

OFFICIAL PUBLICATION OF THE AMERICAN SOCIETY OF RECLAMATION SCIENCES

reclamation *matters*

Spring 2024



2024
CONFERENCE
& PROGRAM





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reclamation matters

is published by
DEL Communications Inc.
www.delcommunications.com

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Publications Mail Agreement #40934510
Return undeliverable Canadian addresses to:
DEL Communications Inc.
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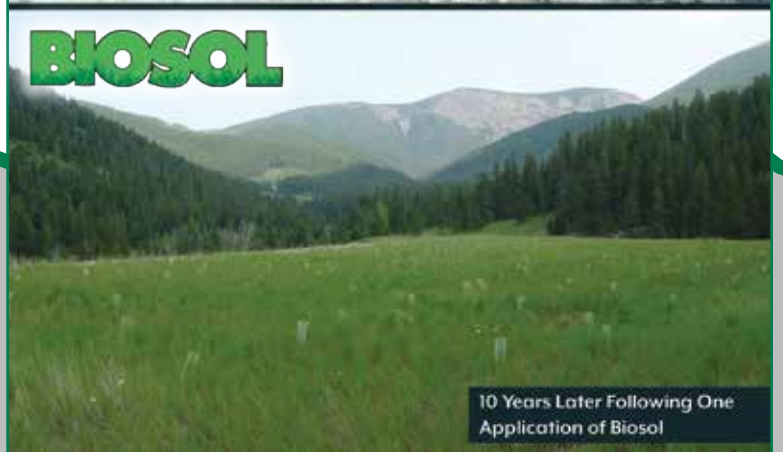
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Get involved and give thanks

JULIE LABAR,
OKLAHOMA STATE UNIVERSITY

As of this writing, it will be in three short months that we will all convene for the Annual Meeting in Knoxville, as well as to welcome a new National Executive Committee. Although this presidency has not quite been what I expected, with major changes in our behind-the-scenes management structure, it has been exceptionally rewarding.

If you were not aware, we have a fantastic NEC – folks who are willing to commit countless hours each month to preserving and advancing the goals of the Society, reviewing and updating policies, attending virtual meetings, planning conference events, running booths at other societies' conferences, and so much, much more.

We also have an excellent contingent of non-NEC volunteers who run our publications, manage our awards programs, explore our finances, support our students and early career professionals, and just generally make things great. It's a common refrain that we've heard from Society presidents in the past: get involved. Well, sometimes things are common because they should be. It truly takes a village to keep this Society vital and engaged.

One of our most consistent goals has been to increase communication and collaboration with our members and other reclamation colleagues, which undoubtedly means increasing the size of our village. As I said in my Fall 2023 message, the NEC is always

looking for folks to contribute through an exhaustive list of options including volunteering to sit on a committee, signing up to present a webinar hosted by the Society, bringing your students/trainees/interns and sending your early career professionals to our Annual Meeting. The sky is really the limit in ways to get involved with the ASRS.

The NEC approved a strategic plan in 2018, which I have turned to repeatedly for inspiration and direction. Several goals have been met over the past few years, including changing the Society's name to better reflect our broadening knowledge base, rebranding to reflect that name change, and updating our website to make information more accessible. The time has come for us to revisit that strategic plan and update it to focus on the remaining goals of enhanced engagement, increased membership, more collaboration with other societies, and improved opportunities for the next generation of reclamation scientists. We are going to be looking for your input on what those opportunities should look like. Details are still being sorted out but

One of our most consistent goals has been to increase communication and collaboration with our members and other reclamation colleagues, which undoubtedly means increasing the size of our village.

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keep your eyes open for details on how to contribute to this discussion in the second half of this year.

Over the past year, I have had multiple random colleagues and acquaintances, none of whom are affiliated with ASRS, thank me for stepping up as president

of the Society. It never occurred to me to do this for thanks or accolades, especially from folks who know nothing about ASRS. My sole purpose was to give back to a society that has done so much for me, on both personal and professional levels...to give thanks through action, if you will. That anyone

would thank me for this seemed, quite frankly, a little weird.

However, as more of those encounters occurred, I realized the random colleagues and acquaintances were all either current or past members of non-profit boards and societies. They had all taken on a role in an organization they cared deeply about, simply to do exactly what I wanted to do – give thanks by giving back. Is there any better way to say thank you to a society that has done so much for so many of us? My takeaway was that it's time for me to say thank you.

Thank you to ASRS for all you have provided me and others in our careers. Thank you to all our Society predecessors who established such an excellent venue for us to learn from each other. And a huge personal thank you to all those NEC members and non-NEC volunteers who have contributed so much to our success this year. Additionally, I want to encourage all of you who are eager to give back to the Society and be a part of accomplishing our future goals to reach out and get involved. When an opportunity is announced, jump in! If there isn't an opportunity announced, but you have a great idea, let us know! We can always be contacted at president@asrs.us.

If you haven't already, set your sights on Knoxville, TN for June 2-6, 2024. This year we will be meeting with the Appalachian Regional Reforestation Initiative, with great tours, social events, technical presentations, and fellowship. I look forward to seeing you all in a few short weeks! 🌱

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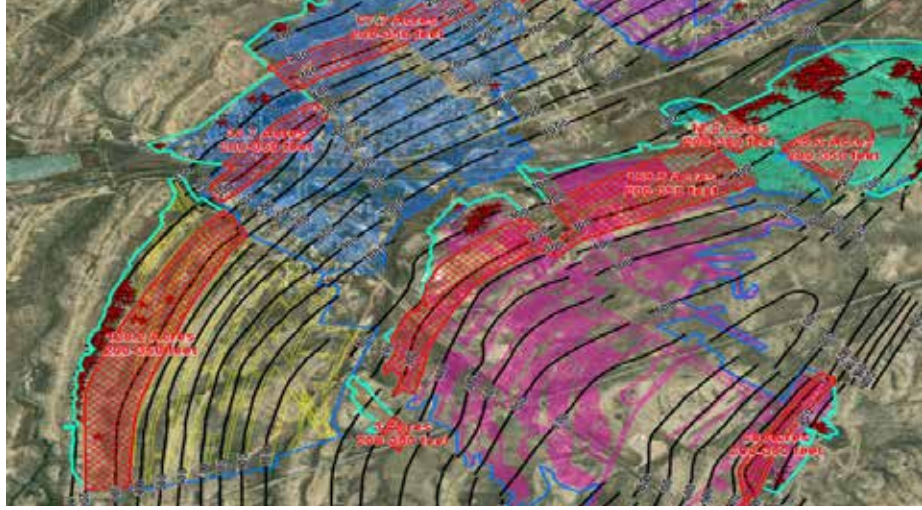


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Over the hill, but not slowing down

MICHAEL CURRAN, ABNOVA ECOLOGICAL SOLUTIONS

At least for me, one of the best parts about being involved with the American Society of Reclamation Sciences is looking forward to a new travel destination for each annual meeting. Between the first annual meeting I attended in Bismarck 2011 and the 2024 Knoxville meeting, ASRS will have been held in 12 different United States despite a hiccup in travel due to the COVID 19 pandemic. Dating back to 1984, the annual meeting has been hosted in 18 different United States and in Alberta, Canada. Our mailing list contains 724 unique postal codes spanning 16 countries throughout the world, covering all continents except South America and Antarctica. Although we are “over the hill”, with Boise being the 40th Annual Meeting last year, I don’t see any lack of excitement looking forward to the 41st Annual Meeting in Knoxville. For those wondering, the title of this article was about the society, not myself – I’m still climbing! It sure is an honor to

be the editor of *Reclamation Matters*, especially since the magazine gets contributions from and is read by such a broad and impressive audience.

I said this in the Fall 2023 Editor’s Message, and I’ll say it again – one of my goals as Editor of *Reclamation Matters* is to ensure a broad geographic range of articles. Inherently, I think covering a wide geographic range in each issue results in a wide variety of topics and perspectives. It will always be an honor that Jeff Skousen’s photo graced the cover of the first magazine I edited, and I look forward to asking him about what some of his favorite parts of being editor were in person at the Knoxville meeting. Up until now, I’ve only really asked him questions about “how” to do this job. I am sure I will continue to learn more and more from him when I get to start asking about the “why”. I bet he learned a lot from the many authors he got to deal with during his tenure as editor.

Aside from it just being fun to be

editor, I am learning and expanding my knowledge base. Going through the phase where I hand the final edits off to the publisher, I am reminded that we also have several interest groups within ASRS for members to interact in different social settings and become more engaged with other members and meeting attendees. So aside from Julie LaBar setting aside time to write a president’s note, thanks to Michele Coleman and Allen Wellborn for sharing information about the Haulin’ ASRS, Wild Women of Reclamation, and the Early Career Professionals groups. I think the runners/walkers and wild women have probably accumulated a lot of great stories from past meetings...but you have to participate to be in on the stories! For newer and younger members, I hope you get involved with these groups and stick around for a while. I think you’ll find it easy to imagine how to apply lessons learned from others to your areas, too. Perhaps consider

sitting down with folks from one of the six technical divisions at their open meetings: Soils, Water, Vegetation, Wildlife, Technology, and Engineering & Construction. Really, it's incredible how much this society covers.

I don't even like to imagine the amount of work it takes to put the annual meeting together. A big thanks to Jennifer Franklin for spearheading that and to all those who took the time to get the information about Knoxville to me in great shape for the magazine.

As always, thanks to the authors for their contributions and to all those within the society for doing so much behind the scenes. I'm looking forward to seeing everyone in Knoxville. If you

have any ideas for articles for future editions, please feel free to come chat with me. I'm looking forward to working with you on future issues of Reclamation Matters.

While we should all be thankful to Dick Barnhisel and others for getting Journal American Society of Mining and Reclamation up and running in 2012, I am sure Natalie Kruse Daniels would love for you to reach out to her to learn more about Reclamation Sciences. Natalie, the editorial board, and associate editors should all get a round of applause at the Knoxville meeting, as what they've done to finalize Reclamation Sciences Volume 1 is nothing short of remarkable.

Having the peer-reviewed companion Reclamation Sciences up and running with an external publisher is something we should all be excited about.

Yes, the society is now "over the hill" in terms of annual meetings, but with the help of so many that it took to get us here I think we can all be confident not only saying that reclamation matters, but that reclamation is recognized as a multi-faceted science. At the heart of it are the many individuals who come together to learn from each other and keep pushing reclamation forward.

With all the talented members pushing for improved reclamation outcomes, I don't foresee ASRS slowing down any time soon. 🌱



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Attention all Early Career professionals and students!

BY ALLEN WELLBORN, STUDENT AND EARLY CAREER PROFESSIONALS REPRESENTATIVE, NAVAJO TRANSITIONAL ENERGY COMPANY

It sure has been a busy few months since our last *Reclamation Matters* publication. The ASRS NEC has voted and approved to form a Student Engagement Committee and we held our first meeting on January 16th. We had our ECP Election for the next term, and we are in progress of developing a Social Media Management committee/position. If you are interested in participating in any of these committees, please reach out to any NEC member. We're also in the planning stages of the ECP/Student event for the Knoxville meeting coming up in June. I have sent out a few emails to those on the ECP email list, so please check your inbox and spam folder and make sure you are getting all the ASRS emails.

These unseasonably warm El Niño

days here in Wyoming have allowed me to seed coal mine reclamation clear into January and implement regrade procedures clear into February. Before we know it, Spring seeding will start up in April and May. Being able to seed in January presented some unique challenges that we are not used to here in the sagebrush plains of the northern Powder River Basin. Typically, the topsoil is frozen solid and covered in snow. With a workable top few inches of soil, that has allowed us to cultipack and seed the first inch of workable soil with a stubble drill and broadcast seeder. Getting that sagebrush seed in the soil before the cold snaps will allow for the cold scarification needed to crack the seed coat in time for Spring moisture and soil warmth for germination.

I previously mentioned we held our ECP election. I would like to take this opportunity to welcome the newly Elected ECP representative, Brandon Holzbauer-Schweitzer. Brandon received his undergraduate degree in Environmental Geoscience from Winona State University in 2014. He then moved to Oklahoma and completed two Environmental Science graduate degrees where he received his Ph.D. Brandon currently works for Jacobs Engineering as an Environmental Scientist. Brandon will take over the ECP Rep Role at the June 2024 NEC Meeting and serve for two years. In the meantime, he has an invited position to the NEC board as well as assisting in planning the ECP event. Please help me give a warm welcome to Brandon in his new role. 🌱



Please welcome newly elected Early Career Professional Representative Brandon Holzbauer-Schweitzer.



*January 2024
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Wild Women of Reclamation

GATHERING AT THE 41st ANNUAL MEETING OF ASRS



Photo of the Wild Women of Reclamation from the 40th Annual ASRS Conference in Boise, ID. Front row (left to right): Natalie Kruze Daniels holding Lena, Shea Zeman Meghan Blair, Whitney Foulkner, Brenda Schladweiler, Micayla Pearson, Marie Sheperd, Sara Klopff, Guadalupe Fattore, Gwen Geidel, Sam Taylor, and Kelsea Green. Middle row (left to right): Jennifer Franklin, Jenise Bauman, Penny Hunter, Cheyenne Morgan, Summer King, and Erzn Hurley. Back row (left to right): Carrie Monohan, Libia Gonzalez, Meagan Graham, Michele Coleman, Chelsea Harris, Jen Schlotthauer, Linda Johnson, Justine McCann, and M'Kenzie Dorman.

To: *All women involved in reclamation are invited; feel free to bring a colleague!*

What: *A networking opportunity targeted towards women in reclamation*

When: *7:00 - 8:15 a.m., Tuesday June 4, 2024*

Where: *Knoxville Convention Center (exact room to be determined)*

Wild Women of Reclamation (WWR) is an ASRS networking social group for women engaged in reclamation. Participants will meet on June 4th at the conference center before the morning technical presentations. Every woman is welcome. We have a presentation, do some networking, get to meet a lot of new attendees, and catch up with life with a few old friends. 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”. This year’s presenter will be Sara

Klopff, Research Associate in the School of Plant and Environmental Sciences and the Department of Forest Resources and Environmental Conservation at Virginia Tech University. She has worked on projects related to water quality, hydrology, forest genetics, American Chestnut restoration, vegetation monitoring of degraded landscapes, urban forestry, and revegetation of mine lands. We look forward to her presentation

on mentoring, juggling a career and motherhood, and her decisions along her career path.

We engage in a mentoring exercise where we match up less experienced reclamationists to women who have more experience and more contacts. This is an easy way to build up contacts, bounce off ideas and to learn about other careers. We also have a newsletter that goes out several times

a year, or as often as we can get stories. The content is a way to inform and to share. Please keep those stories coming!

This will be the 10th WWR meeting at ASRS. There is no membership to Wild Women of Reclamation – just camaraderie and networking! We will have a light breakfast of coffee/tea/muffins so just come on over to the Convention Center on Tuesday June

4 at 7 a.m. and join us! If you end up arriving late for whatever reason, still come on into the room. We try to schedule the group photo for around 8:00-8:05. There will be networking until 8:15 a.m. We look forward to seeing as many of you that can make it. Feel free to bring a friend or new colleague. 🌱

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Brenda Schladweiler | BSchladweiler@bksenvironmental.com



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Who/What: *Anyone attending the conference is welcome and encouraged to meet up for a social pace run or walk to enjoy the sites and scenery Knoxville has to offer.*

When: *June 2-5, 2024; 6:30 a.m. – 7:15 a.m.*

Where: *Knoxville Convention Center main entrance on Henley Street*

What to bring: *Running or walking shoes and an early morning smile*

The World's Fair Park is an excellent place for a walk, and the park and Neyland Greenway along the Tennessee River are just a couple of the options close to the downtown hotels and conference convention center. These runs (or walks) are an excellent time to get some exercise prior to conference proceedings each day and a wonderful way to network, meet new people, and catch up with old friends.

This year we will have a walking group led by incoming NEC delegate Bill Zeaman. The running group will continue to be led by Michele Coleman and Ryan Mahoney. Remember to bring your walking or running shoes!

Let's meet at 6:30 a.m. in front of the Knoxville Convention Center main entrance on Henley Street. We will be passing several other hotels as we run toward the Tennessee River so

we can pick up other walkers/runners along the way if you let us know where you are staying. We return to the hotel between 7:15 or 7:30 at the latest so we can all shower, grab breakfast and get ready for the presentations!

Dates: Sunday June 2 through Thursday June 5th. Some of us may arrive Friday night so there may also be a Saturday morning run! If you want to be added to the running group list before the conference to be able to get updates, please let us know.

Contact:

Ryan Mahony | ryan@biomost.com

Michele Coleman | Michele.m.coleman@gmail.com

Bill Zeaman | bill.zeaman@dnr.mo.gov 🌱

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ASRS Silent Auction

Do you want to help shape and form future reclamationists by assisting in student activities in the American Society of Reclamation Sciences?

Visit <https://www.asrs.us/2024-conference/silent-auction/> for information on the silent auction held in conjunction with this year's annual meeting in Knoxville.

ASRS 2024 Preliminary Conference Program

The 41stth Annual Meeting of the American Society of Reclamation Sciences (ASRS) is June 2-6, 2024, in Knoxville, TN. This conference will focus on the research, technical, and regulatory issues associated with the land and water implications of anthropogenic land disturbances. It will provide a forum for the dissemination of information through presentation of research findings, field tours, and open discussion of public policy relating to the applied science of reclamation, rehabilitation, remediation, and restoration of areas disturbed by mining, oil and gas, conventional and alternative energy production, contaminated sites, agriculture, road construction, large-scale commercial development, and other disturbances to land and water resources.

Schedule at a glance:

Sunday, June 2	Monday, June 3	Tuesday, June 4	Wednesday, June 5	Thursday, June 6
	Haulin'/walking ASRS 6:30-7:15 am ARRI core/Science team meetings 7:30-9:00 am	Haulin'/walking ASRS 6:30-7:15 am Wild Women of Reclamation 7:00 -8:15 am	Haulin'/walking ASRS 6:30-7:15 am	Copper Basin Professional Tour 8:00 am - 5:00 pm
	Plenary session 9:00 am-noon Main Ballroom	ARRI Professional tour 8:00 am -4:00 pm Technical sessions 8:30 am - 12:00 pm	Technical sessions 8:30 am - 12:00 pm	
	ASRS and ARRI Awards Luncheon and ASRS Business Meeting 12:00 - 2:00 pm Main Ballroom	Lunch buffet 12:00- 1:30 pm Main Ballroom	Student awards luncheon	
Registration and Exhibitor set-up 1:00 pm- 8:00 pm Convention Center Lobby and Ballroom	Technical sessions 2:30 - 5:30 pm	Stream Restoration Professional Tour 1:30 - 3:00 pm	Ijams Quarry Professional Tour 2:00 - 5:30 pm	
NEC meeting 4:00-6:00 pm		Technical sessions 3:30- 5:30 pm	NEC meeting 4:15- 5:15 pm	
Welcome Exhibitor/Sponsor Reception 6:00 - 8:00 pm Convention Center Ballroom	Social Event and Dinner 6:30 - 10:00 pm Museum of Appalachia	Poster session 5:30 - 7:15 pm Main Ballroom Film festival 7:30 - 9:00 pm Lower-Level Theatre	Early Career Professional Social 6:00 - 9:00 pm	

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 Michele and Gwen - Wild Women
 Paul Griswold - ASRS Awards
 Scott Eggerud - ARRI Awards
 Michele Coleman & Bill Zeaman - Haulin' ASMR

PROFESSIONAL FIELD TOUR INFORMATION

Tuesday, June 4 - ARRI Reforestation Tour (Full Day)

8:00 a.m. - 4:00 p.m.

- 8:00 Board vans and travel to The Nature Conservancy Ataya property about 75 miles north of Knoxville
- 9:30 Arrive at TNC for an overview of the property and tour of areas of various ages reclaimed using the Forestry Reclamation Approach
- 11:00 Arrive at a University of Tennessee research site where native trees were planted on a legacy minesite after subsoiling to relieve compaction
- 1:00 Arrive at Indian Mountain State Park for lunch and a discussion of reforestation success
- 2:00 Depart for Knoxville



Tuesday, June 4 - Knoxville Stream Restoration (no registration required)

1:30 - 3:00 p.m. - Professional Tour

Meet in the Convention Center lobby for a 1.5 mile walk along the Second Creek Greenway. The University of Tennessee Stormwater Management team will give an overview of the completed and upcoming restoration of Second Creek, and students with the Society for Ecological Restoration will give an update on student-led vegetation improvement projects.



Wednesday, June 5 - Quarry Restoration (no registration required)

2:00 p.m. - 5:00 p.m. - Professional Tour

- 2:00 Board vans for travel to Ijams Nature Center, about four miles from downtown Knoxville
- 2:20 Arrive at The Crag to see the results of restoration efforts at the site of a former agricultural lime packing facility.
- 3:00 Board vans to travel to nearby Mead's Quarry, or walk approximately one mile over good, flat trails
- 3:30 Tour Mead's Quarry recreation area.
- 4:30 Depart for Convention Center



Thursday, June 6 - Copper Basin Reclamation (Full Day)

8:00 a.m. - 5:00 p.m. - Professional Tour

- 8:00 Board bus for Ducktown, TN, about 90 miles south of Knoxville.
- 10:15 Arrive at the Ducktown Mining Museum.
- 11:00 Depart for Burra Burra Creek to see constructed wetlands for the treatment of acidic drainage
- 12:00 Lunch at the London Mills tailings pond, and tour tailings management areas
- 2:30 Depart for Knoxville



SUNDAY, JUNE 2, 2024 AGENDA

All Day

1:00 p.m. – 5:00 p.m.

4:00 p.m. – 8:00 p.m.

4:30 p.m. – 6:00 p.m.

5:00 p.m. – 8:00 p.m.

6:00 p.m. – 8:00 p.m.

ASRS Office – Henley Meeting Room

Exhibitor Setup – Convention Center Ballroom

Registration – Convention Center Lobby

NEC Meeting – Henley Meeting Room

Exhibitor Show – Convention Center Ballroom

Welcome Reception - Convention Center Ballroom

Monday, JUNE 3, 2024 AGENDA

6:30 a.m. - 7:30 a.m.

Haulin' ASRS – Meet at the Knoxville Convention Center main entrance on Henley Street

7:30 a.m. - 5:00 p.m.

Registration – Convention Center Lobby

7:30 a.m. - 8:30 a.m.

Breakfast - Ballroom

7:30 a.m. - 8:15 a.m.

ARRI Core Team Meeting Room C

7:30 a.m. - 8:15 a.m.

ARRI Science Team Meeting Room E

8:15 a.m. - 9:00 a.m.

ARRI Science and Core Team Joint Meeting Room C

9:00 a.m. - 5:30 p.m.

Exhibitor Displays – Ballroom

9:00 a.m. - Noon

Plenary Session – Ballroom

Jennifer Franklin – Conference Chair – Welcome

Julie LaBar – ASRS President – President's Welcome

Keynote Speaker: Kathryn Newfont, Univ. of KY

Break

9:15 a.m. - 10:00 a.m.

Keynote Speaker: Barry Miller, TN Assistant State Geologist

10:00 a.m. - 10:30 a.m.

Keynote Speaker: Bonnie Craighead, TDEC Mining Section

10:30 a.m. - 12:00 noon

Keynote Speaker: Daniel Lawrence, TDEC Mining Section

12:00 noon - 2:00 p.m.

ASRS and ARRI AWARDS LUNCHEON / ASRS BUSINESS MEETING

1:00 p.m. - 6:00 p.m.

Silent Auction opens - Meeting Room B

2:00 p.m. - 5:30 p.m.

Technical sessions:

ARRI - Rooms A

Bat Conservation - Room C

Water - Room E

5:30 p.m. - 6:00 p.m.

Water TD Meeting Room E

6:30 p.m. - 9:30 p.m.

Social Dinner at the Museum of Appalachia

MONDAY, JUNE 3 EVENTS

Social Event and Dinner at the Museum of Appalachia

6:30 p.m. - 9:30 p.m.



Join us for a catered dinner and drinks on the grounds of the Museum of Appalachia. Stroll through the 65-acre grounds and 35 buildings full of pioneer and Native American artifacts in this Smithsonian-affiliated museum.

Tuesday, JUNE 4, 2022 AGENDA

6:30 a.m. - 7:30 a.m.

Haulin' ASRS

7:00 a.m. - 8:15 a.m.

Wild Women of Reclamation - Room A

7:30 a.m. - 8:30 a.m.

Breakfast - Ballroom

7:30 a.m. - 5:00 p.m.

Registration - Convention Center Lobby

7:45 a.m. - 8:15 a.m.

Reclamation Sciences Editorial Board Meeting, Room E

8:00 a.m. - 7:00 p.m.

Exhibitors - Ballroom

8:00 a.m. - 4:00 p.m.

ARRI Reforestation Professional Tour

8:15 a.m. - 6:00 p.m.

Silent Auction - Room B

8:30 a.m. - 10:00 a.m.

Technical Presentations:

Vegetation - Room A

Water - Room C

Soil - Room E

10:00 a.m. - 10:30 a.m.

Break - Ballroom

10:30 a.m. - 12:00 p.m.

Technical Presentations:

Vegetation - Room A

Mercury - Room C

Soil - Room E

12:00 p.m. - 1:30 p.m.

Buffet Lunch - Ballroom Lunch Speaker: Matt Drury

1:30 p.m. - 3:00 p.m.

Stream Restoration Professional Tour

3:00 p.m. - 3:30 p.m.

Break - Ballroom

3:30 p.m. - 5:30 p.m.

Technical Presentations:

Vegetation - Room A

	AML Reclamation - Room C
	Soil - Room E
5:30 p.m. - 7:15 p.m.	Poster Presentations - Ballroom
7:30 p.m. - 9:00 p.m.	Film Festival – Second Floor Theater

TUESDAY JUNE 4 EVENTS

Wild Women of Reclamation

7:00 a.m.- 8:15 a.m. – Room A

Every woman is welcome. Previous topics – choosing your own path, mentoring, starting a business, and juggling a career with family and community obligations. Coffee, tea, and pastries will be provided.

Poster Session Networking Event

5:30 p.m.- 7:15 p.m. - Ballroom

Poster presentations will be on display with authors after the technical sessions. Food and cash bar.

Reclamation Film Festival

7:30 p.m. - 9:00 p.m. - Theater

Join us for the Third Annual Reclamation Film Festival. We will bring reclamation-related topics to you via short (~2-10 minute) films highlighting exciting and intriguing reclamation projects. Awards will be presented to the best in show in Pro and Amateur/Student Categories. Classic movie snacks provided.

Wednesday, JUNE 5, 2022 AGENDA

6:30 a.m. - 7:30 a.m.	Haulin' ASRS
7:30 a.m. - 8:30 a.m.	Breakfast - Ballroom
7:30 a.m. - 5:00 p.m.	Registration – Convention Center Lobby
8:00 a.m. - 7:00 p.m.	Exhibitors – Ballroom
8:00 a.m. - 11:00 a.m.	Silent Auction Last Day – Room B - Winners announced at lunch
8:30 a.m. - 10:00 a.m.	Technical Presentations:
	Technology - Room A
	Wildlife - Room C
	Engineering and Construction - Room E
10:00 a.m. - 10:30 a.m.	Break - Ballroom
10:30 a.m. - 12:00 p.m.	Technical Presentations:
	Technology - Room A
	Wildlife - Room C
	Mine Closure - Room E
12:00 p.m. - 1:30 p.m.	Buffet Lunch – Student Awards/Silent Auction - Ballroom
2:00 p.m. - 5:00 p.m.	Quarry Restoration Professional Tour
4:15 p.m. – 5:15 p.m.	NEC Meeting – Henley Meeting Room
6:00 p.m. - 9:00 p.m.	Early Career Professional Event

How and why U.S. energy developers can achieve a robust ecological impact strategy

BY ELLIE MURPHY, ADVANCED ENVIRONMENTAL ENGINEER, SUSTAINABILITY, MARATHON PETROLEUM CORPORATION

Consider a situation for which necessary industrial development is planned within a highly diverse ecological environment. The potential for ecosystem services naturally abounds. A multitude of threatened and endangered species rely on this quality habitat, along with thriving forb and grass species that stabilize nutrient-dense soils and sequester carbon. Parts of this environment also provide an area of cultural significance to a resident Native American tribe. In other parts, the U.S. Forest Service relies on this area as a fire protection buffer from neighboring dense residential zoning. The local economy relies on the expansive recreational and agricultural value that exists in and around this vast space.

This is not an uncommon scenario for many developers located in U.S.-based oil and gas basins present-day. The needs of many – both human and non-human, direct and indirect – are impacted by the necessary development to meet growing energy demand. So, what practices in reclamation are currently taking place to restore or transform the results of these impacts, and where do we have opportunities to improve?

Start with stakeholder engagement

We must first recognize that meeting the needs of community members, energy developers, and the natural environment simultaneously is possible. A Triple Win can be achieved with early and frequent collaboration,

fit for function to each project, meeting the interests of each group effectively. In this ideal scenario, where stars align and the expressed needs and desires of all stakeholders are uniquely addressed, we will find that energy developers spend less or about the same amount of capital as they would otherwise on reclamation activities, with additional improved outcomes around community and regulatory shared trust. Ideally, community members are given above-and-beyond opportunities to express needs and provide local landscape knowledge; expectations from regulators are exceeded as restoration timelines and habitat quality are carefully examined throughout the asset's entire lifecycle; and finally, the habitat relied on by so many floras



From left to right: these photos show younger to older reclamation efforts on pipeline ROWs within Wyoming's Pinedale Anticline natural gas field.

and fauna is not only restored, but positively transformed during and following construction. This is a reality that, with the help of engaged thought leadership, can and should be expected in energy development.

Let's first explore the regulatory levers governing modern-day land disturbance projects throughout the U.S. The Endangered Species Act is enforced by U.S. Fish and Wildlife Service (USFWS) and provides that the "take" of any threatened or endangered species is unlawful. A "take" is defined as the harassment or death of any identified threatened or endangered species as determined by the USFWS. Sections 401, 402, and 404 of the Clean Water Act (CWA) are triggered based on activities that may impact aquatic resources, including spill events and dredging. The U.S. Army Corps of Engineers oversees a permitting process that "is designed to minimize the environmental impact of construction and dredging activities in U.S. waters and to ensure that all such efforts are well thought-out and carefully coordinated." Understand that this is but a limited set of federal considerations. Other forms of

regulatory oversight meant to quantify disturbance impacts during and following construction activities may include State and local obligations or floodplains and stormwater runoff protection plans.

For the unacquainted, there is a common theme throughout these regulations – success is often determined by soil stabilization, percent of vegetation achieved, and avoiding the number of threatened or endangered species impacted. There is a certain timeframe by which the quantification of this success is expected, and after that, most agencies close out the permit and subsequent need for continued oversight. These measures of success vary according to time and place. The bigger question might be: what risks do developers incur in aligning only to these regulations which do not take into consideration future habitat or land use quality?

For example, seed mixes suggested by various federal government agencies for many decades included introduced species. While introduced species may assist with site stability goals and nutritional forage to livestock, we are

recognizing unintended consequences of their use, including reduction of native vegetation diversity and negative impacts to terrestrial food webs. Examples include lovegrass in Southeast New Mexico, saltbush in Central New Mexico, or crested wheatgrass throughout the Great Basin region of Utah and Wyoming. Now often seen by ranchers, landowners, and communities as nuisances, these species were once recommended or approved by the federal agencies in reclamation seed mixes to promote quality of native-existing habitat. Responsible use of the environment necessitates checks and balances, including the oversight of government agencies; however, we should recognize regulatory oversight is only one of many ecological success measures.

The development of new regulation requires that an issue is both novel and significant to the public and the economy, thereby justifying the need for government intervention. This may be defined by several factors: Congressional recommendations, pending lawsuits, new technologies, or concern from society at large. Environmental impacts resulting from

Taskforce on Nature-related Financial Disclosure

Describe the nature-related dependencies, impacts, risks, and opportunities the organization has identified over the short, medium, and long term.

Describe the impact of nature-related dependencies, impacts, risks and opportunities on the organization's business model, value chain, strategy, and financial reporting, as well as any transition plans or analysis in place.

Sustainability Accounting and Standards Board – Oil and Gas Midstream

Land owned, leased, and/or operated within areas of protected conservation status and endangered species habitat.

Terrestrial acreage disturbed (acres).

Impacted acres restored.

Global Reporting Initiative 2024 Standard 304

Describe its policies or commitments to halt and reverse biodiversity loss, and how these are informed by the 2050 Goals and 2030 Targets in the Kunming-Montreal Global Biodiversity Framework.

Report the extent to which these policies or commitments apply to the organization's activities and to its business relationships.



The image on the left depicts a stretch of Texas pipeline ROW reclamation in the very early stages, with the photo on the right showing the same pipeline maturing.

energy development often incorporate all these elements. Thankfully, we can get ahead of any impending rule through proactive regulatory discussion and education alongside early adoption of collaborative conservation practices at scale.

What do we mean by ecological impacts?

For the purpose of this discussion, ecological impacts are effects on the natural environment that occur during the course of an organization's construction and subsequent routine operations. It's often assumed that any profit-seeking entity's activities would in some way be ecologically depleting. Herein lies the opportunity for measurement and operational improvement – we cannot prove or disprove this assumption without first accounting for activities and quantifying the lifecycle of supposed impacts to the natural environment. Measuring this ecological impact is important – but figuring out where to start can be tough.

How do we know what to measure?

If you're involved with an organization that already manages energy

development reclamation activities, you are already managing a number of key performance indicators that can be used to drive an improved strategy. Look at where your data already exists – capital spent on seeding and planting activities in different geographies; capital spent on monitoring activities, either internally or through the use of contractors; time spent conferring with regulatory agencies and landowners to determine a compliant seeding plan. Each of these activities can be compared project-by-project, geography-by-geography, to determine where efficiencies are found in best practices.

Also, consider how internal success measures can be compared to those of peers – herein lies one purpose of non-financial public disclosures, sometimes referred to as Environmental, Social, and Governance (ESG) disclosures. Within ESG disclosures, there's several industry-agnostic (such as Global Reporting Initiative, or GRI), industry-specific (Sustainability Accounting and Standards Board, or SASB), and topic-specific (Taskforce on Nature-related Financial Disclosures, or TNFD) reporting frameworks that speak to an organization's ability to manage

ecological impact risks. This involves comparing similar metrics to that of peers and customers with the hope of understanding where your organization lands as reported by these frameworks.

When preparing and investigating non-financial public disclosure, the most important audience is internal – front line employees' roles alongside the aspirations of executive leadership. Who owns reclamation activities present day? Who negotiates with landowners? With regulatory agencies? Are these different groups, overlapping groups, or contractors? Taking into account the nature of who makes the decisions aligned with your organizational identity is what will drive a successful starting place for your reclamation strategy. An organization's communication on ecological impacts doesn't need to read like traditional financial disclosures or align exactly with Generally Accepted Accounting Principles (GAAP) formats. Instead, it benefits the organization to disclose these outcomes in common language that can be easily digested by all the audiences previously mentioned while addressing the frameworks required by each. This doesn't require abandoning

a quantitative GAAP format altogether. Ideally, a public disclosure includes both explanatory qualitative narratives backed up by quantitative metrics displayed in a comparable and timely manner.

Mapping Externalities, Efficiencies, and Synergies

For the skeptic of this Triple Win approach, consider how your organization might answer the following questions:

- Are we interested in exceeding regulatory agencies' expectations for reclamation? If so, how do we believe we can achieve this?
- Are we interested in cost-saving measures related to reclamation activities? If so, how can we realize

these cost savings, not only for initial seeding and planting but for established vegetation throughout the life of the asset?

- Are we interested in engaging landowners and affected community members in such a way that we hear and respect expressed needs? If so, how can we make sure that we gather that input and that local knowledge is utilized?
- Are we interested in collaborating with industry groups, customers, and peers to achieve objectives associated with reclamation efficacy? If so, how can we get a seat at the table to engage the right industry players?

Synergies abound in a carefully executed reclamation strategy. In

addition to the responses you may have arrived at by answering the above questions, consider the reduced likelihood of costly washout or erosion incidents due to insufficient soil stabilization following construction. Consider also improved quality of habitat outcomes for flora and fauna, reducing the likelihood of a species being listed as threatened or endangered by USFWS. Costs are also reduced in some jurisdictions where achieving restoration sooner reduces time and resources associated with ongoing monitoring. Furthermore, developing an improved and thoughtful strategy can enhance your license to operate with regulatory agencies, customers, investors, and the public at large. 🌱



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A pilot bait-tree trial to re-establish EMF communities in New Temperate Oak-Birch Woodland on disturbed land in the UK

BY PETRA GUY¹, NEIL HUMPHRIES², BRIAN PICKLES³, AND MARK TIBBETT⁴

A New Legislative Requirement

Oak (*Quercus robur*, *Quercus petraea*) and Birch (*Betula pendula*, *Betula pubescens*) are characteristically the main species of many of the UK's temperate upland and lowland woodlands and landscapes (Rodwell 1991; Peterken 2023). Many of these woodlands, because of their historical

importance and biodiversity richness, have planning policy and legal protection from development (Department for Levelling Up, Housing and Communities 2023). With the recent enactment of the biodiversity net gain (BNG) provisions of the Environment Act 2021 (legislation.gov.uk 2021), built developments in England, including those focused on the extraction of minerals, will be required to replace and expand any lost broadleaved woodlands (the statutory gain) with the same types of woodland, either within the development or off-site (Department for Environment, Food and Rural Affairs 2023).

Hence, there will be a requirement to replace Oak-Birch woodland ecosystems due to the continuing need for the extraction of minerals and other developments (Humphries 2021). The expectation is that woodland ecosystems of at least comparative condition or of a higher biodiversity content and complexity will need to be established as the replacement for the losses. Although not explicit, ectomycorrhizal fungal (EMF) associations may also need to be considered as the disturbance of woodland soils could result in their possible loss or a delay in their recovery (Gardner and Malajczuk 1988; Gebhardt et al. 2007; Glen et al. 2008). Their reintroduction into new woodland could be of importance for its success as the nutrition and water balances of many tree and shrub species is dependent on these associations (Tibbett and Sanders 2002; Smith and Read 2008; van der Heijden et al. 2015; Harris and Bauman 2022).

To inoculate or not to inoculate

The need to inoculate saplings at the planting stage with EMF depends on whether it is necessary, or possible, to introduce EMF species artificially into the new woodlands. Various methods of inoculation have been proposed including use



Figure 1: Oak bait tree (tube removed) planted in undisturbed woodland (Box B).

Figure 2: Oak bait trees in tubes planted on replaced soil (Box C).



of commercial products (Bast et al. 2016), or the addition of leaf litter (Aučina et al. 2007) or woodland soil (St-Denis et al. 2017). However, various factors need to be considered to understand the potential outcomes of these inoculation methods. For example, commercially grown trees are likely to already be colonised by EMF species associated with the nursery. Work from eastern Europe suggests that nursery trees may have colonization rates of up to 100 percent with the specific species and rates depending on propagation methods and fertilisation regimes (Menkis et al. 2005; Iwański et al. 2006; Leski et al. 2010; Rudawska et al. 2019). Further, the initial nursery community will change over time after transplanting due to the different conditions at the planting site compared to the nursery (Chu-Chou and Grace 1987; Dahlberg and Stenström 1991) and tree-age dependent succession (Last et al. 1987). The former is particularly relevant in post-mining situations where there are very different soil conditions found in mature woodlands or nurseries (Scullion 1994).

The question of inoculation must also address whether the EMF species in the inoculum are suited to the intended woodland type and site conditions, and whether they are sufficiently competitive as to be able to replace those already hosted by the saplings. EMF species associated with organic woodland soils, for example, may not be best suited to a disturbed post mining site where the organic matter levels can be low and/or plant litter is absent.

Use of bait trees as inoculum source

An alternative approach to the use of woodland soil or a commercial product to introduce EMF spores and/or hyphae could be the use of “bait” trees. These are trees that are planted into an existing woodland with the intention their new roots are colonised with the in-situ EMF community as they grow into the soil. They are then replanted at the new site as “source” trees. Of course, the same questions must be addressed as to the suitability of the acquired EMF community to the new woodland site.



Figure 3: Oak bait tree planted in replaced soil at harvesting - showing new root growth with EMF colonization (Box C).



Figure 4: Overview of bait tree trial treatments.

Pilot trial in the use of bait trees

A pilot trial using bait trees was devised to help Tarmac, the mineral and construction materials company, to consider its strategy to promote the EMF component in its new woodlands. The trial was carried out at one of its aggregate stone quarries in the English Midlands (Humphries et al. 2019). It comprised the comparison of the EMF communities of young nursery transplants with those acquired on saplings planted into long-established Sessile Oak (*Quercus petraea*) – Small-leaved Lime (*Tilia cordata*) woodland with those in directly replaced soils recovered from mature secondary Sessile Oak-Silver Birch woodland (Figure 4).

As a reference for EMF communities (Figure 4, Box A), the roots of the mature Oaks in the Oak-Lime woodlands had been previously sampled as part of a piece of research looking at oak communities in 19 sites across the UK (Guy 2022).

Twenty two-year-old seedlings of *Quercus petraea* (grown as nursery air-pruned plug plants in a peat-free compost) were planted as bait trees into the undisturbed Oak-Lime woodland (Figure 1; Figure 4, Box B) and into replaced woodland soil from an Oak-Birch woodland (Figure 2; Figure 4, Box C) in February 2020. The bait trees were sheathed with 1.2m plastic “tree tubes”, and application of the standard silvicultural herbicide control of any competing herbaceous ground cover was suspended during the trial. A further 20 nursery grown plants (Box D) were grown-on as a “control” in a compost medium, taking precautions to prevent further inoculation from air borne spores, to identify the EMF community originating from the tree nursery.

The bait trees were recovered intact after seven months (Figure 3), and their roots were removed. These were immediately frozen and stored for two weeks until examined when all root tips with EMF inoculation were removed. The root tips were aggregated for each treatment and sent for metabarcoding at Novogene, Cambridge, UK. DNA extraction was carried out using an Echolution Plant DNA kit and 200ng of DNA was used for the polymerase chain reaction (PCR) amplification with ITS fungal primers set to target the fungal ITS2 region; ITS3 (5'- GCATCGATGAAGAACGCAGC-3') and ITS4 (5'- TCCTCCGCTTATTGATATGC -3').

Findings

The root-tips of the “control” nursery transplanted bait trees (Figure 4, Box D) had 36 EMF species (Annex 1), with 39 and 40 recorded on the undisturbed (Box B) and disturbed (Box C) woodland soils respectively, and 34 on the reference mature Oak tree roots (Box A).

Overall, 14 EMF species were common to all the bait tree samples (Figure 4, Boxes B, C & D; Figure 5) and those occurring in the reference mature Oak tree root-tips (Box A). Of the nursery trees, 29 were in common with those root-tips from the undisturbed woodland soil and 31 from the disturbed woodland soil. The nursery transplants had 15 in common with those reported for the root-tips of the mature oak trees. Only five EMF species were new colonists of the root-tips in the undisturbed woodland soil bait trees with nine new colonists in the disturbed soil.

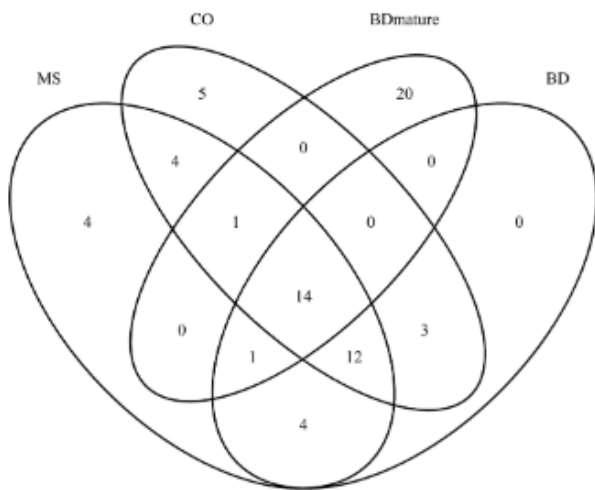


Figure 5: Venn Diagram showing the number of EMF species associated with the reference mature oak tree root-tips from trees in ancient woodland adjacent to study site (Box A), the bait trees in the replaced soil and those in the adjacent oak woodland (Box D), undisturbed woodland soil (Box B) and disturbed woodland soil (Box C) bait tree root-tips.

The root-tips from the undisturbed woodland soil had 14 species in common with the mature reference oak trees and 16 that were not. The two types of woodland used in the bait trail had different compositions and histories with different types of soil, but surprisingly, had 31 in common between the undisturbed and disturbed soils.

Importantly, for woodland ecosystem function, the EMF species found on the bait trees had a high alpha diversity associated with increased ecosystem resilience (Annex 1), and included generalists, species considered “early stage”, and species which are found in association with mature oaks, including the oak specialist *Lactarius quietus*.

A developing strategy

Historically, the practice in the UK has been to plant nursery grown tree stock into the replaced soil/spoil without considering EMF inoculation (Jobling and Stevens 1980; Humphries and McQuire 1994; Rodwell and Patterson 1994). Whilst there is insufficient evidence at present regarding the importance of specific EMF species and community composition and their diversity for the functional ecology of different woodlands, it seems appropriate that the standard planting practice is enhanced by routinely screening for EMF species present and to consider the use of bait trees given the new drive to maintain and enhance biodiversity. The cost of this would be miniscule in the context of the overall planting schemes.

The findings of the trial suggest that EMF found naturally on the nursery stock may provide an initial and diverse woodland EMF community typically found in oak woodlands, irrespective of the disturbance of the soil, without the need

for the use of bait trees or other amendments. Similar findings have been reported by Scullion (1994) for two reinstated surface coal mine schemes where one mine planting had 18 of the 22 species found in nearby woodland. However, the use of bait trees could be a useful adjunct if nurseries were not to be relied upon and/or to increase the diversity of EMF communities in new plantings such as the other woodland Scullion reported as just having eight species. Their use may be pertinent not only where there are rare and specialised EMF species, but also for where there are commonly occurring species. However, the bait trees may still not provide all the species and necessarily those representatives of a particular or mature woodland. Here, recolonization from other woodland will have to be relied upon.

The findings confirm that the recovery and reuse of woodland soils, without storage, in development schemes is likely to be of importance for the recovery of EMF communities. Also, it is likely that new woodland in close/adjoining juxtaposition to existing and mature woodland will be of significance for EMF recolonization (Bauman et al. 2019). The practices of leaving parts of woodland as islands/corridors and/or recovering and reusing woodland soils and wood-debris should be maximised in the mine recovery plan to maintain natural inoculation sources of EMF species.

Further work

To refine the woodland strategy, further investigation is proposed by Tarmac. Because of the COVID epidemic and the national travel restrictions, the trial was only run for seven months. A longer period would have indicated whether the nursery EMF community persisted or was eventually superseded as new tree roots were initiated. In this context the findings of the trial are provisional. Hence, it is proposed to repeat the trial over a longer period to understand more about the successional changes and whether the development of common mycorrhizal networks (hyphal links between neighboring trees) might differ and become a factor. It should also be extended to several types and “ages” of woodland. The occurrence and rates of colonization by EMF species should be monitored to help refine the proposed strategy.

Annex 1 – The following table shows presence or absence of species in the four treatments. These species names were obtained from matching sequences against the UNITE database and assigning names for matches at >97 percent similarity. Potential successional stage is suggested from (Newton 1992; Keizer and Arnolds 1994; Nara et al. 2003). Commonness and whether EMF is found with mature trees is suggested by work data gathered from 19 oak woodlands in Britain (Guy 2022).

Identified Species	Bait trees in undisturbed soil (Box B)	Control bait trees (Box D)	Bait trees in replaced soil (Box C)	Reference mature oaks (Box A)	Species Characteristics
<i>Amanita fulva</i>	0	1	0	0	Late stage
<i>Byssocorticium pulchrum</i>	0	1	1	0	Found on mature oaks
<i>Cenococcum geophilum</i>	0	0	0	1	Ubiquitous non-specialist
<i>Clavulina</i>	0	1	0	0	
<i>Clavulina amethystina</i>	0	0	0	1	
<i>Clavulina coralloides</i>	0	0	0	1	Common with mature oaks in UK, non-specialist
<i>Cortinarius acutus</i>	1	1	0	0	Not common on mature oaks
<i>Cortinarius anomalus</i>	0	0	0	1	Often found with oak, all stages
<i>Cortinarius punctatoides</i>	0	0	0	1	
<i>Cortinarius2</i>	0	1	0	0	
<i>Craterellus tubaeformis</i>	1	1	1	0	Generally found in mineral soils. Non-specialist
<i>Elaphomyces muricatus</i>	1	1	1	1	Often found with mature oaks, non-specialist
<i>Hebeloma alvarens</i>	1	1	1	0	Found on mature oaks
<i>Hebeloma pusillum</i>	1	1	1	0	Found on mature oaks
<i>Hebeloma1</i>	1	1	1	0	
<i>Hebeloma2</i>	1	1	1	0	
<i>Hydnotrya tulasnei</i>	0	1	0	0	Often found with oak, non-specialist
<i>Imleria badia</i>	0	0	0	1	Found on mature oaks, not common
<i>Inocybe petiginosa</i>	0	0	0	1	Not common
<i>Inocybe rufoalba</i>	1	0	1	0	Not common on UK mature oaks, but reported as common in mediterranean oaks
<i>Laccaria amethystina</i>	1	1	1	1	Ubiquitous early stage
<i>Laccaria laccata</i>	1	1	1	1	Ubiquitous early stage
<i>Laccaria proxima</i>	1	1	1	0	Early stage
<i>Lactarius camphoratus</i>	0	0	0	1	Found on mature oaks
<i>Lactarius chrysorrheus</i>	1	1	1	0	Late stage
<i>Lactarius decipiens</i>	0	0	0	1	Found on mature oaks, not common
<i>Lactarius quietus</i>	1	1	1	1	Oak specialist
<i>Lactarius subdulcis</i>	0	0	0	1	Found on mature oaks
<i>Lactarius tabidus</i>	1	1	1	1	Common on mature oaks
<i>Melanogaster ambiguus</i>	0	0	0	1	Found on mature oaks, not common
<i>Melanogaster1</i>	0	0	1	0	
<i>Otidea bufonia</i>	0	0	1	0	Late stage

<i>Paxillus involutus</i>	1	1	1	1	Ubiquitous, late stage
<i>Peziza succosa</i>	1	1	1	0	Found on mature oaks
<i>Piloderma sphaerosporum</i>	0	0	1	0	
<i>Russula amoenolens</i>	1	1	1	1	Common on mature oaks
<i>Russula atropurpurea</i>	0	0	0	1	
<i>Russula densifolia</i>	1	1	1	1	Found on mature oaks
<i>Russula fragilis</i>	1	1	1	1	Late stage
<i>Russula ionochlora</i>	1	1	0	0	Found on mature oaks
<i>Russula nobilis</i>	0	0	0	1	
<i>Russula ochroleuca</i>	1	1	1	1	Ubiquitous, late stage
<i>Russula peckii</i>	0	0	0	1	
<i>Russula puellaris</i>	0	0	0	1	
<i>Russula1</i>	0	0	1	0	
<i>Russula2</i>	1	0	1	0	
<i>Russula3</i>	1	1	0	0	
<i>Scleroderma areolatum</i>	0	0	0	1	
<i>Scleroderma citrinum</i>	1	1	1	1	Ubiquitous late stage
<i>Scleroderma verrucosum</i>	0	0	0	1	Late stage
<i>Sebacina incrustans</i>	0	1	1	1	Found on mature oaks
<i>Sebacina1</i>	0	1	1	0	
<i>Sebacina3</i>	1	0	1	0	
<i>Thelephora albomarginata</i>	1	1	1	0	Found on mature oaks, not common
<i>Thelephora terrestris</i>	1	1	1	1	Ubiquitous, all stages
<i>Tomentella botryoides</i>	0	1	1	0	Found on mature oaks
<i>Tomentella coerulea</i>	0	0	0	1	
<i>Tomentella ellisii</i>	1	1	1	0	Common on mature oaks
<i>Tomentella papuae</i>	1	1	1	0	Found on mature oaks, not common
<i>Tomentella punicea</i>	0	0	0	1	
<i>Tomentella stuposa</i>	1	0	1	1	Found on mature oaks
<i>Tomentella2</i>	0	1	0	0	
<i>Tomentellopsis echinospora</i>	1	0	1	0	Found on mature oaks, not common
<i>Tomentellopsis submollis</i>	1	1	1	0	Found on mature oaks
<i>Tuber anniae</i>	0	1	1	0	Found on mature oaks, not common
<i>Tuber puberulum</i>	1	1	1	1	Found on mature oaks, not common
<i>Xerocomellus cisalpinus</i>	1	1	1	1	Found on mature oaks, not common
<i>Xerocomus ferrugineus</i>	0	0	0	1	
Total alpha diversity	34	39	40	36	

Building on the work of Tibbet and Sanders (2002), the new trials could include novel measures that may be beneficial to promote EMF diversity and successional development (e.g. Glen et al. 2008). This could include the preparation of individual “planting pits” with organic amendments such as leaf mould and/or woodland soil.

Investigation is also needed to determine if post-planting husbandry, such as the standard practice of using herbicides in the first three seasons to control competition from herbaceous ground vegetation (Davies 1987; Humphries and McQuire 1994), has a beneficial or deleterious effect on EMF inoculation, their communities and diversity.

Acknowledgements

Dr. Guy undertook the investigation whilst supported by a UK Natural Environment Research Council Research Grant (NERC grant: NE/P012345/1). Tarmac (a CRH Company) provided financial and logistical support for the bait trial to be undertaken at its Mountsorrel Quarry. David Park (formerly, Tarmac’s National Restoration Manager) is thanked for his help and support.

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Abandoned Mine Lands Native Plants Project

BY GINA CLINGERMAN



BLM Archaeologist and Wildland Firefighter Krystal Hazen McCreary helps Lander Middle School science students plant sagebrush seedlings. Photo by BLM 2017.



BLM Rangeland Specialist Steve Renner helps Lander Middle School science student plant sagebrush seedlings. Photo by BLM 2017.

The Abandoned Mine Lands (AML) Native Plants Project was created in 2016 by the Bureau of Land Management (BLM) Abandoned Mine Lands (AML) Program, the Wyoming Department of Environmental Quality – Abandoned Mine Lands (WDEQ-AML) Division, and the Office of Surface Mining Reclamation and Enforcement (OSMRE). The project aims to restore sagebrush steppe habitat for the health and survival of sagebrush obligate species in Wyoming.

At the start we were preoccupied with how reclamation efforts of the involved agencies at abandoned mine lands could support or help restore sage-grouse populations in the state of Wyoming. Greater sage-grouse populations have been dwindling across the west. A USGS publication shows that sage-grouse populations have declined 80 percent range wide since 1965 and 40 percent since 2002 (Coates et al. 2001). Looking at the sage-grouse was a starting point for our project, but we soon came to understand that sage-grouse population declines are only the beginning.

The problem of dwindling sage-grouse populations is a conglomeration of habitat loss by human encroachment, noise from oil and gas production, wildfires and the scarring legacy they leave behind, the spread of invasive plant species, and human indifference.



Above left: Lander Middle School science student sagebrush planting group photo. Photo by IAE 2019. Above right: Wyoming Honor Farm inmate sagebrush planting group photo. Photo by IAE 2019. Right: Matt Rhodes (Trihydro) and Maggie Eshleman (TNC) setting up seed pod test plots. Photo by TNC 2019.

The problem is not just affecting sage-grouse populations – it's touching all non-human beings who rely on the sagebrush steppe ecosystem for habitat, food, breeding grounds, and summering or wintering grounds.

Western states' wildlife agencies have documented a steady decline in pronghorn populations throughout the west over the last decade (<https://www.gohunt.com/content/the-life/antelope-numbers-across-6-states>). Sharply declining mule deer populations led to the Wyoming Mule Deer Initiative, which states that the population has declined 31 percent since 1991 (Mule Deer Working Group 2018). Other species that rely on the sagebrush steppe ecosystem that are now in decline include the pygmy rabbit, western burrowing owl, American badger, loggerhead shrike, sage thrasher, greater short-horned lizard, sagebrush lizard, Townsend's big-eared bat, and many more.

As we learned more about the decline in populations of sagebrush dependent species our mission broadened to include improving wildlife habitat for sagebrush obligate species, including the greater sage-grouse, at previously

reclaimed mines by re-establishing sagebrush and native plant communities through various means such as sagebrush seedling plantings and innovative seed technologies.

To achieve this mission, we began connecting with nonprofit groups and local agencies that have similar mission statements, including The Nature Conservancy (TNC), Wyoming Wildlife Federation, The Wyoming Outdoor Council, Popo Agie Conservation District, Fremont County Weed and Pest, and Wyoming Mining Natural Resource Foundation. Our combined funding and resources make the project goals more achievable and our plantings more sustainable.

Initially, we developed the project as a sagebrush seedling planting effort using locally available sagebrush seed collected by the Seeds of Success (SOS) that was grown in prison facilities through the Sagebrush in Prisons Project (SPP), part of an ecological education project created by the Institute for Applied Ecology (IAE). Later, it would grow into our own sagebrush-growing facility at the Wyoming Honor Farm and it would include research and design studies

with habitat restoration specialists from TNC and a cofounded seed laboratory.

Sagebrush Seedling Student Plantings

In 2017, we began a partnership with Lander Middle School science teachers to offer a unique field trip to science fair students interested in ecology. We provide the students with sagebrush steppe ecological education as part of the BLM's National Strategy on Education, Interpretation, and Youth Engagement policy. Through this partnership, we teach students the importance of preserving and restoring the sagebrush steppe ecosystem and the impacts of fracturing the ecosystem, and we give them a broad overview of the animals that depend on the ecosystem for survival.

Our first planting took place in 2017. We have planted every subsequent year except for 2020 and 2021 due to COVID-19. In 2017, 45 students and

44 volunteers planted 900 seedlings. In 2018, 48 students and 40 volunteers planted 1,200 seedlings. In 2019, 45 students and 38 volunteers planted 1,490 seedlings. We planted 729 seedlings in 2022 with 105 students and 19 volunteers. To date, we have planted 4,319 sagebrush seedlings and reclaimed approximately 10.5 acres. Our educational planting has had a positive impact on the lives of these budding scientists and the sagebrush survival rate is between 85 and 90 percent as confirmed by yearly monitoring. We are currently planning our fifth year of planting.

This project is a good opportunity for young science students to better understand applied sciences such as ecology, botany, reclamation, and many others. It also shows them that there are science careers in the places they live. Over the years, volunteers who are wildlife biologists, archaeologists, wildland firefighters, botanists, restoration scientists, and conservationists work directly with the students. It's this aspect of the project that keeps the students and the volunteers engaged in the reclamation.

IAE Sagebrush in Prisons Project and Inmate Plantings

In 2018, a lapse in funding for the SPP jeopardized federal agencies' access to sagebrush seedlings for habitat restoration. In response, we connected with IAE with the hope of setting up a direct partnership to continue the SPP. We met with the Wyoming Department of Corrections (WDOC) and IAE personnel with the intent to bring the SPP to the Honor Farm, a minimum-security prison, in Riverton, Wyoming. The interest from WDOC was overwhelming and in 2019 we procured plans and materials to

build a greenhouse. Inmates lent their expertise and erected the greenhouse that May.

Since then, SPP crews have grown a total of 84,541 seedlings for habitat restoration across the west. Inmates have learned about and propagated Wyoming big sage (*Artemisia tridentata* ssp. *wyomingensis* = 51,344), mountain big sage (*Artemisia tridentata* spp. *vaseyana* = 16,733), and silver sage (*Artemisia cana* = 4,508). Our growing plans for this year include approximately 20,000 mountain big sage, 10,200 Wyoming big sage, and 100 silver sage seedlings, for a total of 30,300 seedlings.

SPP crew inmates are paid through the program and are responsible for sowing seeds, watering and tending seedlings, checking for pests weekly, and learning about the ecology of native ecosystems and growing native plants. Each participant receives a certificate of completion detailing the skills they learned as part of the project. In addition to sowing, tending, and growing the seedlings, we have organized three inmate plantings since 2019. A total of 39 inmates have planted 13,064 sagebrush seedlings at two different planting areas in the Gas Hills in central Wyoming. Additionally, 10 inmates collected almost four pounds of sagebrush seed over two days last year. It was a successful and educational field trip with lasting effects as those seeds will be grown into seedlings for continued habitat restoration in the coming years.

To those of us outside the prison system, this might seem like a quaint story, but green programs like the SPP have meaningful impacts on inmate populations. Bureau of Justice statistics reveal that 68 percent of inmates are

re-arrested within three years of their release and 77 percent are re-arrested within five years of release, with little change in these rates over the last 30 years (van der Linden, 2015). Research done by Sander van der Linden, Ph.D. on inmate populations participating in the Greenhouse/GreenTeam Program in Riker's Island, NYC, demonstrates a 10 percent drop in recidivism (re-arrest) rates.

It's hard to determine what is driving the success of green prison programs and the reduction in recidivism rates but "some experiments have shown that when randomly assigned to either a 'green' or 'other' rehabilitation programs, the green program was significantly better for reducing risk-taking behavior, cultivating better decision-making skills, and improving overall psychosocial functioning" (van der Linden 2015). The literature on the benefits of nature is increasing daily, and we believe this project helps inmates learn new and employable skills, develop confidence in themselves, and learn how to cooperate with each other while producing a valuable restoration product.

The SPP is a two-fold reclamation project – not only are we using the seedlings to reclaim sage-grouse habitat, but the act of growing those seedlings is reclaiming the hearts and minds of the inmates who participate in the project. We continue to work to grow the program at the Honor Farm. We completed the construction of the polycarbonate greenhouse, installed permanent metal growing tables in the greenhouse, and last year erected a shadehouse for hardening the seedlings in the fall before planting. We have expanded our field trips to include seed collection, and last spring, we planted a native area around the greenhouse

with native seed and later seedlings in the hopes of having a seed nursery for drought years. We hope to keep expanding our educational offerings as well.

Habitat Restoration Through Developed Seed Enhancement Technologies (SET)

Before our partnership with TNC, they were in the early phases of developing and testing SETs for sagebrush steppe restoration after large-scale wildfires. Sagebrush seed has a traditionally low germination rate and is slow to be established, making large-scale habitat restoration difficult. We were keen to promote the research and work with TNC to develop SETs that were less time consuming than hand planting thousands of sagebrush seedlings and could be widely shared with restoration industries across the west. In 2019, we completed construction on a seed laboratory where research could be designed and trials tested as our work evolved.

TNC's research began with seed pods/pellets and then grew to include herbicide-resistant seed pellets, seed coatings, and dust treatments. The seed pod/pellet consists of ingredients that have the potential to enhance and nourish seeds during germination. Native seed, including sagebrush, grasses, and forbs, were evaluated in seed pellets and herbicide resistant seed pellets. Success has been limited with sagebrush seeds but other native seeds, particularly grasses, have done well in seed pellet trials.

The research is ongoing, but TNC has recently published their research in the journal *Rangeland Ecology & Management* (see references). Seed technologies can play an important part in enhancing habitat restoration

in sagebrush steppe ecosystems, but more research is needed to study what kinds of specific seed technologies will benefit a variety of native seed. Currently, we have funding for the next three to four years to continue this research both in the lab and in the field at AML sites.

The Future of Sagebrush Habitat Restoration

Currently, the future of sagebrush habitat restoration is uncertain, but not for a lack of devoted sagebrush restorationists. It's uncertain because repairing a fragmented habitat takes time and effort. Our project and our partners are trying to figure out how to complete this work efficiently and with the resources that we have, knowing that ecosystems are complex and varied, and disruptions are long lasting.

We have seen that getting people involved in the work, showing them the beauty of this vast landscape, and helping them to understand the connections from the sagebrush through the vast web of living organisms that depend on it makes a difference. We hope that our work with young scientists will inspire them to choose careers in restoration, habitat management, and ecology. We hope that our work with inmates will show them that they are valuable members of this restoration community and society at large. We hope that our curiosity and wonder will eventually lead us to develop sustainable SETs that can be useful to restorationists in all ecological settings.

The future of sagebrush habitat restoration probably will not be resolved by a single grand action but most likely by the small, seemingly simple ones like planting a seedling and caring what happens in the

world around us. To this end, we are committed to helping others establish similar projects by sharing our successes and our failures.

If you have any questions about this project or would like to be involved, please contact Gina Clinger at gclinger@blm.gov.

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A TOOLBOX FOR IMPROVING RECLAMATION SUCCESS: Joint USGS–BLM report establishes best management practices for oil and gas operations, monitoring methods, and standards

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ALL PHOTOGRAPHS BY THE U.S. GEOLOGICAL SURVEY



Monitoring soil and vegetation outcomes on a reclaimed oil and gas pad near Grand Junction, Colorado.



*A pronghorn (*Antilocapra americana*) using habitat with oil and gas development near Vernal, Utah.*

The U. S. Geological Survey, in partnership with the Bureau of Land Management, recently published an oil and gas reclamation techniques and methods report that provides land managers and oil and gas operators specific guidance and best management practices for development impacts, successfully reclaiming disturbed lands during and after oil and gas activities. Resource inventory, monitoring, and protection of oil and gas sites are mandated by federal statutes and regulations, yet this is the first publication defining standards and guidelines for how to successfully monitor soil and vegetation outcomes of disturbed oil and gas sites and evaluate those monitoring data against standards

available at a national level. The report emphasizes the importance of best management practices, clear standards, effective monitoring and minimizing surface disturbance for successful land reclamation.

Initiated through an interagency agreement with the BLM, USGS and BLM drew upon existing federal reclamation policy, scientific literature review, practical field experience and expertise from various sources such as federal and state agencies, oil and gas contractors, and academia to produce the document, intended to be used for each reclamation step from start to finish.

Successful perennial grass establishment on a reclaimed oil and gas pad in the Book Cliffs, Utah.



New, comprehensive guidelines

Prior to this report, the oil and gas industry relied on a set of guidelines known as the “Gold Book” for practical information about oil and gas leasing and permitting, operations, bonding and reclamation planning processes. However, the Gold Book lacks the type of precise guidance often found in instructional memorandums and handbooks produced by surface management agency offices, multi-jurisdictional groups, or state agencies. To maximize the efficacy of reclamation efforts, a set of national guidance and policies specific to oil and gas monitoring and assessment were needed.

This new USGS-BLM report supplements the Gold Book and other existing guidance by providing definitive steps and metrics for reclamation surface management. The report provides uniform monitoring protocols and standards covering standardized soil and vegetation field monitoring methods, indicators, benchmarks, appropriate designs and analyses, and electronic data capture and repositories, supports planning procedures, leasing, permitting processes and bond release decisions.

While it was designed to be specific to the oil and gas industry, many of the report’s concepts and practices hold the potential to benefit reclamation of other fluid minerals development, mined lands, wind and solar energy development, and other disturbances.

Leveraging ecological science to achieve success

The report also provides guidance for developing quantitative benchmarks to determine if erosion and vegetation standards have been met, including indicators of erosion and site stability, species composition, and community structure.

Successful reclamation is achieved when the standards defining soil and vegetation recovery are met, and a self-sustaining, vigorous, diverse, native, or approved plant community that minimizes visual land disturbance, provides forage, stabilizes soils, and prevents noxious weeds from taking hold is in place.

Who does this report support?

In conjunction with the Gold Book, this report primarily supports the BLM — the largest surface management agency in the U.S. — with tools to monitor oil and gas reclamation and ensure environmentally responsible outcomes. BLM field office staff guide operators to create reclamation plans and to ensure that reclamation goals and expectations are clear. They inspect reclamation projects’ progress and status, complete quality assessments and quality control of operators’ monitoring data, and provide feedback.

This report will also be useful for operators and contractors who conduct oil and gas activities on U.S. federal or Tribal lands, surface management agencies who are responsible for advising and enforcing those activities, stewards of private lands and other landowner reclamation projects.

Reclamation has several phases, including interim and final reclamation, which each have differing overall goals. The report can help foster relationships between surface management agencies and operators, highlight timeframes, and provide operators with specific steps and goals in the reclamation process.

To read the full report, *Oil and gas reclamation – Operations, monitoring methods, and standards: U.S. Geological Survey Techniques and Methods*, visit <https://doi.org/10.3133/tm18A1>.

To learn more:

www.usgs.gov/centers/southwest-biological-science-center/science/southwest-energy-exploration-development-and
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