducted to ensure that the structure met all regulatory requirements and could support the intended post mining land use while requiring minimal maintenance for the landowner. The selection criteria included: a water quality assessment, water quantity and capacity evaluation, sediment accumulation rate assessment, and an impoundment structure-stability assessment. While not all sediment ponds were found suitable for conversion to permanent impoundments after the evaluation, the impoundments that were selected will provide important water resources for grazing, and opportunities for wildlife enhancements to be created in the final reclamation plan.

Additional Key Words: Frank Rivera, PE, Senior Consultant Golder Associates, Inc.

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2. Kyle Kutter, PE, Senior Engineer and Mary Siemsglusz, PE, Associate and Senior Consultant Golder Associates, Inc. 13515 Barret Parkway Drive Suite 260, Ballwin MO 63021.

Dominant Trace Metal Removal Products in a Hard Rock Mine Discharge Bioreactor[1]

J.A. LaBar*, P. Eger, R.W. Nairn[2]

Abstract: Two vertical flow bioreactors (VFBR) were constructed in 2005 to treat a low flow (< 15 L/min), net-acidic ferruginous hard rock mine drainage. The VFBR were intended to remove metals predominantly through precipitation as insoluble sulfides. In the years 2005-2014, median influent quality was pH 3.3, 45 mg/L Fe, 8.6 mg/L Al, 2.6 mg/L Mn, and 320 mg/L SO_4^{2-}. The VFBR were effective at producing circum-neutral, net-alkaline water and removing an average of 225 kg Fe/yr, 67 kg Al/yr, and 985 kg SO_4^{2-}/yr. In addition, the low concentrations of Cd, Cu, and Zn were consistently removed to below detection limits. Prior to decommissioning, solid samples were collected at depths of 7.5 cm, 15 cm, 30 cm, and 40 cm of the southern VFBR. Sequential extraction procedures and acid volatile sulfide measurements were used to evaluate dominant trace metal removal products in all samples. Large total concentrations of Al, Cd, Cu, Fe, Mn, Pb, and Zn were found throughout the system, with concentrations generally decreasing with depth. Precipitation as sulfides tended to increase with depth for most of the metals, except for Al and Mn. Complexation with labile organic material and adsorption were the dominant removal pathways for Al and Mn, respectively. Despite Pb concentrations below detection limits in the influent, substantial concentrations were found in the carbonate and sulfide fractions within the substrate. Analyses demonstrated that by a depth of 15 cm, most of the metals retained within the substrate were in stable, stationary fractions that should prevent migration of pollutants to receiving streams.

Additional Key Words: Bacterial sulfate reduction, sequential extraction, acid volatile sulfide

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2. Julie A. LaBar, Postdoctoral Fellow, Saint Francis University, Loretto, PA 15940; Paul Eger, Environmental Engineer, Global Minerals Engineering LLC, Hibbing, MN 55746; Robert W. Nairn, Professor, University of Oklahoma, Norman, OK 73019.

Mummified and Partially Petrified Wood from an Eocene Deposit in Mississippi[1]

[2]Nayeon Lee[a], Sungkwang Mun[a], Mark.F. Horstemeyer[a],
Stephen J. Horstemeyer[a], Ziming Yue[b], Paul Tseng[b], and David J. Lang[b]

Abstract: This study experimentally investigates mummified wood, which is undecomposed wood, and petrified wood from the same piece of material collected at the Red Hills[4] lignite mine in Mississippi, USA. Two kinds of fossilized wood co-exist with lignite. Our work consists of a chemical composition analysis, microstructural observations, and nanohardness testing for material characterization. The chemical analysis revealed that the chemical compositions of mummified wood is similar to those of present wood (carbon based), and petrified wood is mainly composed of silicate (silicon based). From microscopic observations, it is shown that the mummified wood retains well-preserved wood cell structures, and the petrified wood portion has recognizable plant structures. From the observed cell structure, we could assert that the species of the original wood is a conifer. Also, we concluded that chemical reaction would be the main cause for petrification without pressure or heat involved, because no gradient between the mummified and petrified wood was observed. Nano-indentation showed that the nanohardness of the petrified portion is 4.57 ± 3.11 GPa, and the mummified portion is 0.71 ± 0.39 GPa confirming that the petrified wood and mummified wood are clearly different material. To identify the original wood, 185.7 nanograms of DNA from the mummified wood was extracted. The Mississippi Embayment was created during the Paleocene-Eocene geological age. DNA contained in undecomposed wood on one side and petrified wood on the other side indicates a unique depositional environment. This potential DNA from ancient mummified wood may contribute to the growing findings of intact molecules in soft tissue found in fossils. Ongoing sequencing will confirm the identity[4].

Key Words: Mississippi Embayment, Depositional Environment, Fast Petrification.

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2. Nayeon Lee[a], Postdoctoral Associate, Sungkwang Mun[a], Postdoctoral Associate, Mark.F. Horstemeyer[a], Professor of Mechanical Engineering, Stephen J. Horstemeyer[a], Laboratory Manager, Ziming Yue[b], Postdoctoral Associate, Paul Tseng[b] Assistant Professor Plant and Soil Sciences, and David J. Lang[b] , Professor Plant and Soil Sciences. Corresponding authors Nayeon Lee (nayeon@cavs.msstate.edu) and David Lang (dlang@pss.MsState.edu)
3. [a]Center for Advanced Vehicular Systems, Mississippi State University, [b]Department of Plant and Soil Sciences, Mississippi State University, Mississippi State, MS 39762, USA. Supported by a planning grant from the Office of Research and Economic Development at Mississippi State University
4. This work was performed on specimens collected near 33.3101° N, 89.1728° W.

Manganese Oxide Production and Harvesting Using Metal Removal Units[1]

C.A. Lennox[2]

Abstract: Metal Reclamations Units (MRUs) are gravity driven, modular, scalable, rapidly deployed wetland bioreactors. The biofilm which grows upon the organic supporting matrix in the MRUs is self-selecting and determined by the introduced pollutant loads and how they are naturally attenuated. MRUs remove Mn at pH <7 when total Fe is removed to <0.35 mg/L, organic carbon is available, and 4-6 weeks is allowed for biomass accrual in mild to warm Weather. It is hypothesized that organic carbon from upstream wetlands are a food source driving fungal oxidation of Mn^{2+} to MnOx (Birnessite). When the noted conditions are achieved/surpassed, Mn^{2+} is removed at rates up to 370 grams/m^3/day at 225+ Lpm. Data suggests that organic carbon and organic structural matrix additives which consider complimenting biofilm metabolic pathways increase biological remediation of metals. Further, this method of biological manganese oxide production provides useful byproducts for further water treatment, the battery industry, and agriculture.

Additional Keywords: biofilm, natural attenuation, fungal manganese oxidation.

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2. Colin A. Lennox, CEO BioMining Products and MRU Inventor, Altoona, PA 16601
3. Work reported here was conducted near 40° 42’ 54.26” N; 78° 25’21.01” W.

WebGIS Application to Visualize Historical Reclamation Research Sites Using a Modified QGIS2Web Framework[1]

D.J. Leifer, and R. Li[2],

Abstract: The American Society of Mining and Reclamation (ASMR) has recently sponsored projects that connect historical conference proceedings and journal papers on land reclamation with geographic coordinates. The major approach is to geocode these articles as informational placemarks using Google Earth. However, this approach cannot provide users with convenient concurrent access to the articles and their location contexts on a digital map. Thus, we propose a Geographic Information System (GIS) web application interfaced with the Web 2.0 technology as a technical solution. An open-source QGIS plug-in tool QGIS2Web is capable of integrating web mapping application into Hypertext Markup Language (HTML), JavaScript, and Cascading Style Sheets (CSS) as a Web 2.0 framework. This framework allows each article associated with historic land reclamation activities to be displayed in the Internet browser when the users navigate through each placemarks in an online base map – OpenStreetMap. To facilitate the display of the placemarks under different categories (e.g., publication years, technical divisions), a table of contents panel is included to the interface of this application. This tool can potentially be hosted on Amazon Web Service S3 or the ASMR website for comprehensive viewing and inquiry.

Additional Keywords: ASMR; Web 2.0; QGIS; Placemark, QGIS2Web, HTML

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2. David J. Leifer, Graduate Student, Department of Geography and Environmental Resources, Southern Illinois University, Carbondale, IL, 62901; Ruopu Li, Assistant Professor, Department of Geography and Environmental Resources, Southern Illinois University, Carbondale, IL, 62901.

Passive System Rehabilitation of a High Flow Acidic Coal Mine Discharge[1]

R.M. Mahony[2], T.P. Danehy, D.A. Guy, C.F. Denholm,
S.L. Busler, C.A. Neely, M.H. Dunn

Abstract: The multi-component Maiden Mine Passive Treatment System (Maiden PTS) was constructed in 2006 to address two acidic metal-laden coalmine discharges that degraded an unnamed tributary to Dunkard Creek in Greene County, Pennsylvania. This case study highlights the ability to restore a treatment system's functionality after almost a decade of the Maiden PTS not functioning as designed due to needed maintenance being prevented by lack of access. The rehabilitation project is part of a larger ongoing watershed restoration approach led by MEPCO, LLC. Once property ownership was transferred to MEPCO, LLC in 2015, Stream Restoration Incorporated (SRI) spearheaded a public-private partnership effort to rehabilitate the largest passive treatment system in the Dunkard Creek Watershed. Monitoring has shown that the system is performing as well, if not better than a decade ago. The average raw discharge characteristics are 20.3 L/sec (321 gal/min), 2.88 pH, 354 mg/L hot acidity, 46 mg/L Fe, 4 mg/L Mn, and 19 mg/L Al. After system rehabilitation, the treated effluent average values were 20.6 L/sec (327 gal/min), 7.1 pH, 76 mg/L alkalinity, 0.4 mg/L Fe, 0.3 mg/L Mn, and 0.5 mg/L Al. Future system modifications to further improve treatment efficacy are being explored and will be discussed.

Additional Key Words: AMD, vertical flow ponds, solar powered valve actuator.

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2. Ryan Mahony, Environmental Scientist; Tim Danehy, QEP; Dan Guy, PG; Cliff Denholm, Environmental Scientist; Shaun Busler, GISP, Biologist; Cody A Neely, PE; Margaret Dunn, PG; BioMost Inc., 434 Spring Street Ext., Mars PA 16046.

Response of Petro Pipelines to Longwall Subsidence[1]

G. G. Marino[2]

Abstract: When transmission pipelines are planned to be undermined by longwall mining, there is considerable concern for the integrity of the pipeline. With longwall mining, there is typically significant associated subsidence movement. As a result, oil/gas transmission lines are exposed to subsidence induced axial tensile or compressive stresses and bending stresses as well as stress concentrations in associated appurtenances. With the use of case histories, this presentation will discuss the nature of longwall ground movements, the role the backfill properties play in the induced stress, and means to monitor and mitigate those stresses. The presentation will also include important aspects of analysis when evaluating subsidence effects.

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CHINA'S MINING LAND POLICIES AND RECLAMATION PRACTICES[1]

Luo Ming, Zhou Xu, Zhou Yan, Chen Yuanpeng, Xiao Wen[2]

Abstract: This paper first analyzes the characteristics and problems of China's mining land, including the problems of the scale large but inventory unclear, the mining land use procedures imperfect, the number of abandoned land closed due to policy reasons high, and the shortage of basic information. Then three practical land reclamation cases carried out by the Chinese government in recent years are introduced, which are the case of state land comprehensive consolidation and rehabilitation in mining subsidence areas with water logging, the case of abandoned land rehabilitation with construction land quota exchange, and the case of abandoned land reclamation by social capital with reclaimed area's land use right as reward. Finally, upon the analysis, the development direction of China's land policy is put forward, including strengthening policy fund overall integration, improving land use incentive policies, improving the policy mechanism of attracting social capital input, studying the guarantee mechanism of land reclamation expense and optimizing land reclamation supervision system.

Additional Key Words: mining land; reclamation practices; land use incentive policies; fund integration.

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2. Luo Ming, Zhou Xu, Zhou Yan, and Xiao Wen, Land Consolidation and Rehabilitation Center, Ministry of Land and Resource; Chen Yuanpeng, China University of Geosciences (Beijing), School of Land Science and Technology.

Metal Mass Retention in Passive Treatment Systems at the Tar Creek Superfund Site[1]

Robert W. Nairn[2]

Abstract: The Tri-State Mining District (TSMD) was a major producer of lead and zinc concentrates in the 19th and 20th centuries. Upon cessation of mining operations, mine voids filled with groundwater and several dozen artesian discharges of metals-contaminated waters began flowing in late 1979. The U.S. Environmental Protection Agency identified four TSMD-related Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) sites in Oklahoma, Kansas, and Missouri. Due to topographic and hydrologic features, mine water discharges were especially pervasive in the Oklahoma portion of the TSMD, known as the Tar Creek Superfund Site. In the mid-1980s, impacts to surface waters were deemed to be due to "irreversible man-made damages" and action to address them was determined to be inappropriate. Since 2008, two full-scale mine water passive treatment systems (PTS) have been installed to address some of these waters, contaminated by elevated concentrations of iron, zinc, lead, cadmium, arsenic, and nickel. The Mayer Ranch PTS (since 2008) and Southeast Commerce PTS (since 2017) produce effluents which are circumneutral pH, net alkaline, and contain concentrations of ecotoxic metals meeting receiving water body in-stream criteria. On an annual basis, MRPTS and SECPTS respectively retain approximately 57000 and 27000 kg of iron, 3300 and 2200 kg of zinc, 290 and 120 kg of nickel, 18 and 12 kg of lead, 19 and 8 kg of arsenic, and 5 and 7 kg of cadmium. If these systems continue to function as designed throughout their 20-year design lifetimes, they will collectively retain approximately 1700 metric tons of iron, 110 metric tons of zinc, 8 metric tons of nickel, 600 kg of lead, 540 kg of arsenic and 250 kg of cadmium. Although considerable water quality improvement has occurred in the Unnamed Tributary into which these PTS discharge, additional artesian discharges and substantial tailings pile and pond runoff still pollute the main stem of Tar Creek.

Additional Key Words: Mass loadings, mass removals, iron, zinc, lead, cadmium, arsenic, nickel

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2. Robert W. Nairn, Professor, Center for Restoration of Ecosystems and Watersheds, School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK 73019

3. Work reported here was conducted near 36° 55′ 14″ N; 94° 52′ 11″ W

Targeted Maintenance Efforts to Ensure a Decade of Successful Passive Treatment[1]

Robert W. Nairn*, Bryan J. Page and Nicholas L. Shepherd[2]

Abstract: Construction of the Mayer Ranch passive treatment system was completed in late 2008. The large multi-process unit passive treatment system addresses legacy flows from abandoned mines in the Oklahoma portion of the Tri-State Lead-Zinc Mining District (TSMD). The targeted discharges (pH 5.95±0.06, Fe 192±10 mg/L, Zn 11±0.7 mg/L, Cd 17±4 ug/L, Pb 60±13 ug/L and As 64±6 ug/L) have flowed at approximately 400-1000 L/minute for almost 40 years. The system, the first mine water treatment system of any kind in the TSMD, includes an initial oxidation pond followed by parallel treatment trains of aerobic wetlands, vertical flow bioreactors, re-aeration ponds, and horizontal-flow limestone beds, which flow into a single, final polishing wetland/pond. From a biogeochemical performance perspective, the system has met design expectations and produces net alkaline waters meeting in-stream water quality criteria for ecotoxic metals. However, the system demonstrated signs of longer-term hydrologic and hydraulic failure which necessitated maintenance procedures in 2017. Over a period of several years, hydraulic conductivity in both parallel vertical flow bioreactors decreased from 10^{-1} to 10^{-4} cm/s, resulting in water level increases and subsequent impacts to upstream process units. These units were dewatered and the organic substrate (45% spent mushroom substrate, 45% wood chips and 10% manufactured sand) mixed with a small excavator in March 2017. Despite areas of considerably degraded substrate, the original hydraulic conductivity was restored. In addition, the buried piping system between the initial oxidation pond and parallel aerobic wetlands exhibited substantial water throughput issues over several years. Although calculated head losses were approximately 5 cm in this piping system, measured water level differences in these units were as much as 0.7 m, likely due to decreases in cross-sectional areas of the pipes. In December 2017, a wide, open water outlet channel feeding two inlet weir structures was installed to replace the buried piping system.

Additional Key Words: O & M, clogging, precipitation, air pockets, excavation.

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2. Robert W. Nairn, Professor, Bryan J. Page, Research Scientist and Nicholas L. Shepherd, Graduate Research Assistant, Center for Restoration of Ecosystems and Watersheds, School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK 73019
3. Work reported here was conducted near 36° 55′ 20″ N; 94° 52′ 24″ W.

Hydrologic Budgets and Conservative Ions: Potentially Important Yet Neglected Tools in the Evaluation of Passive Treatment System Effectiveness[1]

Robert W. Nairn* and Nicholas L. Shepherd[2]

Abstract: The design of passive treatment systems has advanced considerably in recent decades. Individual process unit designs are typically based on contaminant mass loads and empirically-derived mass removal rates, requiring reliable source water quality data and selected design volumetric discharge rates. However, performance evaluations often depend on water quality concentration changes alone, assuming no changes in water throughput rates, ignoring portions of the hydrologic budget, and disregarding any mechanisms affecting water chemical composition other than those designed to directly address constituents of concern. In this study, hydrologic budgets were estimated for two Oklahoma passive treatment systems in the Tri-State Lead-Zinc Mining District. Reliable inflow and outflow volumetric discharge rates were obtained monthly, pressure transducers were installed in each process unit to monitor water level fluctuations continuously, monthly rates of evapotranspiration were calculated, and daily precipitation data were obtained from the Oklahoma Mesonet. Based on soils data collected during construction, seepage rates were considered negligible. Concentrations of conservative ions (e.g., Mg, Na, K), assumed to be those to change only due to dilution or evaporation, were used to estimate the effects of precipitation, drought, and temperature extremes. Annual evapotranspiration exceeded or was equal to total water volumes of the passive treatment systems. Mean monthly rates of evapotranspiration and precipitation were approximately 8% of volumetric inflow rates. Given the dynamic climate of the Great Plains, precipitation varied considerably both intra- and inter-annually. Monthly precipitation volumes accounted for as much as 20% of volumetric inflow rates. Changes in concentrations of conservative ions indicated that evaporative concentration could underestimate contaminant removal rates by up to 20% in summer months, depending on duration of drought. However, temporal matching of influent and effluent samples may introduce error. These techniques may provide insight into improved passive treatment performance evaluation.

Additional Key Words: water budget, evapotranspiration, precipitation, dilution, evaporative concentration

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2. Robert W. Nairn, Professor, and Nicholas L. Shepherd, Graduate Research Assistant, Center for Restoration of Ecosystems and Watersheds, School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK 73019.

3. Work reported here was conducted near 36° 55′ 31″ N; 94° 52′ 16″ W.

Phytoremediation of Stormwater by Aquatic Macrophytes[1]

Michael Nattrass and Brian Baldwin[2]

Abstract: Stormwater runoff from applied coal fly ash raises concern over potential downstream impacts of selenium (Se) on aquatic ecosystems. Constructed wetland phytoremediation is a sustainable, inexpensive, eco-friendly technology with potential to remove Se from stormwater. The objectives of this study were to: 1.) Evaluate the bioavailability of Se chemical form and concentration on plant uptake and 2.) Determine the potential of aquatic macrophytes to improve water quality in a constructed wetland. The experiment was arranged as a 2 X 2 factorial nested within a split-split plot design replicated three times. Cattail (CT; *Typha angustifolia* L.), duckweed (DWD; *Lemna minor* L.), fanwort (CAB; *Cabomba caroliniana* A. Gray), soft rush (SR; *Juncus effuses* L.), muskgrass (MG; *Chara* spp.) and unplanted controls (UNP) were acclimatized 14 d in 115-L microcosms containing 0.034 m^3 of a Catalpa silty clay loam with 26 L of water supplemented with 0.1% Hoagland's solution. Selenium treatments were applied as a 4-L solution of either sodium selenite (SeO_3^{2-}) or selenate (SeO_4^{2-}) at 0, 0.5, and 1 mg Se L^{-1}. Soil and plant samples were collected at 0, 3, and 6-d post Se application. Water samples were collected daily for six days. Soil, plant, and water samples were analyzed for total [Se] by inductively coupled plasma-mass spectrometry. Data were analyzed using repeated measures with PROC GLM α=0.05. After six days, CT and MG-planted microcosms significantly reduced aqueous [Se] by 76 and 71%, respectively, compared to 60% for UNP. Microcosms planted to CAB, DWD, and SR were similar to UNP controls. Plant tissue Se content in CT was significantly less than CAB, DWD, or MG, suggesting CT has the potential to volatilize Se. Given its abundance and efficacy, cattail is likely a suitable species for Se removal in constructed wetlands supplied with either selenite or selenate contaminated stormwater[3].

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2. Michael Nattrass, Student, Ph.D., Plant and Soil Sciences, Mississippi State University, Mississippi State, MS; Brian S. Baldwin, Professor, Plant and Soil Sciences, Mississippi State University, Mississippi State, MS.

3. Work reported here was conducted 33° 28' 9" N; 88° 47' W.

Selenium, Uranium, and Nitrate: Treatment of Troublesome Contaminants in Mining Wastewaters – EBR Case Studies[1]

O. Opara[2], J. Adams, J. Fudyma, and J. Bowden

Abstract: Selenium (Se), uranium (U), and nitrate (NO_3) are widespread in many North American mining environments and other related industrial waters. These contaminants are often particularly difficult to remove using conventional water treatment methods, such as chemical coagulation/precipitation, reverse osmosis filtration, ion exchange, etc. Treatment system capital and operating expenses combined with additional costs of sludge or concentrate stream disposal, are driving research and application of biotreatments methods for removal of these contaminants from mining and industrial wastewaters. This paper discusses application of the Electro-Biochemical Reactor (EBR) technology for Se, U, and NO_3 bio-reduction and removal from mining wastewaters. Three case studies are presented, based on laboratory bench- and on-site pilot-scale trials with significantly different mining waters (floatation-influenced based metals mine water, leach solution from a gold mine, and coal mine seepage water), each contaminated with varying concentrations of selenium, uranium, and nitrates. Average concentrations of these contaminants were 2,712 µg L^{-1} Se, 2.0 µg L^{-1} U, and 1.53 mg L^{-1} NO_3-N (Site A); 2.9 µg L^{-1} Se, 92.5 µg L^{-1} U, and 189 mg L^{-1} NO_3-N (Site B); and 105 µg L^{-1} Se, 18.4 µg L^{-1} U, and 50 mg L^{-1} NO_3-N (Site C). The EBR technology was demonstrated on all three sites to treat the waters to <0.5 – 3.2 µg L^{-1} Se, <0.1 – 0.8 µg L^{-1} U, and <0.02 – <2 mg L^{-1} NO_3-N. The high combined Se, U, and NO_3 removal efficiency achieved with EBR treatment, at both laboratory and field scale, has positive implications for future treatment system design at many sites. The EBR process would be applicable and beneficial at sites facing the challenge of mixed contaminant treatment to low discharge standards, simplifying the treatment train to one primary process, and eliminating the need for sludge or concentrate stream treatment/disposal.

Additional Key Words: bio-treatment, electro-biochemical reactor

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1. Oral paper presentation for consideration at the Water Management/ARD Technical Session at the 2018 National Meeting of the American Society of Mining and Reclamation, St. Louis, MO: The Gateway to Land Reclamation, June 2 - 7, 2018.
2. Ola Opara, Ph.D., Inotec, Salt Lake City, UT 84119 and Assistant Adjunct Professor at University of Utah, Department of Geography, Salt Lake City, UT 84112; Jack Adams, Ph.D., Inotec, Salt Lake City, UT 84119; Jane Fudyma, Inotec, Salt Lake City, UT 84119; John Bowden, Inotec, Salt Lake City, UT 84119.

Initial Evaluation of Ripper and Tillage Methods on Reclaimed Heavy Mineral Mine Soils[1]

Z.W. Orndorff, S.K. Klopf, W.L. Daniels, R. Stewart, and R. Daniel[2]

Abstract. Heavy mineral sands mining in prime farmland of the upper Coastal Plain in Virginia generates mine soils that limit return to intensive rowcrop production if compaction and other physical and chemical limitations are not ameliorated. Typical reclamation includes initial deep-ripping, topsoil return, and shallow final surface tillage; but, significant subsoil compaction often persists to ~90 cm, and reapplied topsoil may be massive and compact, which limits rooting, lowers crop yields and rainfall infiltration/percolation, and enhances runoff. In 2016, a study was installed to evaluate ripping and tillage practices to alleviate compaction-related limitations. Five initial soil profile pits were excavated and characterized to 1.5 m. Bulk density (Db) cores and bulk soil samples were collected from the surface and at 35 – 65 cm for physical and chemical analyses. The subsequently installed study includes four replicate complete blocks (64 x 64 m) with five main treatments (9 x 64 m) bordered by untreated alleys (3 x 64 m), and three cross-rip treatments (9 x 64 m; perpendicular to the main treatments). The main treatments were: 1) control, no ripping/tillage; 2) dozer deep-rip, one pass with 1.2 m shank centers; 3) dozer deep-rip, two passes with 50% offset creating 0.6 m shank centers; 4) chisel-plow topsoil to ~5 cm below subsoil contact; and 5) agricultural no-till ripper. The cross-rip treatments were: 6) dozer deep-rip, one pass; 7) chisel-plow topsoil to 5 cm below subsoil contact; 8) no-till ripper. During installation, soil samples were collected from 0 – 15 cm and 38 – 53 cm to evaluate moisture content, pH, texture, and acid-extractable nutrients. The plots were seeded with cereal rye and a pasture mix in Sept 2016; vegetation assessments were completed in Nov 2016, Apr 2017, and Sept 2017. In Nov 2017, twenty soil profiles, representing five treatments per block, were described and fully characterized. Prior- and post-installation, surface soil textures were sandy loam and loamy sand; subsoil textures ranged from sand to clay. Prior to plot installation, Db was relatively high (1.46 – 1.72 g/cm^3) in massive surface soils and subsoils, few to no roots were observed in the subsoils, surface pH was 5.3 – 7.0, subsoil pH was 4.4 – 6.9, and extractable nutrients were low. One year after installation, Db was slightly lower with average surface Db = 1.48 g/cm^3 and average subsoil Db = 1.52 g/cm^3, and rooting was more prevalent through the subsoils. Over time, significant differences in total vegetative cover developed among the blocks. Few significant differences were observed among main treatments (without a cross-rip), but were more apparent with the inclusion of cross-rip plots. The dozer deep rip treatment with two passes typically yielded the highest vegetative cover for all sampling dates.

Additional Key Words: Bulk density, compaction, titanium mining, revegetation.

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2. Z.W. Orndorff, Sr. Research Assoc.; S.K. Klopf, Research Assoc.; W.L. Daniels, Professor; R. Stewart, Asst. Professor, Crop and Soil Env Sci, Virginia Tech, Blacksburg, VA 24061; R. Daniel, Rehabilitation Supervisor, Iluka Resources Ltd., 12472 St. John Creek Rd., Stony Creek, VA 23882.

A Pedologic View of Geomorphic Reclamation in Wyoming[1]

Amanda Pennino[1] & Karen Vaughan[2]

Abstract: Mineral commodities generated by surface mining drives much of Wyoming's economy through invasive extraction processes, intensifying the need for vast land reconstruction and reclamation. These activities involve the mass spread of salvaged soil that has been moved, often several times, consequentially homogenizing the soil laid onto the landscape. Complete mixing and transport of soil can disrupt physical structure and the natural order of mature soil horizonation, altering its function to support plant and microbial life. A reclamation project in the Gas Hills of Wyoming, where traditional reclamation practices and geomorphic methods have been implemented concurrently a decade ago, provides an opportunity to observe the outcomes of two different reclamation approaches. This study captures a witness of short-term soil development that has occurred in soils that were, in terms of soil maturity, set back to time-zero. By considering existing morphological features and horizon development, this study evaluates the current state of soils that have been spread and allowed to establish for over ten years using a side-by-side comparison of reclamation methods. Findings from this approach suggest that short-term soil development in semi-arid environments might contribute to the success of reclamation. Through the pedologic lens, this research attempts to offer measures that may aid in determining if geomorphic reclamation can be a suitable practice in Wyoming.

Additional Key Words: mine reclamation, geomorphic reclamation, soil, pedology

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2. Amanda Pennino, graduate student in Soil Science; Karen Vaughan, Assistant Professor in Pedology, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY 82071.

Geomorphic Reclamation: A pioneer method on the frontier of the Wild West[1]

Amanda Pennino, Kurt Fleisher, Kristina Hufford, & Karen Vaughan[2]

Abstract: Geomorphic reclamation is an innovative approach to landscape reconstruction that is praised for creating a diverse topographic environment. Complex landforms provide microtopography and thus microenvironments, which fuel spatial variance in soil properties, resource availability, and vegetation communities. This study examines how landscape heterogeneity, driven by reclamation technique, influences soil quality and recovery of vegetation. We evaluate reclamation success by the comparison of geomorphic designs built adjacent to conventional methods of simple-slope construction. Following >10 years post-reclamation, distinctions in soil physicochemical properties, vegetation structure and established functional groups are observed between reclamation treatments. Presented findings highlight Wyoming's first side-by-side assessment of reclamation practices. This research offers a unique opportunity to observe alternatives to reclamation methods where regrading and revegetation occurred simultaneously.

Additional Key Words: mine reclamation, restoration ecology, soil quality.

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2. Amanda Pennino, graduate student in Soil Science. Kurt Fleisher, graduate student in Rangeland Ecology and Watershed Management. University of Wyoming, Laramie, WY, 82071; Kristina Hufford, Associate Professor in Restoration Ecology. Karen Vaughan, Assistant Professor in Pedology. Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY 82071.

Analysis of EPA Mandated Soil Amendments[1]

Madison Peppers[2]

Abstract: Tar Creek was formally a part of the Tri-State mining district that encompassed Missouri, Kansas, and Oklahoma. Specifically, the Oklahoma portion of Tar Creek had extensive lead and zinc mining that caused contamination throughout the soil and water systems. While many efforts have been made to combat these negative implications, remediation is currently ongoing. At Tar Creek, the Environmental Protection Agency (EPA) has been implementing soil amendments to reduce concentrations of lead (Pb), zinc (Zn), and cadmium (Cd). As part of this study, we tested whether this mandated amendment has been effective as intended. In accordance with the EPA field sampling method, we conducted quarterly sampling for a year after amendments were implemented. Samples were analyzed in a lab to determine total levels of Pb, Zn, and Cd, in addition to organic matter, pH, phosphorus, potassium, and nitrogen. We then compared post-amendment heavy metal concentrations against pre-amendment concentrations. Preliminary analysis suggests that there was no apparent reduction in the amount of heavy metals in the soil following remediation, although we expect that further analysis should more effectively reveal trends in these contaminants. From the preliminary results, we hypothesis that such remediation may not be readily evaluated within the time frame implemented in this study. Therefore, future research should be conducted to determine the impact of soil amendments over time and if any specific component of the amendment and/or environment impacts the success of such remediation methods.

Additional Keywords: Tar Creek, Superfund Site, heavy metal mining, remediation, soil contamination

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2. Madison Peppers, Masters Student, Environmental Science, Texas Christian University, Fort Worth, TX 76129.

Impacts of a Modified Forestry Reclamation Approach on Seedling Growth and Survival on Reclaimed Mines in the Western Gulf[1]

Cassie Phillips[2]*, Jeremy Stovall, Hans Williams, Ken Farrish

Abstract: Surface mining reclamation has resulted in increasingly more stable land use post mining since the implementation of SMCRA, or the Surface Mining Control and Reclamation Act in 1977. While land reclamation efforts have increased stability considerably, research suggests that soil compaction as a result of the implementation of SMCRA hinders the productivity of forests post-mining. The Forestry Reclamation Approach (FRA) was developed to improve forest health in the Appalachian region through a five-step process. This process emphasizes minimizing soil compaction and using proper tree planting techniques. The FRA has not yet been tested in the western Gulf Coastal Plain where shrink-swell clay soils and severe droughts affect land reclamation practices. This study adapted the FRA methods for the soils and common silvicultural practices of the western Gulf. The two-acre study site was installed with a randomized block design with three replicates comparing conventional pan-scraper reclamation methods of the region with that of an unmined control and the FRA-style low compaction treatment. Following soil reclamation, we hand-planted containerized loblolly pine seedlings of a western Gulf provenance. Consistent with intensively managed plantation forests in this region, no cover crops were planted; this will help to optimize tree growth and reduce herbaceous competition. After one growing season, seedlings in the FRA plots had a 97% survival rate with a mean height of 43.06 cm. Soils samples revealed FRA plots also had the lowest bulk density of all the plots. Vegetative analysis on all plots revealed the control plot to have the most vegetation per 1 m^2 at 433.05 g. Photosynthesis and respiration data will be collected to further valuate the health and productivity of trees in all plots.

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2. Cassie Phillips, Environmental Science Graduate Student; Jeremy Stovall, Associate Professor of Silviculture; Hans Williams, Dean of the Arthur Temple College of Forestry & Agriculture; Kenneth Farrish, Director of Division of Environmental Science, Stephen F. Austin State University, Nacogdoches, TX 75962.

Effect of Alders (Alnus Sp.) on Technosols Development on Lignite Combustion Wastes Disposal[1]

M. Pietrzykowski[2], B. Woś, M. Chodak, K. Sroka, M. Pająk, T. Wanic, W. Krzaklewski

Abstract: Combustion waste and fly ash disposal sites display unfavourable properties for revegetation. Owing to its phytoameliorative ability different alder species have long been used in the reclamation of degraded sites, as N-fixing species and forecrop for introducing more demanding tree species in reforestation.We present the effect of black alder (Alnus glutinosa), grey alder (A. incana) and green alder (A. viridis) planted in 2006 into the lignite combustion waste disposal site in central Poland on the physicochemical and biological properties of the developed technosols. The study plots were randomly arranged (72 m^2 of each plot, four replications for variant) at 3 species × 2 different soil treatment: CCW+L (combustion waste with lignite amendment in planting hole) and CCW (pure combustion waste). The obtained results indicate that soil treatment did not significantly influence the studied physicochemical soil parameters, whereas the effect of species was clearly noted. The highest growth and survival was noted for the black alder. Accumulation of litter layer (Oi) ranged from 2.9 to 3.6 Mg ha^{-1} (mega gram per hectare), and grey alder litter was characterized by the highest content of nutrients (N-P-K). Organic C content in the 0-5 cm mineral layer (A) increased from 38.06 to 47.80 g kg^{-1} (gram per kilogram dry soil), respectively for green and black alder, whereas the highest N content in A layer was measured under black alder. Microbial respiration and biomass were significantly lower in the Oi layer under the green alder than under two other alder species. However, in the mineral soil all three alder species stimulated microbial biomass and activity similarly. Because of the highest growth parameters of black alder and the highest litter production under canopy and N content in the soil we recommend this species to revegetation of combustion waste disposal site [3].

Additional Key Words: Fly ash, revegetation, N-fixing, Soil Respiration

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3. Work reported here was conducted near 51°27’34” N; 19°26’50” W. Study was financed by The National Science Centre, Poland, grant No. 2015/17/B/ST10/02712.

Early physical, chemical, and biological impacts of using stockpiled vs directly placed reclamation soils[1]

Brad Pinno[2]

Abstract: Stockpiled soil for use in oil sands mine reclamation in northern Alberta, Canada is an important resource as this soil will be used for approximately half of all reclamation in the region. However, there are some concerns regarding the potential physical, chemical, and biological limitations of stockpiled soils relative to directly placed reclamation soils. For example, stockpiled soil may have higher bulk density and lower numbers of viable plant propagules compared to directly placed soils. The first year post-placement impacts of using stockpiled and directly placed soils were assessed in an operational field study at an oil sands mine. The stockpiled soils also included a tillage treatment to reduce compaction risk on some plots while the directly placed soils included both types of common reclamation soils, i.e. peat-mineral mix and forest floor-mineral mix. In general, the stockpiled soils had significantly higher bulk density, soil strength, and volumetric water content compared to the directly placed soils. The tillage treatment reduced soil strength up to a depth of 15 cm but had little impact on chemical or biological properties. Bioavailable soil nutrients tended to be similar among all treatments but nitrogen was greatest in peat-mineral mix and phosphorus was greatest in forest floor-mineral mix. Planted tree survival was similar across all treatments but natural trembling aspen seedling establishment was greater on directly placed soils with no aspen establishing on the stockpiled soils. For the plant community, forest floor-mineral mix soil had the greatest cover of native forbs, followed by the stockpiled soils and then peat-mineral mix. Overall, it appears that there are immediate impacts on the physical, chemical, and biological properties of using stockpiled soils but it is not yet known what the long-term impacts on ecosystem development will be.

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2. Brad Pinno, Assistant Professor - Silviculture, University of Alberta, Department of Renewable Resources, Edmonton, Alberta, Canada.

Continued Assessment of Acid Mine Drainage Treatment Systems in the Greater Kumurana Valley, Bolivia[1]

Andrew Potopa, Debbie Slovikosky, Justin Hugo, Logan Madison, Nick McKnight, Joseph Goodwill, and William Strosnider[2]

Abstract: The Greater Kumurana Valley in Bolivia, which is just south of Cerro Rico de Potosí, is host to multiple wildcat mines as well as legally permitted operations. These Ag-Pb-Sn-Zn mines produce net-acidic mine drainage with elevated Al, As, Cd, Fe, Mn, Pb, and Zn, among other metals. The water quality in this basin has been monitored since 2006 as mines have closed and opened, and treatments systems came online. Currently, there are two open limestone channels, one anoxic limestone drain, and one lime-dosing active treatment system in the valley. Despite some new wildcat mines opening in the valley, downstream water quality has been protected somewhat by the excess alkalinity generated by the active treatment system. Questions remain about the performance of all the treatment systems in the valley, and the effects of continued wildcat mining expansion.

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2. Nick McKnight, Justin Hugo, Debbie Slovikosky, Logan Madison, and Andrew Potopa, undergraduate Environmental Engineering Students, Saint Francis University, Loretto, PA. William Strosnider, Faculty, Saint Francis University Environmental Engineering Department, Center for Watershed Research & Service. Joseph Goodwill, Faculty, University of Rhode Island, Department of Civil and Environmental Engineering.

Use of Poultry Litter, Swine Mortality Compost, and FGD Gypsum on Reclaimed Mine Soil in Mississippi[1]

J.J. Read[2*], A. Adeli, D.J. Lang, K.D. Jones, and N.R. McGrew

Abstract: Knowledge of soil and plant responses to animal or industrial byproducts is needed for effective use of these potential amendments on reclaimed mine soils. This 4-yr study compared four treatments of 896 kg ha^{-1} NPK fertilizer (13-13-13), 22.4 Mg ha^{-1} poultry litter, 22.4 Mg ha^{-1} swine compost, and poultry litter combined with 11.2 Mg ha^{-1} FGD gypsum at a surface lignite mine in northeast Mississippi[3]. Treatments were applied to plots (3.7 x 12.2 m) of common bermudagrass in May and August each year. In 2013 and 2014, leachate water was sampled periodically at 60-cm depth from one lysimeter per plot. Experimental design was a randomized complete block with three replicates. In the analysis across years, forage yield was affected ($P<0.01$) by the year by treatment interaction, but ranking of treatments was similar each year and values averaged greater in poultry litter than swine compost (6.47 vs. 3.37 Mg ha^{-1}). This response is credited to additional N, P, and K in poultry litter, as well as more C (approximately 35% in dry matter). In general, forage yield did not differ between poultry litter and standard NPK fertilizer treatment, which provides no organic matter. As compared to litter alone, co-application of FGD gypsum reduced soil bulk density by 9% and organic matter by 21%, and increased cation exchange capacity by 9% and soluble salts from 0.25 to 0.83 mmhos cm^{-1}. Among litter-amended plots, somewhat greater forage yield in 2013 than 2014 (4.8 vs. 4.3 Mg ha^{-1}) was associated with low leachate P content of 51 x 10^{-6} g on 18 June and 16 x 10^{-6} g on 25 July 2013, as compared with 130 x 10^{-6} g in June and 97 x 10^{-6} g in July 2014. Applying poultry litter improved plant growth and soil quality parameters in a respread area.

Additional Key Words: bermudagrass, fertilizer, leachate, manure, organic matter, respread soil.

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3. Work reported here was conducted near 33° 18’ N; 88° 0’ W.

Restoring Wyoming Big Sagebrush to Annual Brome-Invaded Landscapes with Seeding and Herbicides[1]

E.P. Metier[2], L.J. Rew, M.J. Rinella, and G.L. Johnson*

Abstract: Restoring degraded grasslands with seeding is a major challenge. Often, seeded species do not establish and areas become/remain dominated by unwanted plants. We combined herbicides and reseeding in former coal mining fields[3] dominated by exotic winter annual grasses [downy brome (*Bromus tectorum* L.) and Japanese brome (*Bromus arvensis L.*), hereafter "annual bromes"]. The main interest was restoring Wyoming big sagebrush [*Artemisia tridentata* spp. *wyomingensis* [Beetle & A. Young] S.L. Welsh, hereafter "big sage"], among the most difficult species to restore to North American grasslands. We tested the non-selective herbicide glyphosate and the grass-specific herbicide quizalofop. The summer following herbicide applications and seeding, annual brome cover was 22 % (13%, 36%) for controls, compared to 11% (5%, 25%) and 16% (7%, 35%) for glyphosate and quizalofop, respectively. Two summers after herbicide applications and seeding, seeding alone and combined with quizalofop did not significantly increase big sage, but seeding combined with glyphosate provided big sage densities of 3.05 (1.42, 6.56) and 0.43 (0.13, 1.40) plants m^{-2} at the two study mines. These results were consistent across experiments initiated in two different years. In addition to big sage, seed mixes contained native grasses, forbs and sub-shrubs, and while seeding consistently increased combined cover of these plant groups, effects of herbicides on these plant groups varied by mine. In the northern Great Plains, growing season conditions amenable to big sage recruitment do not appear entirely uncommon, and herbicides can increase recruitment.

Additional Key Words: downy brome, glyphosate, grass herbicide, grassland restoration, Great Plains, mining, mixed grass prairie, plant establishment.

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2. Emily P. Metier, Rangeland Technician, Fort Keogh Livestock and Range Research Laboratory, United States Department of Agriculture, Agricultural Research Service, Miles City, Montana 5930; Lisa J. Rew , Associate Professor of the Department of Land Resources and Environmental Sciences, Montana State University, P.O. Box 173120, Bozeman, Montana 59717; (Corresponding author) Matthew J. Rinella, Rangeland Scientist Fort Keogh Livestock and Range Research Laboratory, United States Department of Agriculture, Agricultural Research Service, Miles City, Montana 59301. Presenter: Gabe L. Johnson*, Environmental Engineer, Cloud Peak Energy Spring Creek Mine, Decker, MT, 59025.

3. Work reported here was conducted near Spring Creek (45°12' N, 106°91' W) and Decker (45°06' N, 106°84' W) surface coalmines.

Preserving Reclamation Research by Geocoding American Society of Mining and Reclamation Proceedings[1]

Kari Lagan, Lily Currie, Ashley Rovder, Staci Wolfe, Zach Shoff, David Madl, Stefan Long, William Strosnider, and Peter Smyntek[2]

Abstract: The Saint Francis University Center for Watershed Research & Service geocoded the American Society of Mining and Reclamation conference proceedings from 2011 to 2012 as well as the articles in the Journal of The American Society of Mining and Reclamation from 2011 to 2016. This project was undertaken in the context of our Research-Learning structure. Small teams of undergraduate students overseen by professor and postdoc mentors executed the work. Google Earth and Earth Point were applied to allow broader analysis options. Trends have been noted between meeting location and the location of research projects. Aside from that, an easily accessible database has been created that should allow for easy location of the sites of past research, perhaps opening the door for sites to be revisited for follow-on research topics such as long term successional or passive treatment performance studies. This research is a continuation of the same project presented at the 2017 American Society of Mining and Reclamation conference, which included the geocoding of proceedings from 1998 to 2007.

Additional Key Words: geolocation

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2. Kari Lagan, Lily Currie, Ashley Rovder, Staci Wolfe, Stefan Long, and David Madl, Undergraduate Environmental Engineering Students, Saint Francis University, Loretto, PA. William Strosnider, Faculty, Saint Francis University Engineering Department, Center for Watershed Research & Service. Loretto, PA. Zach Shoff, Undergraduate Student, Saint Vincent College, Latrobe, PA. Peter Smyntek, Faculty, Saint Vincent College, Latrobe, PA.

Phytophthora cinnamomi is Capable of Colonizing Forestry Reclamation Approach Sites[1]

Kenton Sena*, Tyler Dreaden, Ellen Crocker, Chase Clark, and Chris Barton[2]

Abstract: Appalachian forests are threatened by a number of factors, especially introduced pests and pathogens. Among these is *Phytophthora cinnamomi*, a soil borne oomycete pathogen known to cause root rot in American chestnut, shortleaf pine, and other native tree species. This study was initiated to characterize the incidence of *P. cinnamomi* on surface mined lands in eastern Kentucky, USA, representing a range of time since reclamation. Incidence of *P. cinnamomi* was interpreted according to overall soil development, as indicated by a variety of measured soil physical and chemical parameters, especially accumulation of soil organic carbon. *P. cinnamomi* was detected in only two of the four sites studied, aged 15 and 20 years since reclamation. These sites were generally characterized by higher organic matter accumulation than the younger sites in which *P. cinnamomi* was not detected. These results demonstrate that *P. cinnamomi* is capable of colonizing reclaimed mine sites in Appalachia; additional research is necessary to determine whether *P. cinnamomi* is capable of causing disease in susceptible tree species on these sites.

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1. Oral paper presented at the 2018 National Meeting of the American Society of Mining and Reclamation, St. Louis, MO: The Gateway to Land Reclamation, June 3 - 7, 2018. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.

2.. Kenton Sena, PhD Candidate, Department of Forestry and Natural Resources, University of Kentucky, Lexington, KY 40546; Kevin Yeager, Associate Professor, Department of Earth and Environmental Sciences, University of Kentucky, Lexington, KY 40546; Tyler Dreaden, Research Plant Pathologist, USDA Forest Service Southern Research Station, Forest Health Research and Education Center, Lexington, KY 40546; Chris Barton, Professor, Department of Forestry and Natural Resources, University of Kentucky, Lexington, KY 40546.

Quantitative Evaluation of Flow Loss Restoration Associated with Undermined Streams at the Bailey Mine in Southwestern Pennsylvania[1]

M.L. Shema, J.M. Silvis, and M.R. Haibach[2]

Abstract: Since 2005, longwall coalmine operators in Pennsylvania (US) have been required to collect extensive biological and hydrologic data to document pre- and post-mining conditions of aquatic resources overlying the subsidence control plan areas (SCPA). Continued operation of the longwall mine depends on empirical data demonstrating that the undermined aquatic resources have either maintained or been restored to the normal range of pre-mining conditions. When subsidence-related flow loss is observed in streams overlying the SCPA, mine operators are required to implement restoration techniques aimed at restoring the flow condition. Streambed grouting is the primary flow loss restoration technique employed at the Bailey Mine. This presentation examines the comparative biological metrics and quantitative hydrologic methods that are used to determine recovery following intervention. The data show that streambed grouting is effective in protecting the overall hydrologic balance and maintaining the aquatic life use of streams within the Bailey Mine SCPA.[3]

Additional Key Words: Stream, Longwall, Flow Loss, Grouting, Restoration, Macroinvertebrates.

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1. Oral paper presented at the 2018 National Meeting of the American Society of Mining and Reclamation, St. Louis, MO: The Gateway to Land Reclamation, June 3 - 7, 2018. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.

2. Michael L. Shema, Principal and Ecologist, Civil & Environmental Consultants, Inc., Pittsburgh, PA 15205; Joshua M. Silvis, Manager Hydrogeology, CONSOL Energy, Inc., Canonsburg, PA 15317; Mark R. Haibach, Vice President and Ecologist, Civil & Environmental Consultants, Inc., Pittsburgh, PA 15205.

3. Work reported here was conducted near 39°53'27.87"N; 80°28'32.08"W.

Metals Retention and Remobilization in a Small Mine Drainage Impacted Stream Colonized by *Castor canadensis* (North American Beaver)[1]

N.L. Shepherd and R.W. Nairn[2]

Abstract: This study investigated three aspects of North American Beaver colonization on a mine drainage impacted tributary to Tar Creek (Ottawa County, OK): (1) retention of metals due to the presence of beaver dams, (2) metals contamination of sediments due to long-term loading and, (3) metal remobilization due to anthropogenic dam removal. The study reach of the tributary is approximately 1.6 km and has been impacted by two continuous net alkaline, metals-rich mine drainage sources since 1979. The primary metals of concern are Cd, Fe, Pb, and Zn. The first source, discharging ~380 L/min, was the perennial starting point of the study reach and remained untreated during the study. The second source is located approximately 0.6 km downstream, discharging ~600 L/min and has been treated by a passive treatment system since 2008. Beaver colonization was first noted in late 2013. By the end of 2014, most of the study reach was transformed into a series of beaver impoundments. The study found, compared to historic stream data, the presence of beaver dams exhibited a decrease in Fe and Cd concentrations, with minimal effect on Pb concentrations. The beaver dam receiving the greatest initial metals concentrations had mean Fe and Cd removal efficiencies of 57% and 63%, respectively. Stream sediments contained elevated Cd, Pb, and Zn concentrations, with many of the metals concentrations more than five times the EPA site-specific probable effects concentrations for sediment toxicity (11.1 mg Cd/kg, 150 mg Pb/kg, and 2,083 mg Zn/kg). The removal of beaver dams displayed remobilization of Fe and Cd, with 98% of Fe mobilization occurring at the most upstream dam. Overall, the study highlights the potentially important role beaver can play in the treatment of mine drainage, and their influence as ecosystem engineers.[3]

Additional Key Words: Beaver, Tar Creek, Ecosystem Engineers

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1. Oral paper presented at the 2018 National Meeting of the American Society of Mining and Reclamation, St. Louis, MO: The Gateway to Land Reclamation, June 3 - 7, 2018. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.
2. Nicholas L. Shepherd, Graduate Research Assistant (Student), and Robert W. Nairn, Professor, Center for Restoration of Ecosystems and Watersheds, School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK 73019
3. Work reported here was conducted near 36°55'30.24"N, 94°52'15.85"W.

Measuring the Recovery of Fish Communities in a First Order Stream to Tar Creek After Implementation of Two Passive Treatment Systems[1]

N.L. Shepherd*, W.J. Matthews, and R.W. Nairn[2]

Abstract: Two artesian discharges of metals-contaminated mine drainage have impacted an unnamed tributary to Tar Creek in northeast Oklahoma since 1979. Prior to any intervention, in-stream concentrations of Fe, Zn, Pb, and Cd were elevated above recommended water quality criteria. Two passive treatment systems (PTS) were constructed and are operating in the tributary watershed: i) the Mayer Ranch PTS, (since 2008 and located 0.6 km from the start of the study reach) and the Southeast Commerce PTS (since 2017 and located at the headwaters of the study reach). Mean metal removal efficiencies for these systems are >99% and 95% for Fe and Zn, respectively, with Pb and Cd effluent concentrations below practical quantitation limits. This study investigated the impacts of improved water quality discharged from these PTS on fish community recovery in the 1.6 km study reach of the receiving unnamed tributary, Tar Creek main stem and four reference streams. Fish collections began in 2005 and have continued through 2018. Prior to PTS construction, mean fish species richness values were 6 immediately below mine drainage inputs and 8 just above the confluence of the unnamed tributary with Tar Creek. Post-MRPTS, species richness values were 11 and 10 at these locations, respectively. Fish densities have also increased, with, for example, catch per unit effort values for a common sunfish (bluegill, *Lepomis macrochirus*) increasing from 1.0 to 6.6 and 0.3 to 4.4, respectively, at these locations. Overall, as in-stream water quality improved post-PTS, the limited fish community in the unnamed tributary showed a trajectory away from the original condition. Since 2016, the return of beavers (Castor canadensis) resulted in deep water impoundments inhibiting fish collections. In addition, completion of the Southeast Commerce PTS in early 2017 resulted in addition of new sampling locations and documentation of fish recolonization directly below the new outfall.[3]

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2. Nicholas L. Shepherd, Graduate Research Assistant (Student), and Robert W. Nairn, Professor, Center for Restoration of Ecosystems and Watersheds, School of Civil Engineering and Environmental Science, William J. Matthews, Professor, Biology, University of Oklahoma, Norman, OK 73019

3. Work reported here was conducted near 36°55'30.24"N, 94°52'15.85"W.

Geospatial Distribution of Trace Metals in Soils of a Mining Impacted Agricultural Watershed[1]

A.L. Sikora* and R.W. Nairn[2]

Abstract: The Elm Creek watershed, located in Ottawa County in northeastern Oklahoma, is situated to the west and south of the Tar Creek Superfund Site, part of the historic Tri-State Lead-Zinc Mining District (TSMD). Trace metals contamination has been documented in this region. However, questions remain about broader impacts in the Elm Creek watershed. Properties purchased by the Grand River Dam Authority (GRDA), a public power provider, are designated to be used as offsite mitigation for fish and wildlife impacts under the Pensacola Dam hydropower license of the Federal Energy Regulatory Commission. In this study, surface soil samples were obtained from the left and right stream terraces (top of bank, primary terrace, and lower terrace) of Elm Creek as well as from upland environments to evaluate lead, zinc, cadmium, and other metals concentrations for estimation of ecotoxic risk. Collected samples were homogenized, pulverized, and air dried in the laboratory and tested using a field portable X-ray fluorescence (XRF) spectrometer. Fifteen sampling locations (yielding 106 soil samples) along a 17 km stretch of Elm Creek were identified. Lead and zinc concentrations decreased as distance downstream increased, however, the TSMD-specific Sediment Quality Guidelines (SQG) for lead (150 mg/kg) and zinc (2,100 mg/kg) were exceeded in 48% and 32%, respectively, of the samples within the first 11.3 km of the creek. Of the total of 278 upland soil samples collected and analyzed with the XRF in the laboratory, no sample concentrations exceeded the Tar Creek Superfund Site-specific Remedial Goal (RG) concentrations of 400 mg/kg for lead, but 2.5% exceeded the RG for zinc (1,100 mg/kg). A subset of samples was analyzed for cadmium via ICP-OES. Of these samples, three of the 56 samples (5.4%) exceeded the cadmium RG of 10 mg/kg. The geospatial distribution of metals was evaluated, hot-spots identified, and spatial statistics conducted. The results of this study will influence long-term land use in the watershed.[3]

Additional Key Words: XRF, ICP-OES, wetlands development, bottomland hardwood forests

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[2] Amy Lynne Sikora, Graduate Research Assistant (student) and Robert W. Nairn, Professor, Center for Restoration of Ecosystems and Watersheds, School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK 73019

[3] Work reported here was conducted near 36° 54’ 41.85” N; 94° 55’ 53.56” W.

A Comparison of Methods for Analyses of Soil Trace Metals in a Mining Impacted Agricultural Watershed[1]

A.L. Sikora*, L.W. Maguire, and R.W. Nairn[2]

Abstract: Field portable X-ray fluorescence (XRF) has become an increasingly popular technology for *in-situ* detection of trace metals. This technology allows for rapid screening of environmental contaminants when compared to other techniques, like inductively coupled plasma-optical emission spectrometry (ICP-OES) or mass spectrometry (ICP-MS). The accuracy of *in-situ* XRF analyses has been questioned due to possible interference from elevated soil moisture and organic content. In this study, three metals analysis protocols were compared for surface soil samples. Soil samples were collected near the Tar Creek Superfund Site in northeastern Oklahoma. A field portable XRF spectrometer was used *in-situ* for analysis of metals concentrations in small field plots cleared of vegetation and debris. Collected samples were homogenized, pulverized, air dried, and sieved to < 250 um fraction in the laboratory and re-tested using the field portable XRF. Samples were also analyzed via microwave-assisted hot HNO_3 digestion followed by ICP-OES analyses. Moisture content and loss-on-ignition (as a surrogate for organic matter) were determined for each sample. Soil moisture exceeding 10% in the field was found to decrease the accuracy of XRF metals concentrations readings. Elevated moisture contents caused underreporting of field XRF readings when compared to the laboratory XRF readings. Relationships between laboratory XRF and ICP-OES concentrations for lead ($r^2 = 0.96$) and zinc ($r^2 = 0.91$) were strong. No statistical relationship between soil organic content and XRF accuracy was established. The relationship for ICP-OES concentrations for cadmium and zinc resulted in an r^2 of 0.93 which allowed for prediction of cadmium concentrations for samples not analyzed by the ICP-OES. This study recommends that when analyzing samples with the field portable XRF, samples should be homogenized, air dried, sieved and analyzed in the laboratory, rather than *in situ*, to yield the most accurate results.[3]

Additional Key Words: XRF, ICP-OES, moisture content, loss-on-ignition

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[2] Amy Lynne Sikora, Graduate Research Assistant (student), Lane Maguire, Undergraduate Research Assistant, and Robert W. Nairn, Professor, Center for Restoration of Ecosystems and Watersheds, School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK 73019

[3] Work reported here was conducted near 36° 54’ 41.85” N; 94° 55’ 53.56” W.

Switchgrass and Giant Miscanthus Biomass from Reclaimed Mine Lands

S. Scagline-Mellor, T. Griggs, and J. Skousen

Abstract: Switchgrass (*Panicum virgatum* L.) and giant miscanthus (*Miscanthus x giganteus* Greef & Deuter ex Hodkinson & Renvoize) are productive on marginal lands in the eastern US, but their productivity and composition have not been compared on mine lands. Our objectives were to compare biomass production, composition, and theoretical ethanol yield (TEY) and production (TEP) of these grasses on a reclaimed mined site. Following 25 years of herbaceous cover, vegetation was killed and plots of switchgrass cultivars Kanlow and BoMaster and miscanthus lines Illinois and MBX-002 were planted in five replications. Annual switchgrass and miscanthus yields averaged 5.8 and 8.9 Mg dry matter ha^{-1}, respectively, during 2011 to 2015. Cell wall carbohydrate composition was analyzed via near-infrared reflectance spectroscopy with models based on switchgrass or mixed herbaceous samples including switchgrass and miscanthus. Concentrations were higher for glucan and lower for xylan in miscanthus than in switchgrass but TEY did not differ (453 and 450 L Mg^{-1}, respectively). Total ethanol production was greater for miscanthus than for switchgrass (5,594 vs 3,699 L ha^{-1}), did not differ between Kanlow and BoMaster switchgrass (3,880 and 3,517 L ha^{-1}, respectively), and was higher for MBX-002 than for Illinois miscanthus (6,496 vs 4,692 L ha^{-1}). Relative to the mixed feedstocks model, the switchgrass model slightly under-predicted glucan and slightly over-predicted xylan concentrations. Estimated TEY was slightly lower from the switchgrass model but both models distinguished genotype, year, and interaction effects similarly. Biomass p-roductivity and TEP were similar to those from agricultural sites with marginal soils.

Additional Keywords: Cellulosic bioenergy feedstock, Mine reclamation, Near-infrared reflectance spectroscopy, theoretical ethanol production, theoretical ethanol yield.

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2. Steffany Scagline-Mellor, USDA-Forest Service, Elkins, WV; Thomas Griggs and Jeff Skousen, Division of Plant and Soil Sciences, West Virginia University, Morgantown, WV 26506-6108; Corresponding author: J. Skousen jskousen@wvu.edu

Reclamation in Smelter-Impacted Landscapes in Northern Regions – A Comparison of Canadian and Russian Experiences[1]

G. Spiers[2], P. Beckett, S. Koptsik, and G. Koptsik

Abstract: The nickel-processing industry has contributed significantly to environmental damage and deterioration both in Sudbury, Canada and the Kola Peninsula, Russia. The long-term effects of air emissions have created vast industrial barrens within the forested ecosystems near the smelter within both regions. Despite a significant reduction in air emissions in the recent decades, the accumulation of bioavailable and potentially toxic metal levels in the acid surface soils, accompanied by soil erosion and associated soil nutrient depletion, impede natural vegetation recovery. The internationally recognized Sudbury Protocol for technogenic barren landscape restoration has evolved over 40 years since 1978 from regreening activities that involved application of dolomitic limestone, fertilizer, seeding of agricultural grasses, legumes and planting of tree seedling to a more complete biodiverse restoration strategy. By 2017, 3470 ha had received soil amelioration and 10 million trees and shrubs had been planted for approximately Can $32 million while employing over 4700 individuals. The effectiveness and success of landscape rehabilitation programs initiated in 2003-2004 in the Kola Peninsula is also largely dependent on the continual decreases in pollutant loading onto the landscapes, on continuing improvements in the physico-chemical conditions of regional soils, and on the effectiveness and suitability of the continuously evolving land remediation technologies. There is an obvious need to accelerate the pace of remediation of the industrial barrens with the diversification and development of improved remediation technologies to enhance sustainable environmental management and regional economic development. Basic remediation options such as chemo-phytostabilization can provide rapid risk mitigation through containment and stabilization of the contaminants while potentially providing a range of additional economic (biomass generation as renewable energy source), social (leisure and recreation, educational value) and environmental (CO_2 sequestration, secondary pollution prevention) benefits. Ongoing research initiatives must include studies of the interactions between plants and microorganisms.

Additional Key Words: forest, regreening, metals, restoration, economic diversification.

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2. Graeme Spiers, Professor of Environmental Monitoring, School of the Environment and Peter Beckett, Restoration Ecologist, Biology Department, Laurentian University, Sudbury, Ontario, P3E 2C6 Canada: Sergey Kopstik, Faculty of Physics and Galina Kopstik, Faculty of Soil Science, Lomonosov Moscow State University, Leninskie gory, Moscow, 119991 Russia.
3. Work reported here was conducted near Sudbury 46° 29' 24" N, 81° 0' 36.'' W: Kola Peninsula (Monchegorsk) (67°55′N, 32°48′E).

Agricultural Longwall Subsidence Mitigation Utilizing Subsurface Drainage Systems: Why Can't We Make It Better?[1]

G. Spinner[2] and D. Barkley

Abstract: Underground coal mining in Illinois has a lengthy history dating back to the early 1800's. Since then, surface subsidence has resulted intentionally from high extraction mining methods as well as random delayed occurrences above standard room and pillar mining. Modern mechanized longwall mining methods were introduced in the 1960's and currently account for a large percentage of Illinois coal production. Regulations governing subsidence from underground coal extraction and the requirement to mitigate impacts to surface structures and surface land became effective in 1983. Restoration of drainage on agricultural land after subsidence is an important issue confronting the coal industry's use of full extraction mining technology. Through decades of experience, much has been learned about various approaches to achieve acceptable results. Reestablishing surface drainage is readily achievable. A second distinct issue is the impact of surface subsidence relative to the near surface water table. Supplementing surface drainage work with subsurface drainage systems can achieve better control of moisture levels in the rooting zone. With an eye towards management of water levels throughout the seasons, implementing subsurface drainage systems that control flow can have the added benefit of retaining soil nutrients by limiting leaching. This presentation will provide an overview of specific subsurface drainage systems being installed in longwall areas and the anticipated long-term benefits to highly productive farming systems in Illinois.

Additional Key Words: Water level control structures, drainage tile.

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2. Gerry Spinner, E&G Construction, 18067 Deer Trail, Hillsboro IL 62049; Daniel Barkley, P.E., Illinois Department of Natural Resources, Office of Mines and Minerals, One Natural Resources Way, Springfield IL 62702.

The Role of Algal Biomass Growth on Nutrient and Metal Interactions at the Sediment-Water Interface[1]

Zepei Tang* and Robert W. Nairn[2]

Abstract: In this research, the goal was to understand the nutrient and metal cycling processes at the sediment layer-water column interface in a large terminal reservoir, the Grand Lake o' the Cherokees, Oklahoma. The study site has both elevated metals concentrations in the sediments from the upstream Tri-State Lead-Zinc Mining District and elevated nutrient concentrations in the water from agricultural and urban run-off, resulting in eutrophication and substantial algae blooms. A greenhouse microcosm study was designed with three different biomass addition treatments: control (no algae addition), low biomass (40 µg L^{-1} as chlorophyll a) and high biomass (80 µg L^{-1}) using lake sediment, groundwater and laboratory-incubated *Microcystis aeruginosa*, which is one of the dominant blue-green algae in this lake. Over 30 days, these treatments with various initial biomass concentrations had overall decreasing trends in chlorophyll-a concentrations, to around 5 µg L^{-1}, despite some changes in the dominant algae species. Dissolved orthophosphate (ortho P) and nitrate nitrogen (NO_3-N) in the water column showed decreasing trends over time, indicating nutrient uptake by the biomass growth. Within the study period, iron (Fe), nickel (Ni) and cadmium (Cd) concentrations from all water samples were below the practical quantitation limit (PQL), while lead (Pb) and zinc (Zn) concentrations were around 0.015~0.04 mg L^{-1} and 0.015~0.05 mg L^{-1}, respectively, due to both residual contamination in the sediments and elevated concentrations from the added groundwater. At the end of study, Fe concentrations in the sediment showed a deceasing trend with greater biomass growth (control < low biomass < high biomass at 16002 mg kg^{-1}, 15216 mg $kg^{-1}$and 14554 mg kg^{-1} , respectively) and all treatments had lesser concentration then the initial sediment (16165 mg kg^{-1}). Sediment extracted ortho P concentrations were also lesser (control, low biomass and high biomass were 17.1 mg kg^{-1}, 17.8 mg $kg^{-1}$and 17.5 mg kg^{-1} respectively) than the initial concentrations (18.0 mg kg^{-1}). The hypothesis was that biomass growth would change the P distribution between the water column and sediment layer. It is expected that the results will show that monitoring biomass growth can benefit P control release in the water column and therefore addressing eutrophication in lakes.

Additional Key Words: phosphorus release control, AMD, iron.

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[2] Zepei Tang, Graduate Research Associate, University of Oklahoma, Norman, OK 73019 (student), and Robert W. Nairn, Professor, Center for Restoration of Ecosystems and Watersheds, School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK 73019.

Biotic Soil Technology for Cost Effective Mine Closure Cover Systems[1]

M. S. Theisen[2]

Abstract: One vexing issue facing successful restoration of disturbed mine sites is lack of available topsoil to create viable environments for establishing sustainable vegetation. In the absence of adequate sources of topsoil, new techniques have been developed to treat and revive depleted soils to render them more capable of accelerating and sustaining vegetative growth. Essentially, on-site soils can be "engineered" to improve their chemical and biological properties. The meticulous introduction of organic matter, agronomic amendments, plant biostimulants, and soil building components can effectively turn marginal soils into productive and sustainable growth media. Biotic Soil Technology (BST) is a generic term to describe the emerging field of manufactured growth media containing biodegradable fibers, biostimulants, biological inoculants, and other components engineered to cost-effectively increase organic content, accelerate sustainable vegetative establishment and promote regeneration of denuded soils. The efficacy of BST is becoming more fully demonstrated with a growing portfolio of successful installations around the world on challenging sites involving civil construction as well as engineered cover systems for mining and waste containment. Beyond the initial mission to cost effectively foster more rapid and complete establishment of vegetation to reduce erosion and improve water quality, there is a need to monitor changes in organic matter levels, soil pH, microbial levels, and other parameters that contribute to sustainable growing environments. This presentation will offer prescribed testing protocol for site assessments to determine suitable Biotic Soil Technologies, agronomic amendments and their rates prior to installation, inspection techniques during installation, monitoring post-installation vegetative species composition, density and cover as well as testing to document changes in soil chemistry and biota over time. Case studies of mining projects in diverse ecosystems will serve as examples to demonstrate the prescribed testing protocol and results obtained to validate BST efficacy.

Additional Key Words: organic matter, erosion control, growth establishment, topsoil, monitoring, inspection, testing protocol.

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2. Marc S. Theisen, Vice President – Technical Services, Profile Products LLC, Signal Mountain, TN 37377.

A Lab-Based System to Study the Microbial Impacts on Passive Remediation Systems for AMD[1]

M. Valkanas* and N. Trun[2]

Abstract: Abandoned mine drainage (AMD) affects over 3,000 miles of streams in Pennsylvania and 300,000 miles in the United States. Passive remediation systems are commonly used to treat AMD and efficiently remove contamination through the increase of pH (if necessary), aeration, settling ponds, and wetlands. Passive systems depend primarily on geochemical reactions. Microbial communities are naturally formed in these systems and vary, depending on the pH and the type of contaminants present. To study causal relationships of observations we have made in situ on contaminant levels and microbial communities, we have developed a lab-based system to study the impacts of bacteria on AMD contaminants. Slurries were collected from several ponds in two different passive remediation systems, both treating alkaline mine drainage. Bacterial communities were isolated and grown in the lab-based system to determine the impact microbial communities have on sterilized AMD. There was resolubilization of iron by bacteria from both systems, showing the potential for microbial communities to affect soluble contaminant levels. Starting with bacteria from the passive systems, enrichment cultures were grown in different media through 5 transfers and incubated in the lab-based system (after 3rd and 5th transfers). The enrichment cultures identified bacterial communities that could resolubilize iron and, to a lesser extent, manganese. We are currently identifying the bacteria and metabolic reactions in the enrichment cultures responsible for the observed effects. This will lead to a better understanding of the bacteria that have a direct impact on AMD.

Additional Key Words: AMD Passive Treatment; Bacterial AMD communities; Microbiome Analysis; Water Quality Analysis; Wingfield Pines; Lowber; Alkaline Mine Drainage.

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1. Poster paper presented at the 2018 National Meeting of the American Society of Mining and Reclamation, St. Louis, MO: The Gateway to Land

2. Michelle Valkanas, Department of Biological Sciences, Duquesne University, Pittsburgh, PA 15282 (Graduate Student); Nancy Trun, Associate Professor, Department of Biological Sciences, Duquesne University, Pittsburgh, PA 15282.

Developing diverse, effective, and permanent plant communities on reclaimed surface coal mines: establishing ecosystem function in reconstructed wildlands[1]

Edward A. Vasquez and Roger L. Sheley[2]

Abstract: Surface coalmine disturbances affect vegetation, soil chemical/physical properties, bedrock, and landforms. Reclamation programs that solely emphasize plant community composition and structure rather than effectively repairing disturbed or altered ecological processes ignores the foundation upon which the sustainability of reconstructed plant communities depends. Reclamation success may be improved by addressing primary ecological processes driving ecosystem function as part of the reclamation process. Altered primary processes requires repair of the physical system in conjunction with adding seeds or plants. Landform design strategies designed to capture, store and release water effectively into re-constructed watersheds is the foundation of successfully reclaimed ecosystems. Because functional groups can differ in their spatial and temporal acquisition of resources, improving functional diversity may be a method to more fully utilize soil nutrients in reclaimed soils and improve resilience to weed invasion. Strategically combining species with different seed/seedling traits in seed mixtures can increase chances of achieving adequate plant establishment during revegetation. Monitoring program design should be an integral part of the reclamation planning process and indicators reflecting landscape-scale processes can be adapted to monitor reclamation project success. Effective reclamation plans are process-oriented, seek to initiate autogenic repair, and address landscape interactions. The probability of achieving successful reclamation is enhanced by pursuing the broader goal of improving ecosystem vigor, organization, and resilience utilizing novel assemblages of species that perform desired functions and produce a range of ecosystem goods and services. Reclaiming mined lands requires realistic objectives that consider the ecological potential of the site, land-use goals, and socioeconomic constraints.

Keywords: Reclamation, Phytoremediation, Native plants, Restoration, Biodiversity, Ecological processes, Ecosystem function.

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2. Edward A. Vasquez, Ecologist, USDI – Office of Surface Mining Reclamation and Enforcement, 1999 Broadway, Denver, CO, 80202; and Roger L. Sheley, Ecologist, USDA-Agricultural Research Service, 67826-A Highway 205, Burns, OR, 97720. Corresponding author's E-mail: evasquez@osmre.gov

Why does cobalt supply need to move out of Africa?[1]

R. Verma[2], B.A. Elliott, G. Gülen, M. Foss, and C-H Tsai

Abstract: Over the years, cobalt's applications have evolved from making blue pigment to building blocks for a green economy. Cobalt forms an important part of the now ubiquitous lithium-ion batteries that power cell phones, laptops, a small but growing fleet of electric vehicles, and large-scale energy storage systems. As societies around the world set ambitious targets for harmonizing wind and solar energy with energy storage systems, as well as moving towards battery-powered transportation, the demand for lithium-ion batteries will increase rapidly. Batteries account for more than 40% of the total cobalt usage and will therefore, have a proportional impact on cobalt demand unless alternative battery chemistries emerge as commercial alternatives. Currently, Africa produces 71% and the Democratic Republic of Congo (DRC) alone, produces 62% of the world's cobalt ore, but contribute very little in the refined cobalt production. Chinese smelters, on the other hand, import more than 90% of the cobalt produced in Africa and dominate world supply of refined cobalt products. We investigate the policies and commercial frameworks across key countries that have led to this concentration of market power and its implications for the global cobalt supply chain. Preliminary results show that the reasons behind the near-monopsony of China on cobalt exports from Africa include commodity-backed loans to Africa by China, Chinese ownership of trading houses, and direct ownership of African mines. Focusing on North America, we further examine policy changes like zoning mineral bearing areas, streamlining permitting process, R&D investments to reduce mining and processing costs, and brining transparency around existing supply chains, that would encourage the development of domestic cobalt resources, including the Idaho cobalt belt in the US, and the Kings Bay in Canada.

Additional keywords: mineral supply chain; commercial framework; critical metals; lithium ion batteries

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2. Rahul Verma, Brent A. Elliott, Gürcan Gülen, Michelle Foss, and Chen-Hao Tsai, Bureau of Economic Geology, University of Texas at Austin.

Quantifying Sulfide Removal Using Solar Powered-Aeration in Passive Treatment of Net Alkaline Mine Waters[1]

Taylor R. Wall* and Robert W. Nairn[2]

Abstract: Although passive treatment systems can improve water quality for mine water discharges, some process units, like vertical flow bioreactors (VFBRs), can produce excess sulfide. Elevated sulfide concentrations are sources of nuisance odors and may lead to direct ecotoxicity. In this study, a novel sulfide removal approach using a custom-designed solar-driven system and activated carbon filter (ACF) was evaluated. The study site, the Southeast Commerce passive treatment system (SECPTS) at the Tar Creek Superfund Site in Oklahoma, addresses 380 L/min of net alkaline lead-zinc mine waters in four process units. VFBR effluent enters a closed odor control structure from which the sulfide-rich atmosphere is pulled into the ACF using a solar-powered exhaust blower. The ACF includes 180 kg of GC Sulfasorb and activated carbon media. VFBR effluent aqueous sulfide concentrations were as high as 0.147 mg/L. ACF gaseous sulfide concentrations were up to 33.8 ppm into the ACF and were consistently below detectable limits out of the ACF. Aqueous sulfide concentrations greater than 0.002 mg/L are considered chronically toxic to aquatic life, and prolonged exposure to gaseous concentrations greater than 20 ppm may lead to fatigue, poor memory, and dizziness. These data were generated during the first year of operation of the SECPTS, during the autumn and winter months. It is anticipated that warmer ambient temperatures will result in greater biological activity and elevated sulfide concentrations, which may impact ACF performance. In addition to the sulfide removal system, solar-powered blowers re-aerate the water column in the post-VFBR final polishing unit (FPU). Aqueous sulfide concentrations exiting the FPU ranged from 0.002 to 0.026 mg/L. Initial evaluation of the off-the-grid renewable energy-powered sulfide-removal and aeration systems indicates that they enhance water quality improvement effectiveness and may be especially attractive for use in remote locations and/or at sites where operation and maintenance budgets are limited.

Additional Key Words: vertical flow bioreactor, sulfate reduction, renewable energy, activated carbon.

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2. Taylor R. Wall, Graduate Research Assistant (student) and Robert W. Nairn, Professor, Center for Restoration of Ecosystems and Watersheds, School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK 73019.

Anticipating the True Costs of Mine Closure Reclamation[1]

Terry Kremmel, and Zachary Wappes[2]

Abstract: As mines approach their economic and/or commercial life, the importance of a realistic mine closure estimate becomes critical. Financing the final reclamation of mine sites requires identifying an extensive list of requirements in order to meet permit, state, and federal requirements, while also understanding the limitations of work in a post closure mine environment. Companies should desire an accurate estimate in order to properly finance reclamation and determine optimal closure timing scenarios. Typically, cost estimates are based on standard assumptions used for the determination of reclamation bond amounts or Asset Retirement Obligations; however, these assumptions often are found to be unrealistic in actual reclamation conditions. In addition, estimates need to be periodically updated to account for changing input costs and new requirements and technologies, like those of geomorphic reclamation. Drawing from experience gained in multiple mine closure projects across the United States[3], this presentation will step through a typical reclamation estimate and detail the shortfalls that have been encountered with respect to grading plans, equipment fleets, labor force, monitoring, and other reclamation cost items. This presentation will prime mine operators to reassess their assumptions regarding their mine closure planning as well as look critically at closure funding to avoid shortfalls.

Additional Key Words: Reclamation Bond, Cost Estimate, Mine Planning, Permitting, Monitoring

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2. Terry Kremmel, PE (MO, NC), Associate and Mining Practice Leader, Golder Associates Inc. and Zachary Wappes, PE (MO), Senior Project Mining Engineer, Golder Associates Inc.
3. Work Reported here was conducted in St Louis, MO with respect to various confidential mines across the US.

Eucalypt plantations for mine site rehabilitation, carbon sequestration and wood products in the Hunter Valley, Australia[1]

A.A. Webb[2*], G.L. Kelly, and N. Cameron

Abstract: Coal mining is central to economic development in the Hunter Valley, New South Wales, Australia with >100 million tonnes of black coal produced annually. Rehabilitation is mandatory following the mining process and it is estimated that 20,000 ha of open-cut mine rehabilitation is required in the Upper Hunter coalfields where mean annual rainfall is ~700 mm. The traditional post-mining land use has been extensive grazing of beef cattle; however, replicated plantation forest trials were established in the late 1990s and early 2000s on buffer sites and reshaped overburden in the Upper Hunter coalfields to investigate the potential commercial viability of growing plantation forests as an alternative post-mining industry – either for wood products or carbon offsets. Following on from earlier establishment trials, the focus of this paper is the ongoing management of the dryland plantations, which are now ~15 years old, with the objective of quantifying the benefits of an early non-commercial thinning and pruning regime. Seven hardwood species were trialled in this project: *Corymbia maculata*, *Eucalyptus camaldulensis*, *E. argophloia*, *E. molluccana*, *E. sideroxylon*, *E. camaldulensis* x *grandis* and *E. camaldulensis* x *globulus*. The best all round performer to date has been *C. maculata* (Spotted gum). While it has grown well on buffer sites, most stands have performed as well or better on the reshaped overburden. Thinning at age 10-12 years has not yet led to an increase in overall stand volume; however at the majority of sites it has resulted in an increase in the mean diameter and height of trees. Initial assessments indicate that thinning is likely to produce stands of better form resulting in the growth of higher value timber products. We used an economic model to compare expected returns from grazing with Spotted gum forestry and agroforestry using growth and yield projections. Net present values and internal rates of return were generated and we conclude that forestry and agroforestry deliver comparable commercial returns (from carbon and wood products) to grazing but with a different investment and risk profile.

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The Use of Calcite Precipitation to Treat Zinc-, Lead-, and Cadmium-bearing Mine Drainage at the Rex Mine Site Coeur d' Alene, Idaho[1]

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Abstract: The Rex Mine and Mill Site is located on the northwest side of the East Fork Ninemile Creek watershed in Shoshone County, Idaho and approximately 7 miles north of Wallace, Idaho. Discharge from the Rex Mine and Mill Site underground mine adit has a pH of approximately 5.6, and zinc, lead, and cadmium concentrations of about 5100 µg/L, 380 µg/L, and 2.9 µg/L, respectively. The sulfate concentration was only 36 mg/L, making a traditional substrate-based biochemical reactor type system potentially impractical without sulfate supplementation. A bench-scale treatability study was conducted to investigate the use of a novel abiotic calcite precipitation-based passive treatment approach. The mine water received at the laboratory (pH ~7) was reacted with carbon dioxide (CO_2) to restore the field pH conditions discharging the underground mine. The water was then passed through a column of limestone in an upflow configuration. The discharge from the column was air-stripped in an open vessel using an aquarium air pump, resulting in a pH increase and precipitation of calcite. Removal of zinc and cadmium was achieved through coprecipitation with calcite within the air-stripping vessel, while the lead was removed via precipitation of lead phosphate at the higher pH. Removals of zinc, lead, and cadmium of about 99% were achieved. The majority of the zinc and cadmium were removed within the stripping vessel, indicating that adsorption within the columns were not the main removal mechanisms. However, the lead was removed mainly within the columns. Geochemical modeling suggested that the lead was removed as a phosphate phase as opposed to an adsorption onto the calcite. The implications of this research provide a potential treatment alternative for slightly lower-pH and CO_2 saturated mine waters containing elevated metals (excluding iron and aluminum), as opposed to costly active treatment systems or biotic sulfate reduction treatment methods.

Additional Key Words: limestone, coprecipitation.

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LAND COVER MONITORING FOR MINING RECLAMATION AREA BASDE RANDOM FOREST CLASSIFICATION FROM REMOTELY SENSED IMAGE[1]

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Abstract: The monitoring of land cover use and land cover change in the mining area is very important for the task of land reclamation and recovery. Comparing with traditional field-based survey and investigation methods, the remote sensing technology provide an effective and cost-efficient approach for fast information acquisition of land cover and land change information in the mining land reclamation area. In the mining land reclamation area, the strong topographic relief, the diversity, breakage, mixed distribution, and scattered layout of the surface features and other factors constitute the difficulties for remote-sensing image classification mapping. In order to improve the classification accuracy for land cover of mining reclamation area and provide technique reference for land reclamation monitoring and supervision, this article explored the monitoring and mapping method based on Random Forest algorithm for the reclamation area. Satellite and auxiliary dataset including GF-1 images, aerial images, DEM, and field investigation data acquired in October 2016 were used in this study. In this paper, the 33 features variables were selected and constructed 4 combined models on the basis of data image spectrum, topography, texture, space and other information to carry out random forest classification experiment, the precision was 82.79%, 84.91%, 86.75% and 88.16% respectively. Comparison with other classification methods such as support vector machine, maximum likelihood, and artificial neural network classifiers indicates that the random forest classifier could achieve the best accuracy with an overall accuracy of 88.16% and the Kappa coefficient of 0.83. Overall, we concluded that the random forest algorithm could achieve a satisfied classification accuracy of 88.16% under the multi-feature variables frame for mining reclamation area land cover mapping, which was better than SVM, MLC, and ANN classification results with the same feature variables. The random forest classifier was more efficient than SVM and more capable of dealing with multidimensional characteristic variables. This study may provide technical support and theoretical reference for the intelligent interpretation of remotely sensed images in the application of land reclamation monitoring and supervision task for land and resources administration.

Additional Key Words: reclamation area; land cover monitoring; random forest classification; multi-feature variables; feature selection.

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Hydrology-Based Design of Geomorphic Evapotranspiration Covers for Reclamation of Mine Land[1]

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Abstract: Currently there are about half a million abandoned mine sites in the U.S. and New Mexico has an estimated 15,000. Surface mining imposes severe ecological effects on the land because it not only alters the vegetation, soils, bedrock, and landforms, but also changes the surface hydrology, groundwater, and flow paths that ultimately result in degraded ecology and water quality. Two relatively new methodologies, fluvial geomorphic landform design and evapotranspiration (ET) waste covers, offer solutions to reclaim these sites for long term. GeoFluv™ is a specific geomorphic grading design method that uses natural analogues for post-mining landscapes and uses design input values taken from stable natural landscapes to make a reclamation design that provides hydrological function, supports ecosystem integrity, and is cost-effective, sustainable, and more visually attractive. It has documented the ability to produce surface runoff water quality equal to or better than adjacent undisturbed lands and has been used for disturbed lands, including active and abandoned mine sites, in Africa, Australia, Canada, Europe, South America, and the USA. To manage the subsurface hydrology, surface ET covers have been used above landfills, waste sites, and mine lands. ET covers protect the underlying materials against erosion, provide a medium for vegetation growth, store precipitation within the cover, and release the stored water into atmosphere so that the infiltration of precipitation is minimized. The storage capacity of an ET cover can be further enhanced by including a capillary break beneath the storage layer. The ET covers with a design life of centuries to a millennium have been successfully demonstrated in the field for over two decades. A conceptual design study is carried out based on an actual, typical abandoned mine site near Raton, New Mexico, to which common problem conditions at abandoned mine sites are assumed. The purpose of this study is to demonstrate that superior covers can be designed by integrating these two remediation technologies (geomorphic grading and ET cover) as a geomorphic ET (GET) cover. The overall shape of the GET cover can mimic the natural topography of the surrounding area, while the thickness and layering of the cover can be optimized for best vegetation growth and infiltration control. Watershed groundwater flow is considered during GET cover design so that the post-reclamation groundwater flow is managed to meet the water quality standards. The application of GET cover technology on mine land is expected to substantially improve the reclamation effects by coupling the benefits of the geomorphic cover (drainage reduction, runoff management) with the benefits of ET covers (vegetation growth and sustainability, percolation reduction, protection of surface and groundwater).

Additional Key Words: Tailings; Geotechnical; Water Management; Vegetation

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