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# reclamation *matters*

Spring 2018



**2018**  
**Conference  
and Program**



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## reclamation matters

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# Mined Land Reclamation in the Anthropocene

*By Kimery Vories, ASMR President*

**T**he Anthropocene Epoch – the unofficial interval of geologic time making up the third worldwide division of the Quaternary Period (2.6 million years ago to the present) – is characterized as the time in which the collective activities of human beings began to substantially alter Earth's surface, atmosphere, oceans, and systems of nutrient cycling. On an almost daily basis, we are made aware of the increasing impacts of human activity on

our world to the atmosphere, the oceans, vegetation, ecosystems, wildlife, and fresh water resources.

The field of energy and environment is very much on the cutting edge of this new reality as most of the resources involved require mining or other large-scale surface disturbance. The benefits of mining can be found in almost everything that makes our civilization work and have been an essential element since the beginning (Genesis 2:11-12). The damage

to humans and environment that can result from the uncontrolled extraction process and pollutant by-products can be massive and long-lasting. The importance of protecting the environment from the destructive aspects of human activity on the environment has become an integral component in the education at every school grade level and in the media. By contrast, however, very few people have any education on where the resources come from and how they are all put



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together to make our civilization work. In fact, people who are not directly involved with mining and reclamation are generally unaware of how extensively their lives depend on products and services that could only be provided with resources that have been mined.

During my lifetime, I have witnessed the results of the most positive and progressive program on the planet for transforming the impacts of mineral extraction with a holistic ecosystem reconstruction process. This program ensures that the site environmental

values are protected for future use. In the early days of the implementation of the Surface Mining Control and Reclamation Act, however, the main actors could easily be mistaken for participants in a shotgun wedding. Over time, the increasingly positive results of this complete integration of planning for the protection of all aspects of the mining and reclamation process can be seen in the annual reclamation awards presented to the mining industry by the Office of Surface Mining Reclamation and Enforcement. These reclaimed mine

sites reveal a landscape that is almost indistinguishable from undisturbed land.

How future generations are going to handle meeting civilization's energy needs in the future with or without fossil fuels is a question that remains to be solved. What has been clearly proven by the Surface Mining Control and Reclamation Act is that the complete integration of environmental protection into the total mining and reclamation process should be the goal both of society and all professionals involved in mined land reclamation. ■

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# Income Opportunities on Reclaimed Mine Land

*By Jeff Skousen  
West Virginia University*

**I**n January 2018, we held a session entitled “Income Opportunities on Reclaimed Mine Land” as part of the West Virginia Coal Symposium. I got the idea for this meeting last fall because there were several groups of people who were doing unique and valuable projects on reclaimed mine lands but none of them knew about each other. So I decided that we should have a meeting where we could share the ideas and opportunities for generating income on reclaimed mine lands. This was the preface to the meeting:

“Surface coal mines prior to 1950 in the eastern US coal region were generally left with little to no reclamation. As government regulations advanced, mine operators were required to backfill the area and plant grasses or trees. After the federal Surface Mining Control and Reclamation Act (SMCRA) was passed in 1977, mine operators were required to conduct pre-mining analyses of the site, prepare a mining plan, and designate a land use that could be achieved after mining. Reclamation on today’s American surface coal mines is fully integrated with the mining operation. A suitable and effective post-mining land use that is sustainable for future generations is crucial to the long-term success and profitability of the mining business and is vital to economic benefits in the future. Accepted post-mining land uses in this region are 1) hay land and pasture, 2) agriculture, 3) biofuel crops, 4) forestry, 5) wildlife habitat, and 6) industrial/urban development. Successful establishment of these post-mining land uses has been demonstrated throughout the region. Post-mining conditions should provide ecosystem services and produce lands capable of supporting societal needs in the future.

Most of the mined land during the past three decades was

reclaimed to pasture or forest land. Establishing agricultural enterprises on mined lands has recently gained attention because of the large acreages of flat or gently rolling reclaimed land that is available. Flat land is highly desirable in Appalachia. The use of reclaimed land for agriculture has only been practiced on a few sites and on relatively small acreages. But it is estimated that as much as 25 percent of the reclaimed land in this region may be suitable for agriculture crops such as livestock production, vegetables, grains, and specialty crops. Specialty crops include lavender, hemp, apples and other tree fruits, Christmas tree plantations, and horticultural crop production in greenhouses. A soil resource is necessary for quality and productivity of the crop grown.”

The session consisted of 10 presentations on land uses ranging from a major Boy Scout National Campground to specialty and high value crops on reclaimed lands. You can go to <https://wvmdtaskforce.com/income-opportunities-on-reclaimed-mine-lands/> to access the presentations.

I hope others are considering the valuable resource that these lands present to landowners. Our goal as land reclamationists is to provide lands that have lasting value and sustainable conditions for future benefits. During land reclamation, we should reflect on the end goal and the ultimate use of that land. Land is a permanent resource, and we should contemplate what the land will be like in 20, 50, and 100 years from now. Will it provide services that will benefit society and the surrounding ecosystem? Will you be proud of the work you did there 25 years after reclamation? ■



# Income Opportunities on Reclaimed Mine Lands



Darrell Sears of WV National Guard holding apple seedling at Muddlety Site



Stone Crusher Demonstration at Mine 22 to make mine soils for agriculture



Chestnut growth on reclaimed mine lands at Arch Coal near Summersville, WV



Students enrolled in the Green Mining Model Business Program at Lavender site



Refresh Appalachia Agriculture Project at Mine 22 is demonstrating livestock production with 60 hogs, 200 chickens and 20 goats

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# 2018 Conference Program

## CONFERENCE SITE

The conference center and hotel is the RENAISSANCE St. Louis Airport Hotel at 9801 Natural Bridge Road, St. Louis, MO 63134. A block of rooms has been reserved at the rate of \$139 per night including hotel parking. A special government rate for government employees traveling on government per diem is available with appropriate ID at \$129 per night. The room block is under ASMR. Room reservations can also be made at [www.asmr.us](http://www.asmr.us). The hotel phone number is (314) 429-1100.

## TRANSPORTATION

The conference center/hotel is located south of Interstate 70 just across from the Lambert St. Louis International Airport. A hotel shuttle is available from the airport to the hotel. Hotel parking is included in the registration for those who arrive by car.

## Sunday, June 3, 2018

8:00 a.m. – 5:00 p.m. .... Registration - Concourse Foyer  
10:00 a.m. – 5:00 p.m. .... Exhibitor Setup – Concourse BCD



10:00 a.m. - 4:00 p.m. .... NEC Meeting – Lindbergh AB

6:30 p.m. – 9:00 p.m. .... Welcome Reception –  
Concourse BCD

## Monday, June 4, 2018

6:30 a.m. – 9:00 a.m. .... Breakfast – Concourse BCD

6:30 a.m. – 7:30 a.m. .... Haulin' ASMR - Meet in lobby

7:00 a.m. – 8:30 a.m. .... Wild Women of Reclamation –  
Lambert A

7:30 a.m. – 5:00 p.m. .... Registration – Concourse Foyer

8:00 a.m. – 6:00 p.m. .... Silent Auction – Lambert CD

9:00 a.m. – 9:30 a.m. .... Plenary Session - Concourse A

Kimery Vories – ASMR President –Welcome

Robert Darmody – ASMR Executive Secretary –Welcome &  
Announcements

9:30 a.m. - 10:00 a.m. .... Break - Exhibit Hall -  
Concourse BCD

10:00 a.m. – 12:00 noon .... Keynote Speakers

Greg Conrad, Executive Director, Interstate Mining Compact  
Commission: **The State of the Regulatory Environment  
from the States' Perspective**

Dan Barkley, Illinois DNR, Office of Mines and Minerals:  
**Longwall Subsidence Mitigation of Farmland: Challenges  
and Accomplishments Over 35 Years**

Peabody Rep, Peabody Energy: **Update and Current Trends in  
Global Coal Mining**

12:00 noon – 2:00 p.m. .... ASMR Awards Luncheon -  
Renaissance Ballroom

2:00 p.m. – 5:30 p.m. .... PM Cultural Tour 1 – Lewis  
and Clark State Historic Site See website at: <http://campdubois.com> - Meet in Lobby

Monday, June 4, Technical Sessions			
	SUBSIDENCE SESSION 1A - ORLY ROOM	FORESTRY EVALUATION SESSION 1B - HEATHROW AB	SOILS SESSION 1C - GATWICK AB
2:00 p.m. - 2:30 p.m.	Agricultural Longwall Subsidence Mitigation Utilizing Subsurface Drainage Systems: Why Can't We Make It Better. By Gerry Spinner and Dan Barkley	Hickory and Oak Growth Over 10 Years in Response to Initial Fertilization. By Jennifer Franklin and D.S. Buckley	Development of Soil Physicochemical Properties of Reclaimed Croplands in a Large Opencast Mining Area on the Loess Plateau. By Yingui Cao
2:30 p.m. - 3:00 p.m.	Overview of Insar Technology For Areas Monitoring Subsidence Over Undermined Areas. By Zach Agioutantis	Survival, Growth, and Blight Incidence of Chestnuts on an FRA-Reclaimed Coal Mine in Southwestern Virginia. By Sara Klopff	Soil Stockpile Seed Viability is Affected by Depth and Current Surface Vegetation. By Jennifer Buss, Student and Brad Pinno
3:00 p.m. - 3:30 p.m.	Response of Petro Pipelines to Longwall Subsidence. By Gennaro Marino	Soil Water Quality of Reforested Mine Site Twelve Years after Reclamation. By Amir Hass	Early Physical, Chemical and Biological Impacts of Using Stockpiled vs Directly Placed Reclamation Soils. By Brad Pinno
3:30 p.m. - 4:00 p.m. BREAK - CONCOURSE BCD			
	SUBSIDENCE SESSION 2A - ORLY ROOM	FORESTRY EVALUATION SESSION 2B - HEATHROW AB	SOILS SESSION 2C - GATWICK AB
4:00 p.m. - 4:30 p.m.	An Assessment of Long-wall Mining Subsidence on Internationally Important Floodplain Meadows: I. Plant Communities and Their Response to Increase in Wetness. By Paul Benyon and Neal Humphries	The Influence Herbaceous Vegetation on Ectomycorrhizal Root Colonization and Nutrient Uptake. By Jenise Bauman, M. Fergus, and J.A. Franklin	Effect of Alders ( <i>Alnus</i> sp.) on Technosols Development on Lignite Combustion Wastes Disposal. By Marcin Pietrzykowski
4:30 p.m. - 5:00 p.m.	An Assessment of Long-wall Mining Subsidence on Internationally Important Floodplain Meadows: II. A Model for the Prediction and Quantification of Impact and Mitigation. By Neil Humphries and Paul Benyon	Using Groundcover to Outcompete Tall Fescue ( <i>Festuca arundinacea</i> ) Without Outcompeting Tree Seedlings on a Legacy Mine Site. By Matt Aldrovandi, Student, and J. Franklin	A Pedologic View of Geomorphic Reclamation View in Wyoming. By Amanda Pennino, Student
5:00 p.m. - 5:30 p.m.	Reliance, Wyoming Mine Subsidence Mitigation Project. By Doug Beahm	Technical Division (TD) meeting -	Geocoding of American Society of Mining and Reclamation Proceedings: A New Tool and Patterns in Reclamation Research. By Kari Lagan, Student and Ashley Rovder
Social Dinner 6:00 – 9:00 PM – Renaissance Ballroom: Living Legends features "The Life and Times of a Career Reclamationist" by Vernon Pfannenstiel.			

## Tuesday, June 5, 2018

6:30 a.m. – 8:30 a.m. ....Breakfast – Concourse BCD  
 6:30 a.m. – 7:30 a.m. ....Haulin' ASMR - Meet in lobby  
 8:00 a.m. –6:00 p.m. ....Silent Auction – Lambert CD

7:30 a.m. – 5:00 p.m. ....Registration – Concourse Foyer  
 8:30 a.m. – 5:30 p.m. ....Poster Session - Heathrow AB

	NOVEL TECHNOLOGIES SESSION 3A - ORLY ROOM	POSTERS SESSION 3B - HEATHROW AB	ABANDONED MINE LANDS SESSION 3C - GATWICK AB
8:30 a.m. - 9:00 a.m.	WebGIS Application to Visualize Historical Reclamation Research Sites Using a Modified QGIS2Web Framework. By David Leifer, Student, and Ruopu Li		Implementation of the 2016 AML Pilot Program in Pennsylvania: Successes, Challenges, and Lessons Learned. By Eric Cavazza
9:00 a.m. - 9:30 a.m.	Using Novel Geophysical Techniques to Relate Surface Coal Mining Fill Characteristics to Effluent Stream Water Quality. By Kathryn Little, Student, and Erich Hester		Planning and Implementation of the 2017 AML Pilot Program in Pennsylvania. By Eric Cavazza
9:30 a.m. - 10:00 a.m.	Surveyor in the Sky: Using Very High-resolution Drone-collected Data to Monitor Ecological Restoration. By Grayson Koenemann, Student		Investigations of Acidic Discharges from the Historic Mining of the Davis and Dekoven Coal Beds in Southern Illinois. By Paul Behum and A. Mick
<b>10:00 A.M. - 10:30 A.M. BREAK - CONCOURSE BCD</b>			
	MINE POOL STUDIES SESSION 4A - ORLY ROOM	POSTERS SESSION 4B - HEATHROW AB	ABANDONED MINE LANDS SESSION 4C - GATWICK AB
10:30 a.m. - 11:00 a.m.	Statistical Modeling of Mine Pool Formation in Underground Coal Mines of Ohio. By Lindsey Schafer, Student, and N. Kruse Daniels		Developing diverse, effective, and permanent plant communities on reclaimed surface coal mines: establishing ecosystem function in reconstructed wildlands by Edward Vasquez
11:00 a.m. -11:30 p.m.	Data Management for OSM Mine Pool Project at Ohio University: Lessons Learned. By Rebecca Steinberg, Student, and N. Kruse Daniels		Eucalypt Plantations for Mine Site Rehabilitation, Carbon Sequestration and Wood Products in the Hunter Valley, Australia by Ashley Webb
11:30 a.m. -12:00 p.m.	Modelling and parameter sensitivity of mine pool formation in the Meigs Mine, Ohio by Frederick Twumasi, Student, and N. Kruse Daniels		Reclamation in Smelter-Impacted Landscapes in Northern Regions - A Comparison of Canadian and Russian Experiences by Peter Beckett

**12:00 P.M. - 2:00 P.M. LUNCH - RENAISSANCE BALLROOM****2:00 – 5:30 PM Cultural Tour 2 – Jefferson National Memorial Gateway to the West**

The Gateway Arch reflects St. Louis' role in the Westward Expansion of the United States during the nineteenth century. The park is a memorial to Thomas Jefferson's role in opening the West, to the pioneers who helped shape its history, and to Dred Scott who sued for his freedom in the Old Courthouse. See website at: (<https://www.nps.gov/jeff/index.htm>)- Meet in the Lobby

	<b>TAR CREEK, OK SESSION 5A - ORLY ROOM</b>	<b>POSTERS SESSION 5B - HEATHROW AB</b>	<b>RECLAMATION SESSION 5C - GATWICK AB</b>
2:00 p.m. - 2:30 p.m.	Metal Mass Retention in Passive Treatment Systems at the Tar Creek Superfund Site. By Robert Nairn		A Proactive Approach to Imperiled Species Management: Monarch Butterfly Habitat Enhancement on Mined Lands to Prevent Federal Listing. By Kristi Dodson
2:30 p.m. - 3:00 p.m.	Geospatial Distribution of Trace Metals in Soils of a Mining Impacted Agricultural Watershed. By Amy Sikora, Student		Geomorphic Reclamation and Landscape Heterogeneity: Results of Vegetation Analysis and Implications for Wildlife. By Kurt Fleisher, Student
3:00 p.m. - 3:30 p.m.	Metals Retention and Remobilization in a Small Mine Drainage Impacted Stream Colonized by <i>Castor canadensis</i> (North American Beaver). by Nick Shepard, Student		Impacts of a Modified Forestry Reclamation Approach on Seedling Growth and Survival on Reclaimed Mines in the Western Gulf. by Cassie Phillips, Student

**3:30 p.m. - 4:00 p.m. BREAK - CONCOURSE BCD**

	<b>PASSIVE TREATMENT SESSION 6A - ORLY ROOM</b>	<b>POSTERS SESSION 6B - HEATHROW AB</b>	<b>FORESTRY RECLAMATION SESSION 6C - GATWICK AB</b>
4:00 p.m. - 4:30 p.m.	Phytoremediation of Stormwater by Aquatic Macrophytes. By Michael Natrass, Student		Phytophthora cinnamomi is Capable of Colonizing Forestry Reclamation Approach Sites. By Kenton Sena, Student
4:30 p.m. -5:00 p.m.	Measuring the Recovery of Fish Communities in a First Order Stream to Tar Creek After Implementation of Two Passive Treatment Systems. By Nick Shepard, Student		Aspen Sprouting Response to Above Ground Disturbance on a Reclaimed Boreal Oil Sands Site in Alberta, Canada. By Stephanie Jean
5:00 p.m. - 5:30 p.m.	A Comparison of Methods for Analyses of Soil Trace Metals in a Mining Impacted Agricultural Watershed. By Amy Sikora, Student		Switchgrass and Giant Miscanthus Biomass from Reclaimed Mine Lands. By Jeff Skousen and Steffany Mellor

**Social Dinner: 6:00 – 8:00 PM Renaissance Ballroom: featuring the Muddy Horse Band**

## WEDNESDAY, JUNE 6, TECHNICAL SESSIONS

6:30 a.m. – 7:30 a.m. ....Haulin' ASMR - Meet in lobby

7:30 a.m. – 5:00 p.m. ....Registration - Concourse Foyer

6:30 a.m. – 8:00 a.m. ....Breakfast – Concourse BCD

8:00 a.m. - 11:30 a.m. ....Silent Auction – Lambert CD

	RECLAMATION CONSTRUCTION SESSION 7A - ORLY ROOM	PASSIVE TREATMENT SESSION 7B - HEATHROW AB	RECLAMATION SESSION 7C - GATWICK AB
8:00 a.m. - 8:30 a.m.	Initial Evaluation of Ripper and Tillage Methods on Reclaimed Heavy Mineral Mine Soils. By Zenah Orndorff	Passive System Rehabilitation of a High Flow Acidic Coal Mine Discharge. By Ryan Mahony	Land Cover Monitoring for Mining Reclamation Area Based Random Forest Classification from Remotely Sensed Images. By Chen Yuanpeng
8:30 a.m. - 9:00 a.m.	Selection Criteria for Sedimentation Ponds that may be Transitioned to Permanent Impoundments for a Reclaimed Surface Mine in the Southwest USA. By Kyle Kutter	Targeted Maintenance Efforts to Ensure a Decade of Successful Passive Treatment. By Robert Nairn	The Use of GPS Treatment Data and ArcGIS Tools to Evaluate Herbicide Treatment Effectiveness on a Reclaimed Coal Mine. By Wayne Erickson
9:00 a.m. - 9:30 a.m.	Integrating Geochemical Characterization and Field Procedures in Construction to Mitigate Potentially Acid-Generating Materials in Northern Minnesota, USA. By Mehgan Blair	Manganese Oxide Production and Harvesting Using Metal Removal Units. By Colin Lennox	Why Does Cobalt Supply Need to Move Out of Africa? By Rahul Verma
<b>9:30 a.m. - 10:00 a.m. BREAK - CONCOURSE BCD</b>			
	RECLAMATION AND BOND COST SESSION 8A - ORLY ROOM	WATER TREATMENT SESSION 8B - HEATHROW AB	RECLAMATION SESSION 8C - GATWICK AB
10:00 a.m. - 10:30 a.m.	Case Study to Assess the Costs of the Appalachian Regional Reforestation Initiative's (ARRI) Forest Reclamation Approach. By Jacob Johnson	Peat Based Sorption Media – Passive Treatment of Trace Metals Without a Stink. By Paul Eger	The Deployment and Risks Associated with Different Types and Combinations of Earth Moving Equipment in the Restoration of Soil Profiles. An Updating of the UK Guidance. By Neil Humphries
10:30 a.m. - 11:00 a.m.	Anticipating the True Costs of Mine Closure Reclamation. By Zachary Wappes	Dominant Trace Metal Removal Products in a Hard Rock Mine Discharge Bioreactor. By Julie LaBar	Hydrology-Based Design of Geomorphic Evapotranspiration Covers for Reclamation of Mine Land. By Z. Fred Zhang

11:00 a.m. - 11:30 a.m.	Reclamation Bond Optimization Using 3d-dig Plus. By Jake Anderson	Selenium, Uranium, and Nitrate: Treatment of Troublesome Contaminants in Mining Wastewaters – EBR Case Studies. By Ola Opara	Hydrologic Budgets and Conservative Ions: Potentially Important Yet Neglected Tools in the Evaluation of Passive Treatment System Effectiveness. By Robert Nairn
<b>11:30 P.M. - 1:00 P.M. STUDENT AWARDS AND SILENT AUCTION RESULTS - RENAISSANCE BALLROOM</b>			
<b>1:00 p.m. – 5:00 p.m. Cultural Tour 3 – Cahokia Mounds State Historic Site</b> <b>Website: <a href="https://cahokiamounds.org">https://cahokiamounds.org</a> Meet in Lobby</b>			
	<b>HYDROLOGY SESSION 9A - ORLY ROOM</b>	<b>WATER TREATMENT SESSION 9B - HEATHROW AB</b>	<b>RECLAMATION SESSION 9C - GATWICK AB</b>
1:00 p.m. - 1:30 p.m.	Quantitative Evaluation of Flow Loss Restoration Associated with Undermined Streams at the Bailey Mine in Southwestern Pennsylvania. By Michael Shema	The Use of Calcite Precipitation to Treat Zinc-, Lead-, and Cadmium-bearing Mine Drainage at the Rex Mine Site Coeur d' Alene, Idaho. By Kent Whiting	What is the best time of year to use prescribed fire to control invasive shrubs? A Case Study from the Upper Midwest. By Yari Johnson
1:30 p.m. - 2:00 p.m.	Innovation of Filling Reclamation with Multi-Layered Soil Profile. By Zhenqi Hu	Retrofitting a Lime Doser with Automatic Siphon and MixWell System. By Tim Danahy	Loblolly Pine Survival and Growth on a Reclaimed Mineral Sands Mine in Southeastern Virginia. By Sara Klopff
2:00 p.m. - 2:30 p.m.	Seasonal Trends in Water Quality in a Treated Acid Mine Drainage Impaired Stream. By Natalie Kruse Daniels	Lion Mining Borehole Project: Drilling a Flowing Artesian Water Well into a Mine Pool. By Daniel Guy	Restoring Wyoming Big Sagebrush to Annual Brome-Invaded Landscapes with Seeding and Herbicides. By Matthew Rinella
<b>2:30 P.M. - 3:00 P.M. BREAK - CONCOURSE BCD</b>			
	<b>WATERSHED APPROACHES SESSION 10A - ORLY ROOM</b>	<b>TD BUSINESS MEETINGS SESSION 10B - HEATHROW AB</b>	<b>SOIL TECHNOLOGY SESSION 10C - GATWICK AB</b>
3:00 p.m. - 3:30 p.m.	A Suite of Options at Tar Creek. By Tim Kent, Craig Kreman, and Summer King		Sloping Sand Filtration Bed for Mineral Sand Plant Effluent Clarification by Jim Gusek
3:30 p.m. - 4:00 p.m.	Treatment Success in a Heavily Mined Watershed in Ohio. By Natalie Kruse Daniels	TD Business Meetings	Biotic Soil Technology for Cost Effective Mine Closure Cover Systems. By Mark Theisen
4:00 p.m. - 4:30 p.m.		TD Business Meetings	
4:30 p.m. - 5:00 p.m.		TD Business Meetings	
<b>5:00 PM – 7:00 PM NEC COMMITTEE MEETING – BOARD ROOM 4</b>			
<b>6:00 PM -8:00 PM EARLY CAREER PROFESSIONALS EVENT—MEET IN LOBBY—DINNER ON YOUR OWN</b>			

## Thursday, June 7, 2018

Breakfast on Your Own

7:30 a.m. – 5:00 p.m. .... Professional Tour #1: Remediation of Underground Mine Subsidence on Farmland in Illinois.  
Meet in Lobby at 7:30 a.m.

8:30 a.m. – 2:00 p.m. .... Professional Tour #2: Prairie State Power Plant and Coal Mine, Meet in Lobby at 8:30 a.m.

## Titles of Posters Presented on Tuesday, June 5, 2018

1. Individual Tree and Stand-Level Carbon and Nutrient Contents Across One Rotation of Loblolly Pine Plantations on a Reclaimed Surface Mine **by Hannah Angel, Student**
2. Investigation Acidic Discharges at the Monahan Abandoned Mine Lands Site, Kansas **by Paul Behum**
3. Restoring an Oak Savanna in the Upper Mississippi Valley Zinc-Lead District **by Dan Brumm, Student and Cody Zink, co-presenter**
4. Mine reclamation using bioenergy crops: An investigation into plant-microbe interactions of switchgrass (*Panicum virgatum*) **by Zachary Freedman and Brianna Mayfield, Student**
5. Correlating Surface Water Quality and Spectral Reflectance with small Unmanned Aerial System (sUAS)-Collected Imagery **by Brandon Holzbauer-Schweitzer, Student**
6. Stormwater management for a large open-cast coal mine: A case study and proposed solutions **by Justin Hugo, Student**
7. Seasonal recovery of an Appalachian stream affected by acid mine drainage and municipal wastewater **by Justin Hugo, Student, and John Gaughan**
8. Seeding Techniques to Promote Woody Plant Establishment in the Northern Great Plains **by Gabe Johnson**
9. Restoration of the Soil Microbiome Following Mine Land Reclamation **by Jennifer Kane, Student**
10. Rehabilitation of the Reitz #1 Passive Treatment System **by Julie LaBar and Grace Bailey, Student (presenter)**
11. Mummified and Partially Petrified Wood from an Eocene Deposit in Mississippi **by David Lang**
12. China's Mining Land Policies and Reclamation Practices **by Luo Ming**
13. Geomorphic Reclamation: A pioneer method on the frontier of the Wild West **by Amanda Pennino, Student**
14. Analysis of EPA Mandated Soil Amendments **by Madison Peppers, Student**
15. Continued Assessment of Acid Mine Drainage Treatment Systems in the Greater Kumurana Valley, Bolivia **by Andrew Potopa, Student**
16. Use of Poultry Litter, Swine Mortality Compost, and FGD Gypsum on Reclaimed Mine Soil in Mississippi **by John Read**
17. The Role of Algal Biomass Growth on Nutrient and Metal Interactions at the Sediment-Water Interface **by Zepei Tang, Student**
18. A Lab-Based System to Study the Microbial Impacts on Passive Remediation Systems for AMD **by Michelle Valkanas, Student**
19. Quantifying Sulfide Removal Using Solar Powered-Aeration in Passive Treatment of Net Alkaline Mine Waters **by Taylor Wall, Student**

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## Monday, June 4, 2018 Social Dinner

Social Dinner 6:00 PM – 9:00 PM –  
Renaissance Ballroom

Living Legends features “The Life and  
Times of a Career Reclamationist” by  
Vernon Pfannenstiel.



## Tuesday Night Social

Social Dinner: 6:00 PM – 8:00 PM -  
Renaissance Ballroom featuring the  
Muddy Horse Band.

## Thursday, June 7, 2018 Professional Field Trips

Professional Field Trip 1 - Remediation  
of Underground Mine Subsidence on  
Farmland in Illinois. This field trip  
will tour the surface areas over two  
longwall mines in Central Illinois.  
The first mine performed longwall  
operations in 17 panels from 1994 until  
2007. Much of the area is flat prime  
farmland and experienced substantial  
drainage problems. The panel subsidence  
troughs are readily evident in many  
areas. Successful drainage restoration  
work through both surface waterways  
and subsurface drainage tile will be  
discussed and viewed. Lunch will be  
at a restaurant in Litchfield Illinois on  
Historic Route 66. The second mine was  
more recently initiated but has been  
idled due to underground issues. Three  
longwall panels were mined and subsided  
at this facility prior to the idling in 2015.  
Maximum subsidence experienced in  
the two longwall areas range from about  
4.5 feet to 7 feet. For participants who  
have not had the opportunity to see  
subsidence from longwall mining, the  
tour will give an excellent perspective of



the magnitude of longwall subsidence  
and a good overview of the practices  
necessary to restore

## Thursday, June 7, 2018 Professional Field Trips

Professional Field Trip 2 - Prairie State  
Power Plant and Coal Mine – The Prairie  
State Energy Campus is setting a new  
standard for clean coal production. The  
state-of-the-art energy campus uses  
modern technology to produce cleaner,  
baseload electricity for their member  
communities. See website at: <https://prairiestateenergycampus.com>. Meet in  
Lobby at 8:30AM. Trip should last about  
5 hours returning at 2 PM.

# Extra Activities at 2018 ASMR Meeting in St. Louis



## Haulin' ASMR

Where/When: 6:30 a.m., conference hotel lobby, Sunday through Thursday during the conference.

Haulin' ASMR is the low-key running group that meets for 6:30 a.m. runs in the conference hotel lobby. We usually run for 30-50 minutes (depends on the conference schedule). The pace is approximately 5-6 mph but is generally based on the ability of the participants. Some people stay with the group for part of the run and then branch off to either go faster, farther, or slow down. Last year in Morgantown, we had a running group, a walking group and a fast-paced training group. These morning activities are a wonderful way to meet new people, get some exercise, and to explore the lovely airport access roads and adjacent cemetery in St. Louis. Remember to bring your running or walking shoes to ASMR in St. Louis in 2018!

Contact:

Michele Coleman:  
MColeman@nbpower.com



## Wild Women of Reclamation

Where/When: 7:00-8:15 a.m., Tuesday June 5th. All women involved in reclamation are invited – just grab your breakfast and a colleague and meet at the designated conference room.

Wild Women of Reclamation (WWR) originated in Laramie in 2013 as an idea of Brenda Schladweiler. WWR was an integral part of the agenda at the 2014 national meeting of ASMR. Participants meet before the morning talks at a kickoff breakfast early in the conference. Every woman is welcome. Presentations in the past have dealt with choosing your own path, mentoring, starting your own business, and juggling a research career with family and community obligations. The presentations had one theme in common: adaptability. Feedback from participants at the breakfast meeting and after indicated that those participants just starting their careers appreciated the honest feedback on “how it used to be” and, in many ways, “how it still is.”

To keep the fire going throughout the year, we divide the group into “more experienced” individuals (i.e., greater than five years in your career) vs. “less experienced” (i.e., less than five years). One person from each group is paired with one from the other group. Those mentors and “mentorees” are then given the assignment

to keep in touch with each other throughout the coming year. This is an easy way to build up contacts, share ideas and receive counsel, and to learn about other careers. It is always interesting to find out how well this has worked throughout the year. We have now started a newsletter that will go out several times a year, or as often as we can get stories. The content is a way to inform and to share. After the first newsletter went out, we had many requests from women not yet members of ASMR to be added to the circulation list. Please keep those stories coming!

This will be the fifth annual WWR meeting at ASMR. We will continue this tradition by meeting Tuesday morning at 7:00 a.m. for breakfast. Please join us. We have two incredibly inspirational women speakers on the agenda: Dr. Jennifer Franklin and Ms. Summer King.

There is no membership – just grab your breakfast and come on over to the Wild Women of Reclamation presentation area. We look forward to seeing as many of you as can make it.

Contacts:

Michele Coleman  
MColeman@nbpower.com

Cindy Adams  
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# Coal Mining in Illinois: Reclamation of the Land Surface, Soils and Drainage

*By Dean Spindler and Dan Barkley, Land Reclamation Division, Illinois Department of Natural Resources*

**F**arming and coal mining are both billion-dollar industries in Illinois. Coal underlies about two-thirds of the state's 35 million acres (Figure 1). Most of the area above the coal deposits are considered either prime farmland soils or high capability soils. High-capability soils are routinely farmed but are classified one step below prime farmland based on soil type and slope (Figure 2).

## Surface Mining

The first recorded commercial surface mining was in 1810 from coal outcrops

*Figure 1. Coal underlies about 65 percent of Illinois land area of 35 million acres.*



in southern Illinois. The state's first reclamation law, effective in 1962, only regulated surface mines. Spoil ridges were required to be struck off (Figure 3) and the reclaimed area had to be planted to pasture or forest. Mine refuse was not regulated. Approximately 100,000 acres had already been surface mined before this law was passed. In 1968, a new law was passed that included reclamation of mine refuse at surface mines and performance standards for pasture and forest reclamation.

Due to the significance of agriculture in Illinois, a third law was passed in 1971 to recontour the surface mined land to its approximate original topography and replace four feet of subsoil to make the land capable of growing crops. It is notable that the rationale for this was that the replaced subsoil would provide sustainable cropland restoration. This assumption proved false. In 1976, the law was amended to require the topsoil and subsoil to be replaced to improve soil quality for crop growth. Although an improvement, particularly for the seedbed, replacing four feet of topsoil and subsoil still did not guarantee restoring crop productivity on reclaimed lands.

During the time covered by the three laws (1962 to 1976), another 100,000 acres of Illinois were surface mined. During this period, research conducted by universities, USDA-NRCS, state regulatory agencies, and the coal industry identified problematic soil parameters such as soil compaction and structure to cause the poor crop productivity. Cooperative research and demonstration projects were conducted by these entities to remediate adverse

soil conditions created from replacing soil. One practice that proved effective to restore productivity was reducing soil compaction. Figure 4 shows the DM2 deep tillage equipment used to remove soil compaction. A smaller version of the deep tillage equipment (Figure 5) has replaced that shown in Figure 4 due to the conversion from scrapers to trucks for soil replacement. Some of the soil reconstruction requirements introduced as part of the three Illinois laws were incorporated into the prime farmland requirements under the federal 1977 Surface Mine Control and Reclamation Act (SMCRA). Currently, restoration of prime and high-capability farmland at surface mines is a routine and well-known process with over 30,000 acres having met all the crop growth and productivity standards specified in regulations.

## Underground Mining

In Illinois, the surface facilities of an underground mine were not regulated for environmental protection and reclamation until the passage of SMCRA in 1977. Regulation of impacts from underground mine subsidence did not go into effect until several years later in 1983. Like most states, coal ownership and subsidence rights in Illinois can be severed or separated from land surface ownership. Most of these subsurface and subjacent support rights were severed from the land surface estate and sold many generations ago. Underground shaft mining began in the 1840s, while room and pillar underground mining methods were established around 1910. Modern mechanized longwall mining was first attempted in the 1960s and after several early failures is now the dominant

method of underground mining and accounts for the largest coal tonnage production in the state.

Illinois coal production was 65 million tons in 1970 (50 percent by surface and 50 percent by underground). In 1990, Illinois' total coal tonnage was approximately the same at 62 million tons, but the predominant production method was changing to underground (70 percent in 1990). A low of coal tonnage was produced in 2003 at 31 million tons. However, coal production has rebounded, and 56 million tons were mined in 2015 with 90 percent of the production by underground methods. In recent times, technological advances have resulted in increased panel widths from 800 feet to over 1,400 feet and daily panel advance rates have also increased significantly. Lengths of panels have also grown dramatically from one mile to six miles in some instances. In the past decade, Illinois coal production has slightly increased due to an increase in longwall mining and productivity. Figure 6 is a representation of a modern longwall mine and continuous mining sections.

Figure 2. Prime farmland covers about 68 percent of Illinois land area.

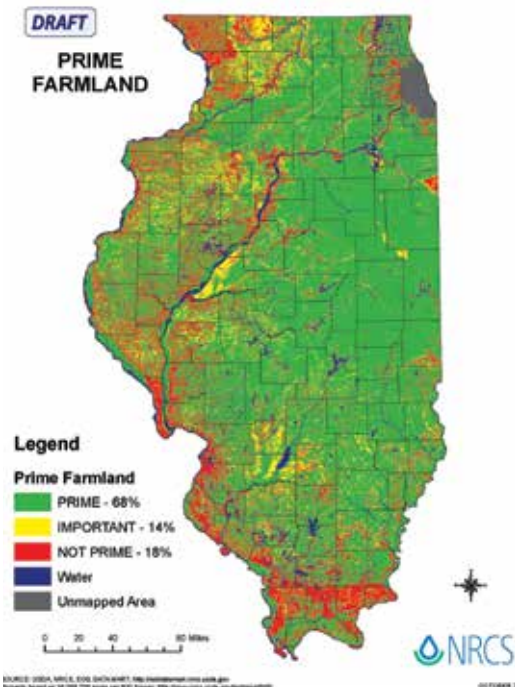


Figure 3. Surface mining before passage of reclamation laws in Illinois often resulted in abandoned highwalls, pits of water, and undulating land surface due to ungraded, weathered spoil ridges.

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Figure 4. Deep tillage equipment to reduce soil compaction on Illinois surface mines after 4 feet of topsoil was replaced.



Figure 5. Smaller equipment was used to reduce soil compaction for truck and shovel operations.

## Mine Subsidence

The first statewide analysis of the impacts of subsidence were published by the Illinois State Geological Survey in 1916. This early report dealt with small subsidence depressions from early underground mining on small acreages. The first Illinois abandoned mine reclamation law dealing with surface and underground mining was passed in 1975 and the first subsidence insurance program was initiated in 1979.

Approximately 900,000 acres of Illinois have been undermined, which includes about 200,000 acres of urban area. Of the total undermined acreage, 240,000 acres were after 1983, and that total includes 43,000 acres by longwall mining.

Subsidence from room and pillar mining (unplanned) is uncommon from post 1983 underground mining, but it does occur. Subsidence from room and pillar mining is very difficult to predict in terms of location and timing of occurrence.

Subsidence may occur within five years after mining or more likely decades after the coal extraction took place. Typically, room and pillar subsidence is smaller in extent and magnitude making impacts to agricultural land relatively easy to repair.

Planned subsidence from longwall mining creates more challenging issues. Historically, over 300 longwall panels have extracted coal and subsided more than 50,000 acres of land in Illinois. Longwall subsidence has impacted buildings, infrastructure of all kinds (roads, pipelines, utilities), vast acreages of farmland, and surface and subsurface hydrology. As a given area is progressively and sequentially longwall mined from panel to panel, impacts to surface topography on agricultural land must be reconfigured to re-establish drainage patterns. A much broader regional approach to drainage restoration over multiple panels must be considered and implemented to effectively repair subsided farmland. This can cause a significant delay in drainage construction work, and the permittee must be responsible for the crop loss in the interim.

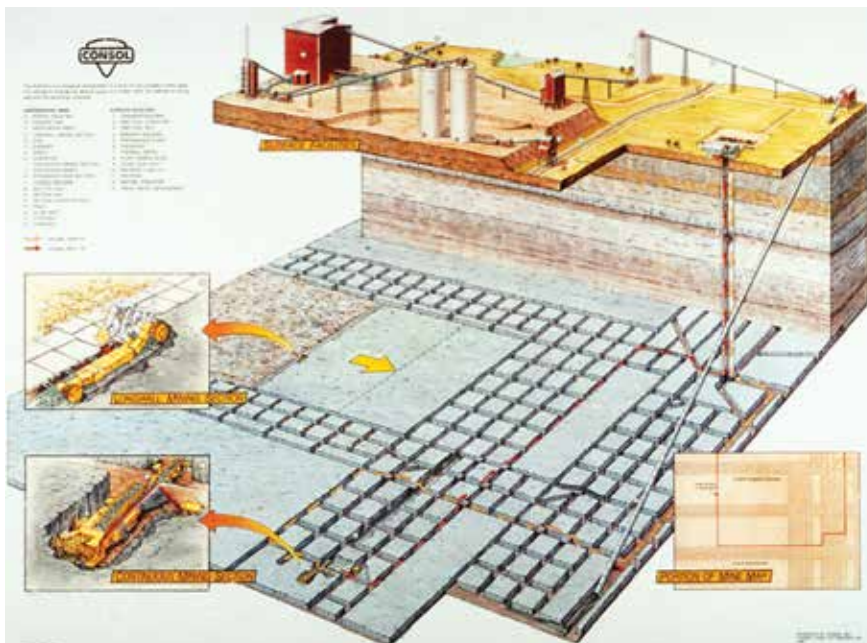
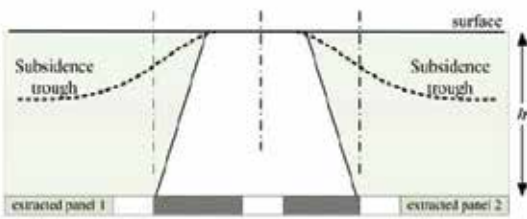


Figure 6. Diagram depicting longwall mining panels and continuous mining sections.



*Figure 7. Typical subsidence profile and trough development from land surface overlying underground mines.*

A typical subsidence profile or trough is depicted in Figure 7. The subsidence trough occurs over the extracted panel and may be as deep as seven feet in the center of the trough where coal extraction heights reach 10 feet. The locations of the first modern longwall mines were originally confined to south central Illinois where lower quality soils and more rolling topography existed. Drainage patterns were primarily restored by land leveling and constructing waterways and ditches in the rolling topography.

In more recent years, longwall mining has moved farther north into the flatter, more productive soils. Drainage restoration for these areas now includes installation of drain tiles. Several years ago, two longwall mines extracting coal from beneath prime farmland soil areas in this more northern area with a history of only room and pillar mining proved to be controversial. Figure 8 shows the impact of longwall mining on the surface where subsided land became ponds of water. The controversy intensified because of substantial delays in implementing a regional drainage restoration project and the closing of sections of road which had been impacted. Figure 9 shows the same area after reclaiming the subsidence areas and restoring drainage patterns.

The first mine performed longwall operations in 17 panels from 1994 until 2007, and reclamation efforts continued through 2010 over the last several panels. The second mine was more recently initiated and completed three longwall panels before being idled due to underground mining issues. Thus, the controversy has subsided, no pun intended, for now. The restored longwall areas will be part of one of the tours for



*Figure 8. Aerial view of subsided land surfaces where underground mining had occurred. The subsided areas became locations for water collection.*



*Figure 9. Aerial view of the same area in Figure 8 after reclamation had filled subsidence depressions and restored drainage patterns.*

this year's ASMR meeting in St. Louis.

While longwall mining subsidence possesses its own unique challenges, the subsidence patterns are predictable and can be reclaimed soon after the mining takes place. However, it is the room and pillar mine subsidence that can and will continue to occur in an unpredictable manner into the future as post SMCRA

underground mines age. This will be further complicated when the mining company is released from their reclamation bond liability after successful surface facility and land reclamation. If subsidence occurs after the company has departed, who will take responsibility then? SMCRA clearly does not address this long-term issue. ■



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***“Planning for the Annual 100 Year Event”***



*Photo from cbc.ca*

This is a call for abstracts to present at the **43<sup>rd</sup> CLRA/ACRSD National Conference and AGM** held in conjunction with the **2018 Atlantic Reclamation Conference (ARC2018)** on **October 15-18, 2018** at New Brunswick Community College Miramichi Campus in Miramichi, New Brunswick. Abstracts are due May 1, 2018. Submission details and additional conference information can be found on [www.atlanticclra.ca](http://www.atlanticclra.ca).

# Establishing Riparian Woody Vegetation for Constructed Streams on Mined Lands Using the Forestry Reclamation Approach

*By C.E. Zipper, R.J. Krenz, S. E. Sweeten, C.T. Agouridis, C.D. Barton, P.N. Angel*

**C**onstruction and renovation of streams and riparian corridors on mined lands have become common activities in Appalachia. Surface mining for coal can disturb ephemeral and intermittent streams, and may disturb permanent streams in some cases. Under the Clean Water Act, operations that fill or otherwise disturb streams must perform compensatory mitigation.

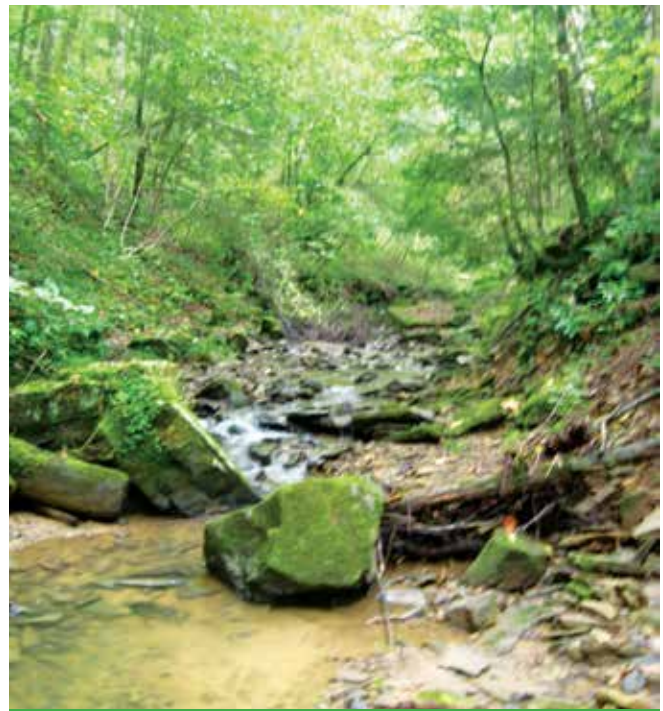
Scientific studies have identified beneficial effects of woody vegetation (trees and shrubs) in riparian areas of streams on mined areas and elsewhere. This advisory describes the reasons for establishing woody vegetation in constructed streams' riparian areas, and describes proper methods for mine sites.

## Riparian Trees and Shrubs

The riparian zone of a river or stream is the adjacent land, including the stream's banks, the overflow zone, and a transitional zone. These areas may be vegetated in forests or contain large boulders and coarse woody debris (Figure 1). The size of the riparian zone may be narrow in steep mountain forests or wide in flatter regions. The benefits of streamside trees and shrubs in naturally forested regions are well known and have been well documented for natural streams. Specifically, riparian woody vegetation helps control erosion and mitigate stream temperatures and flow, which sustains aquatic life within the streams and the ecosystem functions they provide.

Riparian woody vegetation stabilizes streamside soils, protects the stream channel, and enhances watershed processes that support healthy stream life. Establishing riparian forest helps to buffer excessive runoff, sedimentation, and pollutant movement from watershed areas into streams. Forest vegetation aids water infiltration processes that support streamflow and helps to prevent extreme streamflow that can damage channel features (Booth et al. 2004; Price et al. 2006). Dense plantings of a diversity of riparian trees foster those functions (Rowntree and Dollar 1999; Berendse et al. 2015).

Riparian trees and shrubs also support aquatic life and associated stream functions. Streamside woody vegetation deposits leaves and woody debris into the stream. These organic materials serve as energy sources for aquatic insects and other biota that consume plant matter directly; these organisms, in turn, process



*Figure 1. Forested riparian zone along a mountain stream.*

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the raw organic materials, transforming and reducing them into smaller pieces that support other aquatic organisms. The plant-matter consuming organisms themselves are food sources for higher trophic-level species such as fish salamanders and birds (Cummins 1975). The leaves and branches that fall into streams also form stream features, such as pools, riffles, runs and glides, which create habitat for aquatic life (Webster et al. 2012). Riparian woody vegetation also shades both the stream's banks and its waters during the warm weather season, helping to maintain water temperatures that are favorable to native aquatic life (Webster et al. 2012), and provides nesting habitat for birds. These riparian-vegetation functions are especially important for maintaining aquatic life in small headwater streams, such as those that are often disturbed by Appalachian surface mining.

Regulatory requirements emphasize restoration of aquatic life and stream processes in streams that are constructed as compensatory mitigation. Results from recent studies suggest that re-establishing riparian woody vegetation can aid in restoring stream life and stream processes, thus aiding satisfaction of those legal requirements.

Krenz (2015) and Krenz et al. (2016) compared in-stream organic-matter processes in streams constructed as compensatory mitigation on mine sites to those in streams draining unmined forested areas ("reference streams"). Although all constructed streams were performing these functions to some degree, most were not functioning at the same level as the reference streams at the time of the study. Some individual constructed streams did, however, exhibit organic matter functions similar to reference streams. Dense canopy cover and presence of riparian forest-like vegetation – with high levels of stream shading and low stream temperatures – characterized the constructed streams that functioned most similar to reference streams. Therefore, the authors concluded that establishing woody riparian vegetation contributes to restoration of organic matter processes as well as temperature regimes in constructed streams.

Riparian forest cover can be important for larger organisms also. Sweeten (2015) and Sweeten and Ford (2016) collected stream salamanders from 70 stream segments with a variety of riparian conditions and land uses including surface coal mining. They found that greater canopy cover of the riparian zone had higher abundance and occupancy rate of dusky salamanders (*Desmognathus* spp.) than riparian zones without trees and shrubs. Additionally, mature forest-like conditions such as a high diversity of native tree species, large woody debris, and detritus cover, were found to greatly influence the presence and abundance of dusky salamanders. Wood and Williams (2013) also found lower abundances of dusky salamanders in reclaimed grassland and shrubland where there was less detritus, lower stem densities, less large woody debris, less canopy cover, and an increase in invasive herbaceous species, such as *Sericea lespedeza*, as compared to forested or partially forested sites. Invasive herbaceous species may not produce the necessary forest-like microhabitat (i.e., leaf litter, cover, and large woody debris) to provide the cool, moist habitat needed for salamanders and birds in Appalachian riparian zones (Lemke et al. 2013; Murray and Stauffer 1995).

Given the above information, establishing riparian buffers for constructed streams on mine sites is critical to re-establish aquatic life and essential stream processes.

## **Establishing Forested Riparian Buffers for Mine-Site Streams**

During reclamation, surface mine operators endeavor to establish riparian woody vegetation when constructing and repairing disturbed streams on mine sites. The Forestry Reclamation Approach (FRA) (Burger et al. 2005; Forest Reclamation Advisory #2) is often used to establish native trees in mined areas. Agouridis et al. (2010) describe methods for establishing riparian buffers for streams in urban and agricultural areas; these methods can also be adapted and integrated with FRA practices to establish effective riparian woody vegetation on mine sites. Considering the above, the following sequence is recommended for establishing riparian woody vegetation along streams constructed on surface mines:

### **1. Ensure Suitable Riparian Soils**

Stream construction designs should ensure that streamside soils are suitable for establishing shrubs and trees.

When soil material is being manipulated and moved to construct stream channels, suitability of soil chemical properties for shrubs and trees should be considered. The ARRI guidelines for soil-material selection (Skousen et al. 2011; FR Advisory #8) can be followed when constructing riparian areas and stream channels. When natural soils can be used, these will generally be more favorable for trees and shrubs than mine spoils to support native vegetation and good growth. Natural soils can be used alone, if quantities are sufficient, or mixed with mine spoils – preferably weathered spoils. When natural soils are not available, weathered mine spoils will be more favorable for trees and shrubs than unweathered spoils.

Survey the mine soils and vegetation in the areas intended for tree planting, using assessment methods recommended by Skousen et al. (2011; FR Advisory #8) and Burger et al. (2013; FR Advisory #11). For soil assessment, consider both chemical properties such as soil pH and conductivity and physical properties, such as density and compaction. Take soil samples and submit those samples for soil analysis as described by Burger et al. (2013; FR Advisory #11). Use the results of those soil assessments to plan soil amendments, soil loosening, and tree species selection (as described by Davis et al. 2012; FR Advisory #9 and Rathfon et al. 2015; FR Advisory #13).

Soil physical properties must also be suitable if planted trees are to survive and grow. Stream construction often uses heavy equipment that compacts soil adjacent to the stream channel. Compacted soils should be loosened before planting trees. Soil loosening procedures are described by Sweigard et al. (2007; FR Advisory #4) and by Burger et al. (2013; FR Advisory #11). Soil ripping, as described by these advisories, can be applied in areas away from the stream.

When soils directly adjacent to the stream become compacted, different loosening procedures should be applied. For example, an excavator with a ripping tooth can be used to loosen soils (Burger

et al. 2013; FR Advisory #11). Care should be used during this operation – compaction of soils near the stream bank should be loosened while assuring that the stream banks themselves remain stable. An area surrounding each planting hole should also be loosened, to enable root growth, soil drainage, and soil aeration. Loosening soils along the contour, when possible, is likely to produce better results than if loosening is only applied to the planting hole. It is important to note that such activities within the streambank are utilized only during re-establishment of the riparian forest.

Finally, where feasible, include large rocks and large woody debris within the riparian zone to provide habitat for wildlife. These materials can be placed along and even in the stream channel.

## 2. Develop a Planting Plan; Select Tree Species

Planning to re-establish shrubs and trees in a large segment or all of the constructed stream's watershed, when possible, will be beneficial, because the entire watershed influences water quality and flow – consequently influencing stream biota and processes. Where only the streambank is to be reforested, at least 25 feet on both sides of the stream is recommended (Agouridis et al. 2010); but reforesting larger areas will be more advantageous over the long run.

Follow the guidance of Agouridis et al. (2010) and Davis et al. (2012; FR Advisory #9) and consider soil and site properties when designing the planting area. As general guidance, we recommend at least two rows of trees and shrubs identified as suitable for “wet sites” by Davis et al. (2012; FR Advisory #9) and Rathfon et al. (2015; FR Advisory 13) be planted at eight-by-eight-foot spacing along each side of the stream. If moist riparian soils extend further back from the stream, additional rows of moist-site species can be established. Only native species of trees and shrubs should be planted.

Similarly, on drier upland areas further back from the stream, select species that are recommended for those site types. Matching tree species with their appropriate moisture/site type is critical for successful riparian reforestation.

## 3. Re-establish Trees, Shrubs, and Other Vegetation.

Most active and legacy mine sites are planted using bare-root seedlings, as described by Davis et al. (2010; FR Advisory #8).



Figure 2. Live willow stakes planted in a riparian zone.

These same methods can be applied to establish trees and shrubs in riparian areas.

Rapid re-establishment of streamside woody canopy is important to aquatic life and in-stream ecosystem functions. Therefore, tree-establishment methods intended to accelerate woody vegetation growth are sometimes used in the near-stream riparian areas. As described by Agouridis et al. (2010), live-stakes and cuttings can be used to re-establish willow species (Figure 2) and other species such as silky dogwood, Virginia sweetspire, alder, elderberry, ninebark and buttonbush. Also, container seedlings are available for a wide range of tree species. Both methods enable establishment of larger-sized seedlings than the bare-root plantings that are typical on surface mines.

Container seedlings, grown in pots ranging from very small (16 cubic inches) to as big as five gallons, can be planted with a mass of roots and the soil-like growth media. These container seedlings will be more costly than bare-root seedlings but, if planted correctly and protected, they will grow more rapidly, and establishment under harsh conditions is usually much higher. Given the likelihood that more rapid streamside tree establishment will encourage more rapid return of stream life and function, use of containerized seedlings can be advantageous despite the increased cost.

Herbaceous vegetation should also be established on non-vegetated soils in the constructed stream corridor. Herbaceous

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*Figure 3. Using a tree shelter and fabric mat provides protection from both animal browsing and competing vegetation.*



*Figure 4. Reconstructed stream channel and riparian zone, with a variety of woody vegetation and stream habitat. Cranes Nest Gob Pile, Wise Co. VA.*

vegetation should be selected while understanding requirements of shrubs and trees. Burger et al. (2009; FR Advisory #6) describe herbaceous vegetation that is compatible with newly-planted trees on mine reclamation areas. The tree-compatible seed mix described by these authors can be seeded on stream banks in association with newly planted trees, although other revegetation practices are also possible. For example, Agouridis et al. (2010) recommend selecting native grass and forb plant species for riparian plantings. Numerous reference sources are available to aid plant-species selection, such as Virginia DCR (2011) and UK CES (2013).

Other erosion control methods such as coir mats, brush layer and wattles may also be acceptable and may be used with or without herbaceous seeding treatments. Native vegetation often colonizes rapidly, especially when there is an intact riparian system upstream.

Although sometimes recommended for riparian areas because they provide rapid and dense vegetative cover, fast- and tall-growing grass species such as tall fescue should be avoided when establishing riparian shrubs and trees. Such grasses will compete aggressively with growing trees for nutrients and water, may threaten their survival, and will often slow their growth. Also, tall fescue is known to be allelopathic, meaning that it releases biochemical substances into the soil that can inhibit desired vegetation such as planted trees.

Trees are often planted in riparian areas using protective devices such as shelters and weed mats (Figure 3; Agouridis et al. 2010). Tree shelters are plastic or mesh tubes, large enough to accommodate early growth, that protect young seedlings in areas where browsing by white-tailed deer, eastern cottontail rabbits or rodents (such as pine voles), or destruction by beavers might otherwise occur. Tree shelters can be especially helpful for riparian plantings given the likelihood that browsing animals (such as white-tailed deer) will frequent such areas to access water. Weed mats are made from weather-resistant fabric that, when placed on the ground at the base of a young tree, transmit air and water but inhibit growth of competing plants directly adjacent to the planted seedling's base. Use of weed mats on sites

with high populations of small mammals should be carefully considered however, as the weed mats may add to increased seedling mortality by providing winter refuge/habitat for the small mammals.

#### 4. Protect and Maintain the Plantings

Re-establishing trees as bare-root seedlings on areas with pre-existing vegetation requires that such vegetation be controlled, as described by Burger et al. (2013; FR Advisory #11). Container seedlings are larger than bare-root seedlings and, hence, better able to survive competition by herbaceous plants. Regardless, tree seedling growth will be more rapid if they are not subjected to vigorous competition from other plants.

Riparian plantings should be inspected on a regular basis for undesirable invasive plants. Certain invasive plants are fast-growing and, if established while planted trees are still young, may proliferate, overtop the planted trees, and become dominant within the riparian area. Two species with significant potential to cause such effects are autumn olive and Japanese knotweed; other invasive plant species known to be problematic for reforestation plantings on mine sites are listed by Burger et al. (2013; FR Advisory #11). If problematic invasive trees or shrubs become established on a newly planted riparian area, they should be eliminated immediately.

#### Summary

Stream construction on surface coal mines occurs commonly as a means of replacing stream resources that have been disturbed by mining. Restoration of aquatic life and processes in such streams can be encouraged by establishing woody vegetation – trees and shrubs – in these streams' riparian areas and elsewhere in their watersheds. This can be accomplished by combining practices recommended by the FRA for establishing forest trees on surface coal mines with those used commonly for riparian reforestation in non-mining areas. Successful riparian reforestation is a positive outcome for aquatic life, wildlife, and people, and can greatly enhance the overall reclaimed ecosystem (Figure 4). ■

## Photo Credits:

Figure 1: R.J. Krenz, Western Carolina University.

Figure 2: courtesy of City of Golden Valley, MN.

Figure 3: Christopher Barton, University of Kentucky.

Figure 4: Richard Davis, Virginia Department of Mines, Minerals and Energy.

All Forest Reclamation Advisories are available on the Appalachian Regional Reforestation Initiative's web page ([www.arri.osmre.gov](http://www.arri.osmre.gov)). In addition, a compilation of Advisories 1-12 can be found in *The Forestry Reclamation Approach: Guide to successful reforestation of mined lands*, published by the USDA Forest Service, Northern Research Station, available from

<https://www.nrs.fs.fed.us/pubs/54344>.

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# MUSHROOM COMPOST: What is it and How is it Used?

By Lisa Van Houten, Full Circle Mushroom Compost, LLC

**T**he descriptive generic definition of compost by the US Composting Council is:

“Compost is the product resulting from the controlled biological decomposition of organic material that has been sanitized through the generation of heat and ‘processed to further reduce pathogens’ (PFRP), and stabilized to the point that it is beneficial to plant growth. Compost bears little physical resemblance to the raw material[s] from which it originated. Compost is an organic matter source that has the unique ability to improve the chemical, physical, and biological characteristics of soils or growing media. It contains plant nutrients but is typically not characterized as a fertilizer.”

According to the definition, compost is a decomposed organic material. Therefore, it is not soil, nor is it dirt, which contains some organic material along with inorganic minerals.

Mushroom compost is a particular kind of compost that has applications in reclamation and water treatment. It is produced in four phases. Phase I mushroom compost is a mixture of hay, horse bedding straw, cottonseed hulls, cocoa shells, corncobs, poultry litter, gypsum, and water. It is pasteurized and turned several times to reach temperatures of 155-185°F over a two-week period. Phase II compost is the product after final pasteurization process prior to harvesting for another one to two weeks and then inoculated with mushroom spawn and placed in a mushroom house. Phase III compost has sphagnum peat moss added to initiate mushroom growth and harvesting. Phase IV compost is the product after post-production in which steam at 145F is injected into the compost for 24 hours to kill the mycelium, weed seed and bug larvae, prior to removal from the mushroom compost house. There is generally a 40- to 60-day period between

Phase I and Phase IV mushroom compost. Because mushrooms are grown all year, mushroom compost is made all year.

Phase IV mushroom compost is considered an agricultural by-product. Its primary use is as a soil amendment to add organic matter, improve soil microflora, increase soil tilth, and improve water retention. Other uses include using it as a mulching material, as an inhibitor of artillery fungus when mixed with hardwood mulch, and as an organic material for anaerobic acid mine drainage wetlands, vertical-flow wetlands, and selenium bioreactors.

There are two “grades” of Phase IV mushroom compost:

1. Phase IV Fresh is pasteurized compost recently removed from the growing house and is less than three months old.
2. Phase IV Aged or Fully Composted is actively windrowed and turned to obtain complete biological decomposition for more than three months.

In general, Phase IV Fresh will have the highest micronutrient levels and soluble salts concentration, but the lowest C:N ratio. It will also be the least expensive. It should only be sold in bulk quantities because of its potential for additional decomposition and mass reduction. Phase IV Aged or Fully Composted material can be bought as bagged or bulk quantities.

Testing methods for compost vary by State and Agency. Agricultural agencies use Test Method for the Examination of Composting and Compost (TMECC). The US Department of Agriculture (USDA) and the Composting Council Research and Education Foundation (CCREF) jointly publish TMECC. Government funded projects may use compost tested by TMECC or by the American Association of State Highway & Transportation Officials (AASHTO). AASHTO is an international leader in setting technical standards for all phases of highway system development.



Standards are issued for design, construction of highways and bridges, materials, and many other technical areas.

Table 1 compares compost parameters for vegetated and non-vegetated areas for AASHTO projects. It is important for users (including farmers, design engineers, contractors, landscapers, or reclamationists) to understand the footnotes in the tables as well as units for each parameter. This is especially important if fresh pasteurized mushroom compost is to be considered for use in both vegetated and non-vegetated use. Table 2 lists the average and standard deviation of fresh pasteurized mushroom compost from a series of mushroom compost samples since 2008, all of which are considered “wet” or “as is.”

In comparing the AASTHO standards in Table 1 with the average values of fresh mushroom compost in Table 2, average particle size of the compost is within the AASHTO limits, but soluble salts in compost (with an average of 12.9 dS/m in Table 2) can be two to three times higher than the “Max 5” dS/m standard in Table 1. The apparent elevated values of soluble salts for mushroom compost raise concerns for many people who want to use mushroom compost as a mulch or potting substrate for vegetables and ornamental plants or soil amendment. Soluble salts refer to plant nutrients such as potassium, calcium, magnesium and sodium which are often complexed with anions such as carbonates, sulfates, chlorides, and phosphates. While soluble salts are needed for soil fertility and plant growth, an excessive amount of these salts can have a negative influence on plant growth. As noted in footnote c of Table 1, each plant has a salinity tolerance rating and therefore it is crucial to know current soil characteristics prior to amending with mushroom compost so that excess concentrations are not added which may cause high soluble salt concentrations in the soil or material being used for plant growth.

Examples of salinity sensitive plants that have been grown in soil amended with fresh mushroom compost include the following four examples.

Figure 1

Parameters <sup>A,B</sup>	Reported as (Units of Measure)	Surface Mulch to be Vegetated	Surface Mulch to Be Left Unvegetated
pH <sup>C</sup>	pH units	5.0-8.5	N/A
Solubule Salt Concentration (Electrical Conductivity)	dS/m (mm/hos/cm)	Max 5	Max 5
Moisture Content	% wet weight basis	30-60	30-60
Organic Matter Content	% dry weight basis	25-65	25-100
Particulate Size	% passing a selected mesh size, dry weight basis	3 in. (75 mm), 100% passing 1 in. (25 mm), 90% to 100% passing ¾ in. (19 mm), 65% to 100% passing ¼ in. (6.4 mm) 0% to 75% passing Max particle length of 6 in. (152 mm)	3 in. (75 mm), 100% passing 1 in. (25 mm), 90% to 100% passing ¾ in. (19 mm), 65% to 100% passing ¼ in. (6.4 mm) 0% to 75% passing Max particle length of 6 in. (152 mm)
Stability/ Maturity <sup>D</sup>			
Carbon Dioxide Evolution Rate	mg CO <sub>2</sub> -C per g OM per day	<8	N/A
Physical Contaminants (Man-made Inserts)	%, dry weight basis	<1	<1

*A Recommended test methodologies are provided in Test Methods for the Examination of Composting and Compost (TMECC, The U.S. Composting Council)*  
*B Landscape architects and project (field) engineers may modify the allowable compost specifications ranges based on specific conditions and plant requirements.*  
*C Each specific plant species requires a specific pH range. Each plant also has a salinity tolerance rating, and maximum tolerable quantities are known. When specifying the establishment of any plant or turf species, it is important to understand their pH and soluble salt requirements and how they relate to the compost in use.*  
*D Stability/ Maturity rating is an area of compost science that is still evolving, and as such, other various test methods could be considered. Also, never base compost quality conclusions on the result of a single stability/ maturity test.*

Figure 2

Material as is	Value	Unit	SD of value
pH	6.8		0.6
Organic Matter	24.7	%	2.6
Moisture	61.9	%	4.2
Nitrogen, Total	1.0	%	0.1
Nitrogen Ammonium	0.1	%	0.2
Nitrogen, Organic	0.9	%	0.2
Phosphorus [P2O5], Total	0.5	%	0.1
Potassium, [K2O]	1.0	%	0.2
Carbon	13.2	%	2.4
C:N Ratio	13.9		2.9
Soluble Salts	12.9	dS/m	1.9
Calcium	2.2	%	0.4
Magnesium	0.3	%	0.0
Sulfur	0.8	%	0.1
Copper	39.9	ppm	12.1
Iron	998.6	ppm	329.9
Manganese	132.2	ppm	26.6
Zinc	78.7	ppm	15.3
Aluminum	617.6	ppm	124.4
Sodium	1159.2	ppm	370.8
Sodium Adsorption Ratio (SAR)	2.6		0.8
Particle Size % <9.5mm	83.7	%	6.5
Stability/Maturity, mg CO <sub>2</sub> -C/g organic matter/day	7.4		1.8



*Example 1. Strawberries are growing in a high tunnel where a 6-inch layer of compost was applied around the plants and irrigated. Salinity tolerance of strawberries is <4 dS/m.*



*Example 2. Mushroom compost was applied two inches deep over heavy clay soil without tilling and seeded with fescue grass directly into the compost. The fescue seed has a salinity tolerance of 3.9 dS/m.*



*Example 3. In Baltimore, a community garden group tilled compost into the soil at a 1:1 ratio and directly seeded lettuce and spinach. Salinity tolerance of these plants are 8 dS/m.*



*Example 4. A grower used a two-inch mushroom mulch cover for this Norfolk Island Pine houseplant. Typical potting soil has a soluble salt concentration of <4 dS/m.*

These examples show that mushroom compost can be used as an amendment or as a potting substrate in a wide variety of plants. When using mushroom compost as a mulching material or as a material for growing plants on reclamation sites, it is

important to understand the properties of the material being amended and to understand the nutrient requirements of plants being grown to correctly apply appropriate rates. This evaluation process will enhance growth conditions for plants

using fresh mushroom compost.

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The logo features the word "granite" in a lowercase, rounded, brown font. Below it is a stylized green seed icon with horizontal lines, followed by the word "SEED" in a large, bold, brown, sans-serif font. At the bottom, the words "and erosion control" are written in a smaller, green, lowercase font.

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# AMERICA'S LARGEST LIGNITE COAL MINE

**NOW YOU SEE IT...**



**...NOW YOU DON'T**



THESE TWO PICTURES WERE TAKEN FROM THE SAME LOCATION AT THE FREEDOM MINE IN WESTERN NORTH DAKOTA DURING MINING AND AFTER LAND RECLAMATION WAS COMPLETE.

