# Canadian Reclamation

An official publication of the Canadian Land Reclamation Association /
Une publication officielle de l'Association canadienne de réhabilitation des sites dégradés

FALL/WINTER • 2017

# JACK WINCH and the founding of the CLRA

CLRA | ACRSD

Canadian Land Reclamation Association
Association canadienne de réhabilitation des sites dégradés

*Celebrating over* **40 Years** of Reclamation

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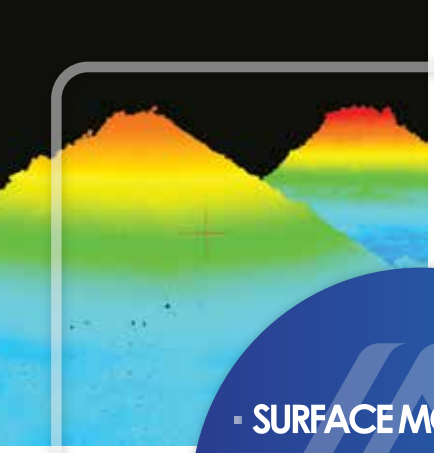

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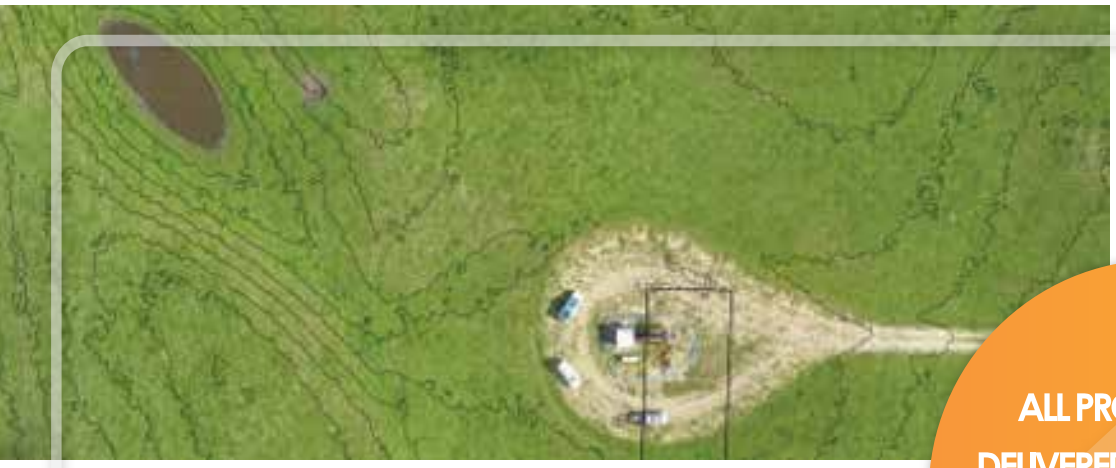

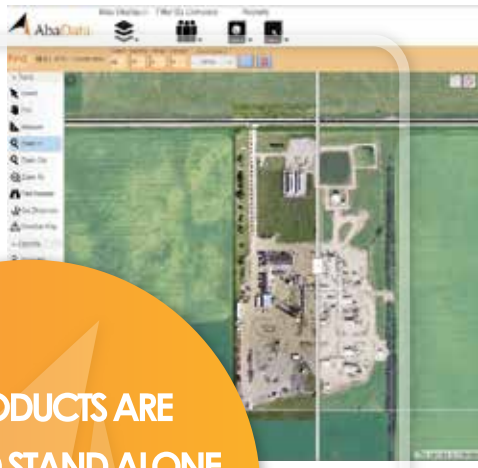


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# national president's message

# Andrea McEachern

It's an exciting time for the CLRA/ACRSD as we continue to grow and adapt, remaining always flexible, motivated and responsive to our members. Our association is confronting a time of many changes and we're meeting these changes during a time of larger nation-wide and global change. The world of reclamation is an exciting area in which to work/study/play, and we'll continue to meet and bring inspired people together in forums like this, to ensure our association remains at the cutting edge.

We're transforming the way we operate to continuously improve our ability to serve you better. Our chapter directors across Canada have continued to meet the challenges of our field and to excel. We should all be very proud of where we are today and excited about where we are headed.

The 2017 Canadian Land Reclamation Association (CLRA|ACRSD) Annual General Meeting, Conference & Tours ("Road to Recovery") will be in beautiful Fort McMurray, Alberta. For those of that are attending, I look forward to meeting/speaking with each of you. Please come and introduce yourself if I haven't come by to introduce myself first. A special thank you to the Alberta chapter for hosting and for all the time & effort put into this amazing event.

During 2017 we had to bid farewell to two people who were instrumental in the success of the CLRA/ACRSD: Andy Etmanski and Chris Powter. Both Andy and Chris have been longtime, very active members. Both served on the national boards and contributed immensely to the reclamation community.

Andy assisted the CLRA|ACRSD during a very delicate time when our longtime treasurer/secretary, Lina Jones passed away. As national treasurer helped keep our affairs in order and set up a solid process to keep our due diligence in place.

Chris – more fondly known as the curmudgeon of the *Canadian Reclamation* magazine's "Curmudgeon's Corner" – wrote inspiring articles that made us think about what we do, how we do it, and why we do what we do in the reclamation community. His thought-provoking words will be dearly missed.

A very heartfelt thank you to you both for all of your time, effort and dedication. We wish you all the best in your new endeavors.

For all of our members, you as reclamation leaders have the vision, the knowledge, and the experience to help us pave our way into the future. You are truly our greatest asset today and tomorrow, and we could not accomplish what we do without your support. Throughout the remainder of the year and moving forward, I ask you to stay engaged, keep us proactive and help us shape the future of the CLRA|ACSRD and reclamation in Canada. My personal respect and thanks goes out to all of you.

Respectfully,

Andrea McEachern

# editor's message

## Lyndon McLean

For this Fall/Winter issue of *Canadian Reclamation*, DEL Communications Inc. is proud to be taking the reins of a publication that showcases the latest news and information in the field.

Appropriately enough, in this issue, we start at the beginning, with a profile of founder and first CLRA president Jack Winch. This also marks the first appearance of Chad Green and "The Green Retort", successor to "The Curmudgeon's Corner." We also have articles on moss and mine tailings, the value of biosolids, genomics, and more.

I admit that I'm pretty green when it comes field of reclamation, though I have learned a few things through editing the ASMR's *Reclamation Matters* and through the articles in this issue and the information passed along from past editor Tracy Patterson. My aim is to continue Tracy's work and to learn more each issue so I can help make *Canadian Reclamation* the best it can be. My thanks to her, as well as to CLRA/ACRSD president Andrea McEachern, and all of the contributors to this edition.

If you have any questions, feedback, or ideas for upcoming issue, please email me at lyndon@delcommunications.com.

Cheers,

Lyndon McLean, Editor

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# The GREEN RETORT with CLRA CORRESPONDENT Chad Green

Last issue (Spring/Summer 2017), our favourite curmudgeon announced he had "run out of grumpy". Thank you, Chris Powter, for the honest, direct insight you shared with us over ten plus years. "Curmudgeon's Corner" was about best technical practices, mentoring, policy, and much more. In essence, Chris pushed us to get involved, to put our hearts into our work, to use our heads, and to have gumption. As a U of A student about 15 years ago, I also remember Chris altruistically sharing his wealth of reclamation experience by guest lecturing Dr. Naeth's land reclamation class. Chris has been giving back to the industry for many years. Thank you Chris. And if there's one thing I know about curmudgeons, they never really go away! Let's hope not anyhow.

When I read Chris' last article calling for someone to take up his cause, I got interested. CLRA VP Fannie DesRosiers had been working on me for a few years to get more involved. I promised I would when the time was right. Finally the opportunity and timing seemed right. I can't remember if it was Clint Eastwood or maybe Jesus who once said, "tomorrow is promised to no one", but I do know this: I'm one day closer to living to 100 and I'm finally fulfilling my promise to Fanny – my two pinnacle goals. If you hang around the CLRA any amount, you'll see calls for volunteers. Please, please give this serious thought. I want to encourage everyone to get involved for the connections you'll make and the difference you can create.

Have you ever acted on a good idea only to follow with internal dialog of "what did I just get myself into and what am I going to do with this?" That's a standard pattern in my stream of consciousness. My intuition prompted me to begin my new mission by thinking about the prime CLRA mandate: promoting and enhancing land reclamation efforts across this country. From a macro context, we are interested in how land reclamation blends into the environmental sustainability continuum. We know our members work in various sectors of this continuum, or spectrum if you prefer, and that reclamation sometimes includes watercourses and water bodies, contaminant risk management and remediation, energy and resource issues, policy approaches, and many other things beyond soil and vegetation. No matter where you practice within this spectrum, stay mindful of and interested in public perceptions and involvement, indigenous community considerations, policy debates and development, regulatory matters, and best technical practices. We all have the knowledge and ability to influence these things. We can take a stand for our pro-

fessional practice, and we can promote our mandate to manage and mitigate disturbances to the earth. For all parts of society expressing concerns about the environment, legitimate, exaggerated, or outright false, we should have something to say about how environmental science is put to work every day. For example, every day I'm monitoring reclamation work involved with pipeline construction. Wouldn't it be fair to say all of our members have some role in promoting reclamation? Much of the public doesn't even know what that entails. Let's promote what we do. If opponents argue that developments can create environmental disasters, let's voice our experience with planning, construction, and operation of mines, or pipelines, or powerlines, and so on. Let's talk about the remediation projects we complete and the brownfield sites we redevelop (hey, that could be a topic for a future article – brownfield redevelopment can be problematic regulatory, financial, and liability perspective, yet they nearly always result in a net environmental benefit over the legacy of poor past practices). We know humans have an ecological footprint that threatens sustainability. We are a field of practice that's actually doing something about it! We all consume, by choice, for wants and needs. Let's advocate for the role reclamation takes in the natural resource extraction lifecycle. Talk about the Earth's natural processes. The Earth is resilient. Yes, fragile too sometimes. We account for these things in our reclamation work.

My retort to those opposed to natural resource developments is that science based reclamation practitioners are stewarding these projects. And the resource demand will remain through a conglomerate of individuals making similar choices until they make alternate choices in satisfying their wants and needs. Yes, that's basic economics when individuals have free will and choice based on the benefits exceeding the costs. Some argue that all of the environmental costs have not been included in the market price of a resource. True, but in this country, we are held to a high standard through tightening regulations achieved with improving technologies and practices. We all know this. Reclaiming environmental disturbances by working with the Earth's natural processes is our business; we need to promote our craft broadly whether the audience is listening or not.

Returning to the mandate, allow me to remind us that the CLRA is for the entire country. I sit in Alberta, where much of our membership is based. This is a result of the relatively high amount of resource extraction and reclamation efforts that are happening here. Our members are in other provinces as well. The reason I'm explicitly recognizing and discussing this is because I'm not from Alberta so I'm extra aware that our diversity brings strength and our members require relevance regardless of where they practice. Reading the case study articles from across the country in *Canadian Reclamation* issues shows me our members in all areas are engaged. This is excellent and highly encouraged, as there are vast cultural, historical, geographical, geological, biological, pedological, regulatory, industrial, economic, climate and other diversities across the country from north to south and east to west.

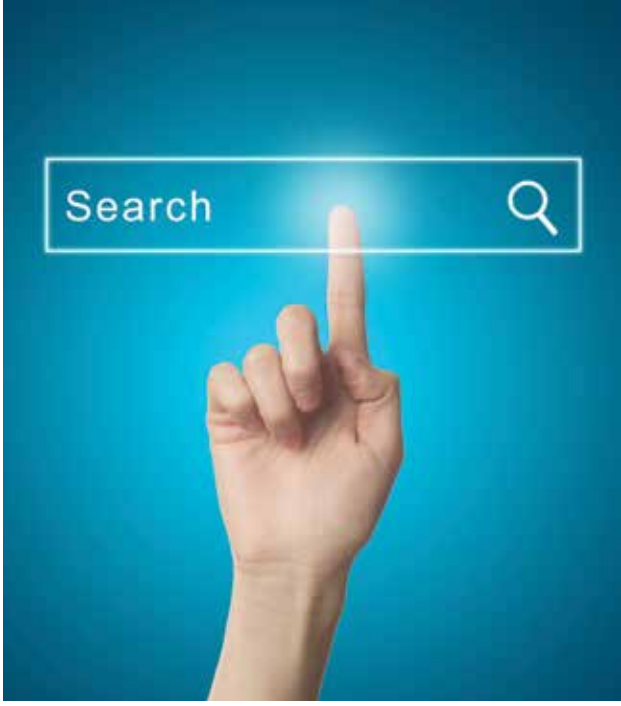
If you've read this far, thank you kindly for indulging me.

***In retort and in science,***

***Chad***

# THE PATH LESS TRAVELLED?

## Searching for work at the CLRA Annual Conference




By Elissa Berrill

Moving to a new city is always a challenge. Moving to a new city without a job lined up adds a second dimension to the task at hand. Moving to a city without a job lined up, an unconventional skill set in the environmental field, and in a somewhat depressed economy, results in a multi-dimensional employability issue which takes some perseverance and creativity to solve.

Having completed my M.Sc in Environmental Management in Sweden, with a background in Environmental Geography (BA) from UBC, I got a great job and moved to Yellowknife to work as an Environmental Regulator in 2014. After two years in a long-distance relationship, having gained fantastic experience in the environmental regulatory field and a strong interest in mine closure, I moved to Halifax to be together with my partner, who is studying medicine here in the Maritimes.

Despite many months of searching and applying to job posting online, I had not been able to land myself a job prior to moving to the east coast. I negotiated to work long distance for my employer in Yellowknife for three months to assist with the transition, and I hit the ground running looking when I arrived in Halifax. Or at least, that was what I tried to do.

Prior to arriving in Halifax I had made several contacts in variety of sectors in the environmental field including consulting, non-profit, and education. I met with these people once I arrived in Halifax. However, despite their friendly reception and assistance, including introducing me to several more contacts in the area, the market in the Maritimes is slower than the Canadian north, and my unconventional skill set was not an easy fit within many organizations. And yet, I felt I had so much to offer – both in energy and ability, as well as willingness to gain new skills. It was frustrating. After five months of meetings, following-up, volunteering, and reaching out to many new contacts, there wasn't even a hint that some work might become available in the near future. I was starting to feel disheartened. Luckily, I had been able to continue working as a consultant to my former employer on a few projects, but there was no stability in this, nor was it full-time.

Then one day, one of the contacts I had reached out to suggested I check out the Annual Atlantic Canadian Land Reclamation Association's Conference, right here in Halifax. It was set to happen in one week, and my initial thought was "Amazing! What a great networking opportunity!" But my second, which followed quickly on its heels was, "conferences are usually relatively cost-prohibitive." Regardless, I checked it out and to my surprise, the registration cost was very reasonable. I registered within 30 minutes of receiving the recommendation.

Next step: business cards. I needed some way for people to remember me after the conference. I ordered standard template business cards online and picked them up the day before the conference.

Arriving at the conference with my business cards in hand, professional attire, and a new haircut, I was nervous. How does one strike up a conversation at a conference? Networking is not something many of us have the opportunity to do if we aren't in sales or business acquisition. I was pretty shy to start. Listening to the presentations, I tried to identify questions I could ask the speakers during the break; questions that were relevant to my abilities and that could lead to a discussion of potential work. I also tried to identify individuals who weren't presenting that worked for organizations I could see myself working for and those who may find value in my skill set.

I realized quickly the first thing that happens when you introduce yourself to someone is they glance at your name tag, which should state the company you represent, but in my case only had my name, and then they ask "who do you work for?" or "who are you here with?" I of course, was there representing…myself. And from the initial confusion that I noted on people's faces, I don't believe this is a very common occurrence. However, after a quick explanation that I was

new to Halifax, interested in closure and reclamation and, looking for work, everyone was very friendly. Some introduced me to others in their organizations, while others explained what they did and we discussed how I may fit in their companies. There were two presentations in particular I felt I really had an ability to converse with the speakers about. Though every conversation was a bit difficult to start, I began to feel more confident as.

The business cards came in exceedingly handy – offering to give one also meant I always received one in return; perfect for being able to follow-up after the conference. However, I also realized that somehow these people had to remember me, and if possible, recommend me as a candidate to their employers, so I tried to spend a bit of time with everyone and let them know I was looking for work, instead of just giving my card to as many people as possible and moving along; which would have been easier!

After two days at the conference and having attended the evening social and field trip, I had 12 new contacts! I had covered as much if not more ground in two days than I had managed on my own in five months! Some contacts were more relevant than others and some more likely to result in work. Regardless, I followed up with every single person and sent them my résumé. Most of them got back to me and offered to pass my info along or file it.

Then three weeks later I got an email. The contact that I thought I had the least chance of getting work with said they wanted my help with a project. Attending the conference had paid off!

After a few weeks of meetings and negotiations, I am now working for Arcadis Canada Inc. in Halifax as an environmental planner, supporting a client with navigating the regulatory system in the Northwest Territories. I'm able to work in Halifax but apply my northern experience to help a client with their work in the Northwest Territories. I'm also being provided opportunities to expand my skill set, get field experience, and be part of the development of the Atlantic Chapter for Arcadis, newly based here in Halifax.

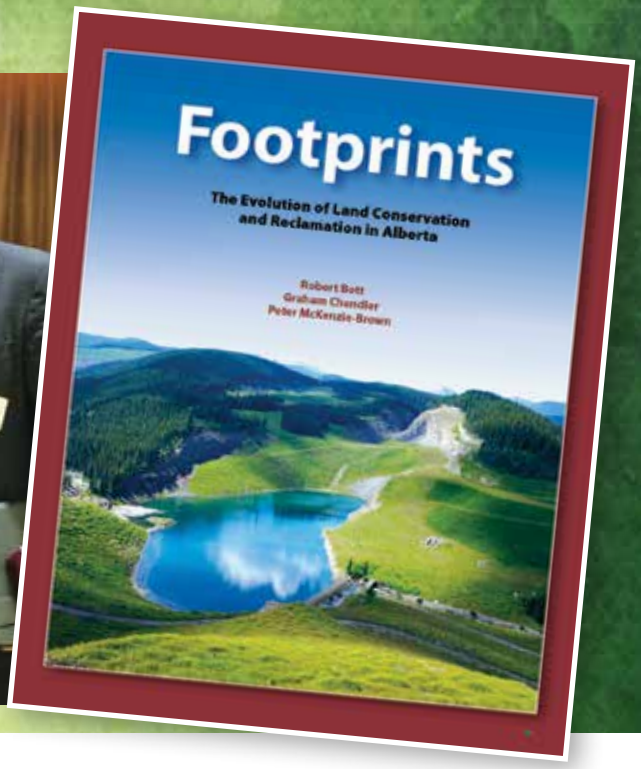
It took time, but I am now employed. And really, it was all thanks to attending the Annual Atlantic CLRA Conference. I hope to attend again next year.

I recommend anyone looking for work in a new city or region, especially students, or young professionals who do not have extensive experience or connections, to attend a conference to gain the face-to-face opportunity to make an impression that is so hard to get through other networking channels.

Thank you for making your conferences affordable and approachable!

# Footprints

## Wins Petroleum History Society Book Award




By Chris Powter

On March 29, 2017, Robert Bott, Graham Chandler and Peter McKenzie-Brown, authors of the 2016 book *Footprints: The Evolution of Land Conservation and Reclamation in Alberta*, received the Petroleum History Society's Book of the Year award. The award is presented annually for a book selected by society directors as a significant contribution to petroleum history.

The book, which was financially supported by the CLRA (both the National Board and the Alberta Chapter), as well as government, industry and many individual reclamation practitioners, first received attention from the society in March 2016 when it was described in the "Books of Note" section of the *Petroleum History Society Archives* (Volume XXVII, Number 3) as a landmark publication. Footprints was initiated by a steering committee of several retired or still-active Alberta land reclamation practitioners whose careers reach as far back as the 1960s and chronicles the story of land conservation and reclamation from the first legislation in 1963 to 2016. With the assistance of the committee members, the authors used historical documents and interviews with practitioners to weave a compelling story of the cooperative development of Alberta's regulatory framework over half a century.

Receiving the award from Society President Clint Tippett (left) was author Bob Bott (second from right) and committee member Bruce Patterson (second from left). Also shown in the photo is Preston Manning, the guest speaker at the awards ceremony. Bruce noted in his remarks that it was fitting that Mr. Manning was in attendance as his dad was the Minister of Mines and Minerals at the time the reclamation legislation came into force and that his Deputy Minister, Hubert Somerville, was the actual architect of the program.

*1977 CLRA/ACRSD Conference and AGM, Edmonton, Alberta. Group flying to Fort McMurray for the Athabasca Tar Sands field trip. First CLRA/ACRSD President, Dr. Jack Winch, second from the left.* PHOTO COURTESY OF SARAH LOWE, DUFFERIN AGGREGATES.

# LOOKING TO THE FUTURE

## Jack Winch and the founding of the CLRA

By Lyndon McLean*

Taking a new direction, finding a better way to get things done, and bringing together the best ideas takes leadership, passion and vision. Those who know Jack Winch know that he exemplifies those qualities, qualities that led him to groundbreaking research and the formation of the Canadian Land Reclamation Association.

Born John Earl Esworthy Winch in Paris, Ontario, Jack attended Paris Public School and Paris High School, after which he enlisted in a militia unit of the Stormont Dundas Highlanders in Peterborough. In 1941, with his brother Aubrey, he enlisted in the Royal Canadian Air Force, and after time in Trenton, Winnipeg, and Lethbridge, Jack was posted to # 2 CAC Detachment at Dartmouth, Nova Scotia, then transferred to #5 CAC Torbay, Newfoundland. Jack was sent to Bournemouth, England in July 1943, where he was involved in a number of missions with various crews – even surviving a crash in December 1943 – until he retired from the RCAF in 1945.

Jack soon got a job in the Field Husbandry Department of the Ontario Agricultural College (OAC) in Guelph. After obtaining his grade thirteen certificate in Kitchener, he entered the OAC, receiving his Bachelor of Science in Agriculture (BSA). He entered graduate school at OAC, working under Dr. J. R. Weir, graduating in 1953 with a Master of Scientific Agriculture. Jack was then awarded a Fellowship in the Department of Plant Science at Cornell University in New York, where he majored in agronomy with minors in genetics/plant breeding and crop physiology. After receiving his PhD in 1958, Jack was offered a position in the Agronomy Department of Cornell University, which he declined. However, he was invited on a number of occasions to attend and give lectures at Cornell.

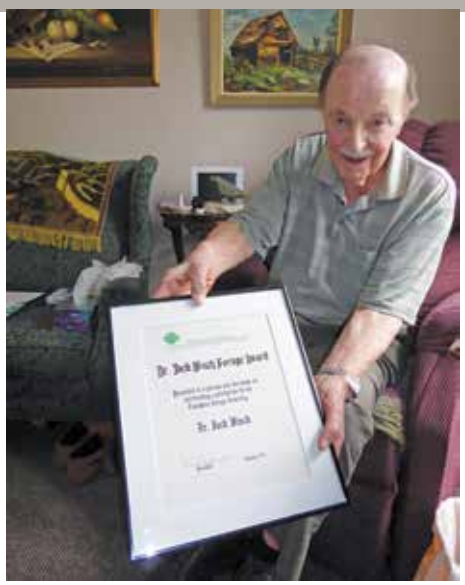
Jack accepted a position as Assistant Professor in the Crop Science Department of the University of Guelph, where he taught crop and forage production, as well as plant physiology, to diploma, undergraduate and graduate students, until his retirement in 1986.

*Jack with fellow founding members Sarah Lowe and Sherry Yundt.*

*Jack with Bryan Tisch.*

*Jack with his daughters.*


*Jack at home.*



Jack's research focused on the evaluation and introduction of bird's-foot trefoil and crown vetch, which became widely used in Ontario. As a result, a sizeable trefoil seed industry developed and large farm acreages were established.

Jack was also involved in the extension of the use of trefoil, which was rapidly accepted by the beef industry, due to the availability of green nutritious forage in the mid-summer months. He travelled throughout Ontario, speaking at meetings and installing demonstration projects, and he became interested in the quality of forage, developing an in vitro method for evaluating forage crops. Jack established a quality laboratory in the Crop Science Department and "three-cuts/per practice" methodology resulted in marked changes in the cutting times for forage and was well received by the dairy industry. Interest in this method increased markedly, and Jack saw an increase in the number of graduate students from Canada and other countries. He travelled extensively in the process of supervising his student's theses and, as a result of these trips, became interested in global agricultural development. He travelled to Finland, South America, Mexico, France, Italy, Great Britain, the United States, and China – often at the request of local and/or federal authorities – for agricultural assessment and assistance.

## CANADIAN LAND RECLAMATION ASSOCIATION

While at the University of Guelph, Jack recognized the need for a professional organization supporting the developing multi-disciplinary field of land reclamation. In 1970, he was instrumental in forming the Ontario Cover Crops Committee (OCCC). The OCCC held an annual informal workshop in Guelph, with Jack serving as President and Dr. E. M. Watkin as Secretary. Members – researchers and practitioners from universities, government, and industry – hailed from Ontario, as well as Alberta and British Columbia, and later the United States and United Kingdom.

# Jack Winch and the founding of the CLRA

After a few years, the OCCC, under Jack's leadership, recognized the need for a broader-based and more formal organization as a means to consolidate and develop the diverse group of professionals and practitioners in the field of Land Reclamation across Canada.

At the December 1974 OCCC meeting, a suggestion was made to form a Canadian association "which would concern itself with the problems and solutions to land reclamation in the broadest sense". The following September, it was announced that half a day during the December meeting would be devoted to "the discussion of the proposal that the Ontario Cover Crop Committee be dissolved and be replaced by a national organization called the Canadian Association for Land Reclamation."

Following a number of meetings, motions and discussions on December 9th and 10th, 1975, the CLRA was formed. The first official business meeting was held December 11th in the Arboretum Centre at the University of Guelph, and Jack was elected to a three-year term as president.

The newly formed association had 60 founding members from six provinces, the U.S., and U.K. Jack led the association through its initial years, developing professional affiliations, establishing the by-laws and objectives, which have largely guided the association since its founding. Jack's impact was felt immediately, and membership grew from those first 60 to 300 during his initial term as president, with a world-wide mailing list 1,200.

The association quickly established a forum for annual conferences, with an emphasis on technical papers and field trips, and a journal for publishing papers in the field of reclamation, which until then had been scattered across many other publications. The first Annual General Meeting (AGM) was at the University of Guelph on November 1976.

Some years later, in 1991, the vision to have a truly international association was realized when the International Affiliation of Land Reclamationists was formed. Canada (through the CLRA/ACRSD) was one of the five participating countries, along with the US, UK, Australia and China.

Jack's vision and passion made possible what the CLRA does today as it continues to provide a valuable forum for professionals, educators and practitioners across Canada and internationally. In addition to the national organization, most provinces are now members of provincial or regional chapters. Members represent the entire scope of land reclamation, from areas associated with reclaiming mined and disturbed land and waterways, to agriculture and forestry, from earth and natural sciences to social sciences. Today, the CLRA has approximately 800 members, with a continued increase in corporate membership.

As well as being a founder and first president of the Canadian Land Reclamation Association, Jack was involved in other associations, including the Canadian Society of Agronomy, the Canadian Agriculture Institute, and the American Forage and Grassland Society. He also received many awards of merit, including the CLRA's Distinguished Land Reclamation Award, the University of Guelph Alumni Association's Distinguished Teaching Award, and the 1993 Distinguished Grasslander Award from the American Forage & Grassland Association.

Jack's impact on the field is probably best summed up by founding members Sarah Lowe and Sherry Yundt:

"Looking at photos of Jack in the field 30 years ago brings back memories of the enthusiasm he brought to the subject, his great charisma and strong leadership in the early days, and his continued interest and participation as the CLRA developed into a large and internationally affiliated association of professionals and practitioners with the broadest scope imaginable."

**With information provided by Tracy Patterson, Sarah Low and Sherry Yundt, and "the History of the CLRA".*

# GROWING SUCCESS WITH RECYCLED RESIDUALS FOR LAND RECLAMATION

## Major projects in eastern provinces demonstrate the value of biosolids and paper mill residuals

By Ned Beecher, MS, Executive Director, Northeast Biosolids & Residuals Association




*Top: Thetford Mines after – aerial - October 2015.*

*1) Gagetown aerial, 2003.*
PHOTO CREDIT: TRANSAQUA/ GREATER MONCTON WASTEWATER

*2) Thetford Mines – Phase 1-2, May 2015.*

*3) Thetford Mines – Close up of SPF and germination, May 2015.*

With demonstrated successes dating back to the 1970s, using municipal biosolids and other residuals has proven to be an environmental win-win, providing rapid ecosystem restoration while putting to use materials once considered "wastes."

Today, the variety of recyclable residuals includes biomass wood ash, water treatment residuals, effluents, food wastes, and construction debris (e.g. gypsum board). This variety allows engineered topsoils tailored to meet the specific chemistry and needs of diverse sites. The challenge comes in matching reclamation needs with the residuals locally available. And, especially when municipal biosolids are involved, projects must consider potential negative public perceptions.

Across Canada, high-profile mine reclamation projects with residuals are ongoing. For example:

- Award-winning work at Sechelt, B.C. – where biosolids are used to support poplar plantations;
- Pronto Mine at Elliott Lake – the first tailing reclamation in Ontario using

*Thetford Mines after – Talus Bench – 2015.*

papermill residuals; saving the mine $2 million and halving the paper mill's cost for residuals disposal; and

- Sudbury, ON – where residuals are critical in ongoing reclamation.

Although fewer in number, there are similar successes in eastern provinces.

## HISTORY AND RESEARCH

Extensive research on the use of biosolids/residuals for land reclamation began in the 1970s. Experiments were conducted at coal mines in Pennsylvania and hard rock mines in the west. Published literature accumulated, documenting understanding of the decreased bioavailability of heavy metals in soils after application of biosolids, the establishment of stable ecosystems, and the reductions in water quality impairment. Several researchers closely monitored the quality of vegetation and the health of mammals and other organisms that took up residence on reclaimed sites, finding no significant negative impacts. This accumulated research led to best management practices that minimize negative impacts while maximizing the many significant benefits.

## REVEGETATING MILITARY TRAINING GROUNDS AT GAGETOWN, NEW BRUNSWICK

In 2003 and subsequent years, the Department of National Defence (DND) and its Cape Gagetown, NB base worked with Greater Moncton Wastewater's biosolids compost program to research the use of compost to "restore soil fertility in a denuded section of the Range and Training Area (RTA), and to restore a self-sustaining vegetative cover to minimize soil erosion and the sediment-laden runoff that leads to water quality degradation." The RTA had been deforested, with debris bulldozed into windrows, to create a training area that would look like a particular combat zone (Bosnia). No restoration efforts had been made. Federal authorities required action. Conrad Allain at Greater Moncton Wastewater, recalls that "base employees were very skeptical of being exposed to 'human waste' – biosolids."

Initial trial plots were worked in the fall of 2003. The existing soils had only one to two per cent organic matter and pH of 5 or lower. Three four- to seven-hectare areas were graded, with the decomposed wood-waste windrows spread evenly over the surface. This was the only treatment in one area. On the other two plots, biosolids compost was applied at an estimated average rate of 188 tonnes/ha. On one, the compost was tilled into the soil; on the other, it was left on the surface.

The 2003 trial included testing a variety of equipment for efficient land work and compost application. In addition, hours for various tasks and costs were tracked. In one day, 0.6 ha were completed by one bush-hog, two excavators, and two dozers preparing the sites, and one loader, one small dozer, and one towed straw mulcher/seeder completing the compost application and seeding. The total project cost was ~$220,000, or an estimated ~$15,300/ha (2003 dollars).

Convincing Gagetown management and other stakeholders of the safety and success of the project depended on monitoring of compost and surface water quality. No significant negative impacts were measured, and the trial was deemed a success.

In the fall of 2005, another 39 ha were treated with different biosolids composts. The application rate was lower: ~70 tonnes/ha. Otherwise, the same procedures were used. Within one month, vegetative cover was robust on 70 per cent of the site area. Water quality and other environmental monitoring found no significant concerns.

Allain notes that the project ameliorated any skepticism about biosolids use and included training of Camp Gagetown operators, so they could continue ongoing reclamation if they so chose. "They went from being very skeptical to working with the compost. I don't know if the project has continued…. The area to be completed is very large. But vegetation has gradually taken over windrows and stripped areas, resulting in less silt runoff. The urgency to complete more reclamation may no longer be there."

## RECLAMATION OF ASBESTOS MINE TAILINGS AT THETFORD MINES, QUEBEC

There is urgency for reclamation at asbestos mines in Quebec. Beginning in 2011, residual management companies collaborated with mine owners, providing residuals, engineering, and expertise to mitigate asbestos tailings at Thetford Mines. The environment ministry-approved demonstration project led to the revegetation of soil- and nutrient-deficient talus slopes and benches of coarse tailings, as well as finer, post-processing tailings (~10 cm or less in size). The project was seen as sustainable development: using residuals to restore a large site in a stigmatized area where years of intensive exploitation occurred during the last century. As with the Gagetown project, it involved developing a topsoil recipe using local residuals; determining the most efficient site preparation and application techniques; and monitoring environmental parameters.

Creating the engineered topsoil recipe began with lab experiments with various tailings mixed with various recipes of mu-

*Gagetown after reclamation, with Conrad Allain.*

nicipal biosolids, paper mill residuals, and wood waste. Focus was on the levels of key agronomic parameters. An effective mix of residuals and tailings needed to address all of the following:

- providing adequate organic matter and release for plant uptake of N;
- providing adequate concentrations of other critical plant nutrients, including P and potassium (K);
- being able to incorporate the chosen mix 20 to 30 cm into the dense (1.75 tonne/lm$^3$) tailings;
- addressing the unique characteristic of serpentine tailings – toxic levels of magnesium; and
- ensuring total trace metal concentrations were acceptable.

Final recipes included paper deinking residuals (for organic matter and bulk), municipal biosolids (for plant nutrients), and, in parts of the site, wood waste (for added organic matter).

Site work began in 2011, and residuals were stockpiled at one location for mixing with a bulldozer. Thorough mixing was critical, because any reclaimed spots with excess papermill residual with high C:N ratio would not support vegetation. The mix was transported to the reclaim areas, spread with dozers, and worked into the tailings. Various seed mixes were applied, some of which included legumes. The resulting germination resulted in plant cover of 90 to 100 per cent on slopes and benches. Some bare spots were reworked and reseeded subsequently, although many became vegetated on their own over time.

Monitoring of the reclaimed sites continued through 2014. The soil organic matter generally ranged from five to 20 per cent and the pH was somewhat alkaline due to the chemistry of the tailings. Available phosphorus levels were found to be high, but that was deemed acceptable because further P additions are not expected. Water quality monitoring demonstrated no significant impacts to nearby streams and minimally elevated N in shallow groundwater, which is expected and unavoidable when first establishing vigourous vegetation; excess levels decrease with time. Monitoring found no indication of any remaining toxicity from metal contaminants; even the unique concern of excess Mg had been addressed by balancing the Ca:Mg ratio.

The project was completed without any registered complaints over the three-year period, in part because of the isolation of the sites and in part because of careful management of those residuals that could potentially cause odours.

## CONCLUSION

Residuals can help address numerous environmental challenges. As healthy soils and carbon accounting initiatives advance, they are being recognized for their role in replacing fertilizers and topsoils and building soil carbon stores. Their use can generate carbon credits; currently, Quebec and Ontario are developing protocols for marketable carbon credits for organic residuals diversion under their new cap-and-trade programs. In California, biosolids are central to healthy soil initiatives. These 21st-century benefits increase the value – beyond the already-demonstrated benefits – of using residuals in land reclamation.

*Gagetown before.*

## ACKNOWLEDGEMENTS

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# The role of moss in the establishment of stabilizing vegetation cover on mine tailings

By Colette Preston, BSc. Environmental Science & Geography; MSc. Candidate, Environmental & Life Sciences, Trent University; and Phaedra Cowden, BSc. Ecological Restoration, MSc. Candidate Environmental & Life Sciences, Trent University


*FIGURE 1: Map of the Unimin Ltd. Nephton tailings ponds including the field research site, Tailings Pond 4. Credit: Unimin Ltd.*

*FIGURE 2: Nepheline syenite blast area at the Unimin Ltd. mine. Credit: C. Preston.*

## INTRODUCTION

Mine tailings often encompass large areas consisting of fine particulate matter and may be significant sources of fugitive dust emissions. One common method of preventing dust emissions from tailings ponds is the establishment of vegetation to protect the surface from wind erosion. This study considered the role of moss in the vegetation cover on the nepheline syenite tailings ponds at the Unimin Limited Nephton Mine in southern Ontario.

Mosses are a hardy and tolerant species which have been known to form colonies in harsh environments such as mine tailings (Hutchinson and Symington, 1997). The initial growth stage of moss, protonema, is a filamentous and highly branched structure which forms on and just below the substrate surface (Goffinet & Shaw, 2008) effectively binding particles together and protecting against wind erosion (McKenna Neuman et al., 2005; McKenna Neuman and Maxwell, 1999). The presence of moss can aid in the catchment of windblown seeds providing a safe site by protecting them from predators and erosion (Delach and Kimmerer, 2002). Moss cover also encourages germination due to the reduction of surface temperatures, the provision of shelter and nutrients, and the retention of moisture (Campeau, 2012; Delach and Kimmerer, 2002; Gornall et al., 2011).

In 2012, the Unimin Ltd. Nephton Mine experienced instances of fugitive dust emissions from their tailings ponds. To prevent continuing off-site dust impingement, they established an irrigation system to suppress surface dust which was also capable of supporting vegetation on the dry tailings areas. One unexpected consequence of irrigating the tailings was the establishment of naturally occurring colonies of *Gemmabryum caespiticium* (Hedw.) J.R. Spence. *G. caespiticium*, an acrocarpous, or carpet forming, moss common to North America, is known to establish on disturbed, slightly alkaline substrates and is sun tolerant (McKnight et al., 2013), conditions which are similar to those at the field site. The field component of this study investigated the influence of moss on the establishment and maintenance of a vegetation cover. The laboratory component assessed the capacity of the moss in capturing windblown seeds and was conducted in the Trent University Environmental Wind Tunnel. In combination, these study components allowed for a more comprehensive evaluation of the role of the moss *G. caespiticium* in tailings ponds stabilization.

## METHODS

***Site Description***

The field research was conducted on Tailings Pond 4 at the Unimin Ltd. Nephton Mine near Havelock Ontario (Fig. 1). The tailings are a product of the milling process of nepheline syenite, a feldspathic, hydrocrystalline, plutonic igneous rock that is composed of alkali feldspar, sodium feldspar, and nepheline (McLemore, 2006; Fig. 2). The tailings ponds are quite variable in terms of moisture content and the dryer areas have extensive irrigation systems to provide dust suppression and aid in the establishment of vegetation (Fig. 3).

***2014 Field Research***

Twenty 1m$^2$ research plots were established in July on Tailings Pond 4, much of which was plowed and seeded with Buckwheat *(Fagopyrum esculentum)* and Ontario Ministry of Transport Roadside Seedmix (MTO mix) that spring (Fig. 4). Buckwheat is an annual crop plant that is intended to be harvested within 12 weeks of being sown (Oplinger, 1989). The MTO mix is a mixture of three perennial grasses: Creeping Red Fescue *(Festuca rubra)*, Perennial Ryegrass *(Lolium perenne)*, Kentucky Bluegrass *(Poa pratensis)*, and White Clover *(Trifolium repens)* (Ontario Ministry of Transport, 1997). The research plots consisted of four different plots types, with five replicates of each:

- Seeded Bare Tailings: Areas that were plowed and seeded with Buckwheat and MTO mix
- Control: Areas in the Seeded Bare Tailings that were cleared of all vegetation
- Seeded Moss: An area of well-established moss cover that was plowed and seeded with Buckwheat and MTO mix
- Undisturbed Moss: Areas between irrigation pipes and on the periphery that had well-established moss cover

The following measurements were conducted weekly from July to September and then bi-weekly until November:

- Point quadrat method: a plant sampling method in which a grid with 81 measurement points was placed over the plot. A plumb was lowered at each measurement point and the height and species of the tallest plant as well as the presence of any other plants was recorded.
- Gravimetric moisture content (GMC): a measurement of soil water content by mass, indicating water availability for plant growth.

***2015 Field Research***

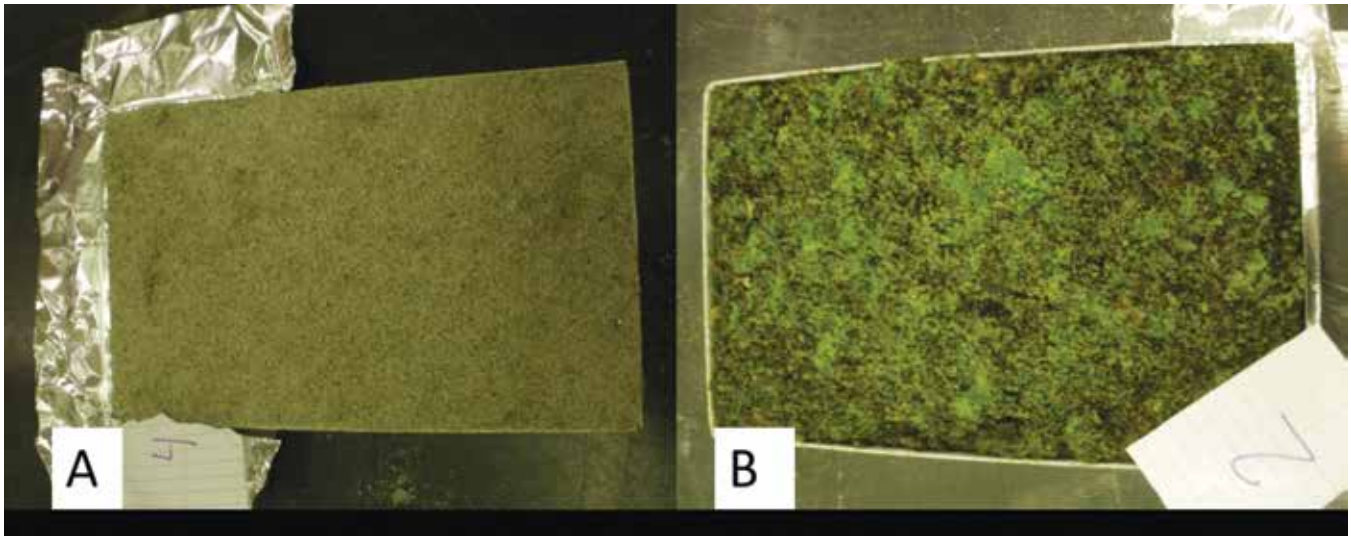
Following recommendations based on results from the 2014 field research, Unimin Ltd. did not plow and seed Tailings Pond 4 again in 2015, which afforded the opportunity to continue monitoring the growth of moss and vascular vegetation on the pond (Fig. 5). Eight 70m long transects were established and the vegetation was measured bi-weekly from June to October. Sixteen 4m$^2$ quadrats were also established at random points along the eight transects and were surveyed once in the summer and once in the fall.

*FIGURE 3: Tailings Pond 4 with irrgation system running, Unimin Ltd. mine. Credit: C. Preston.*

*FIGURE 4: Seeded Bare Tailings research plot showing Buckwheat and MTO mix growth on the Unimin Ltd. Nephton Tailings Pond 4, July 2014. Credit. C. Preston.*

*FIGURE 5: Vegetation established in 2014 and still persisting in 2015 on Tailings Pond 4 with some orange transect flags visible, Unimin Ltd. Nephton Mine May 2015. Credit: C. Preston.*

*FIGURE 6: Trays prepared for wind tunnel experiements: A) bare tailings; B) moss cover. Credit: P. Cowden.*



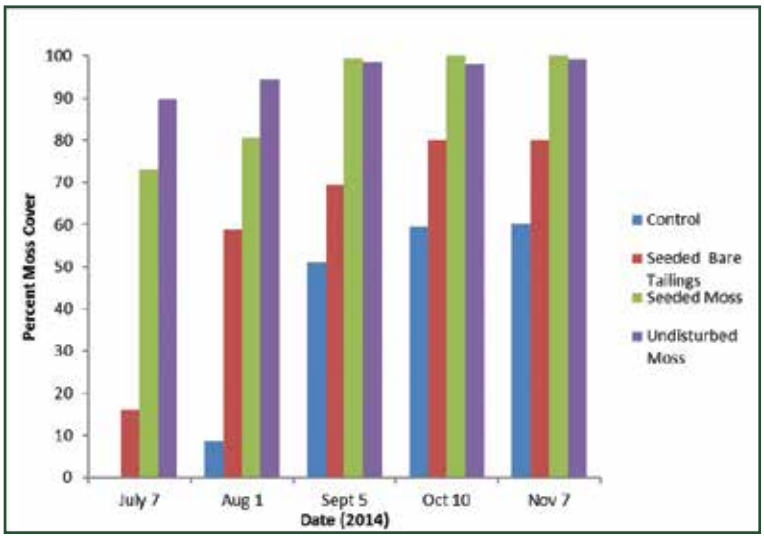




*FIGURE 7: Moss cover on Tailings Pond 4, July to November 2014.*

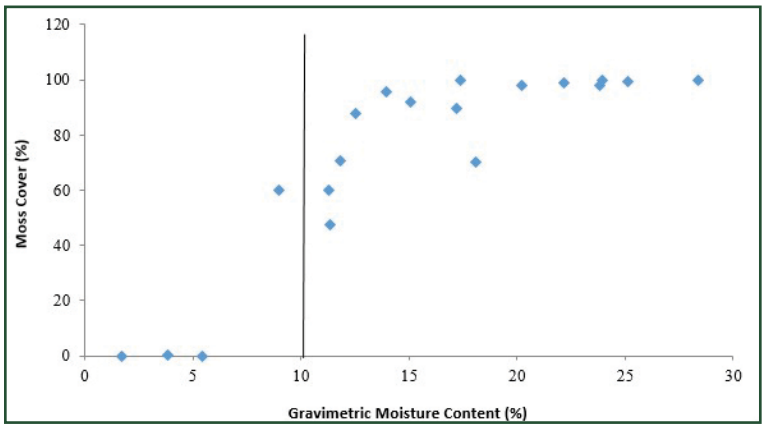



*FIGURE 8: The relationship between moss cover and gravimetric moisture content.*

***Laboratory Research***

Ten aluminum trays measuring 16.4cm by 26.5cm and 2.2cm deep were filled with tailings from the field site. Moss from the field site was used to create a slurry following the methods outlined by Shaw (1986). This slurry was then applied to the surface of five of the trays, placed in the Trent University Greenhouse for six to eight weeks and watered daily until moss was completely established. Five control trays were left bare (Fig. 6).

Seed capture experiments were conducted in the Trent University Environmental Wind Tunnel, a straight-line suction wind tunnel with a 0.71m x 0.76m working section and length of 13.8m. This facility and the instrumentation employed during the testing is described in detail in McKenna Neuman et al. (1996). All experiments were run with a requested freestream velocity of 4.33m $s^{-1}$ and the release of 40g of MTO mix upwind from the tray. A seed count conducted after each tunnel run determined capture capacity and distribution across three zones of the trays: front, middle, and back.

## RESULTS AND DISCUSSION

***2014 Field Research***

Moss Cover: The Undisturbed Moss plots maintained close to 100 per cent moss cover throughout the study. In the Seeded Moss plots, the moss cover, which was 73 per cent in July after being disturbed by the plowing and seeding in June, was able to re-establish to 100 per cent cover by September (Fig. 7). The Seeded Bare Tailings developed 100 per cent moss cover in four of the plots, and no cover in one very dry plot located outside the range of the irrigation sprinklers. In fact, moss was found to be able to establish easily on the bare tailings with sufficient irrigation, and the

three Control plots located within sprinkler range had 100 per cent moss cover by the end of the season whereas the two non-irrigated Control plots had no moss development. This resulted in and average 60 per cent moss cover among the five Control plots by November (Fig. 7).

Gravimetric Moisture Content: GMC measurements varied significantly among the plots. In general, approximately 10 per cent GMC was required for moss to become established on the tailings, with the moss achieving 100 per cent cover at 15 per cent GMC or greater (Fig. 8). Indeed, other than the three plots which were out of sprinkler range, the other 17 plots exhibited 100 per cent moss cover by the end of the season.

Relationship between Moss and Vascular Plant Growth: The Buckwheat grew faster and maintained its height better in the Seeded Moss area than in the Seeded Bare Tailings. Likewise, the MTO mix grew to three times the height in the Seeded Moss area compared to the Seeded Bare Tailings (Fig. 9). There was also a positive relationship between moss cover and vascular plant cover which suggests improved growing conditions for vascular plants in areas with well-established moss (Fig. 10).

***2015 Field Research***

The 2015 field measurements indicated that the moss established in 2014 was able to persist throughout the winter and into the 2015 field season (Figs. 5 & 11). In the Undisturbed Areas, in the presence of 100 per cent moss cover, vascular plant cover was seen to increase from 15 per cent in 2014 to 27 per cent in 2015. On the other hand, the Seeded Bare Tailings areas demonstrated a much lower level of colonization by vascular plant species with only a modest increase from four per cent in 2014 to 10 per cent in 2015 (Fig. 11). This suggests that seeding the tailings with MTO grasses may not be the best option if the goal is to encourage the natural encroachment of vascular plant species, even though the MTO mix does provide excellent short term dust control. One possible approach to rehabilitating the tailings ponds would be to allow a natural progression of encroachment and succession on the tailings.

***Laboratory Research***

Seed Capture: The seed count illustrated that the moss trays had a higher seed capture capacity than the bare tailings trays (Fig. 12). It is assumed that the morphology of moss is responsible for the higher degree of catchment and retainment of seeds. The moss *G. caespiticium* is characterized by overlapping and clustered branches

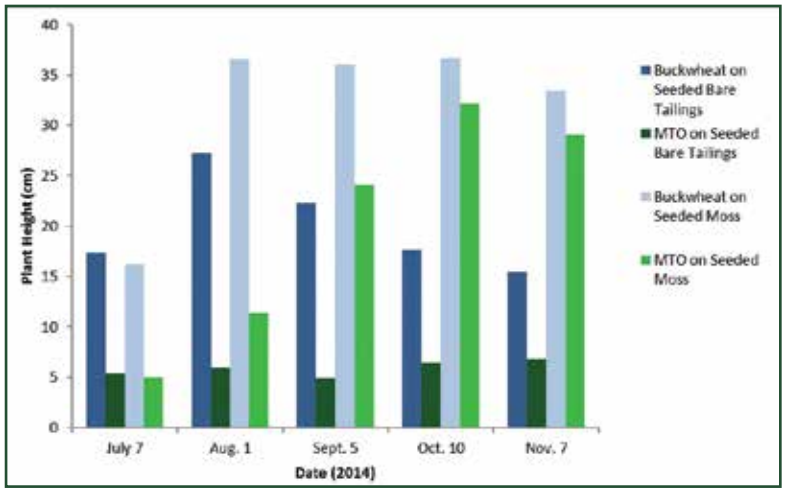



*FIGURE 9: Buckwheat and MTO mix height on Seeded Bare Tailings and Seeded Moss.*

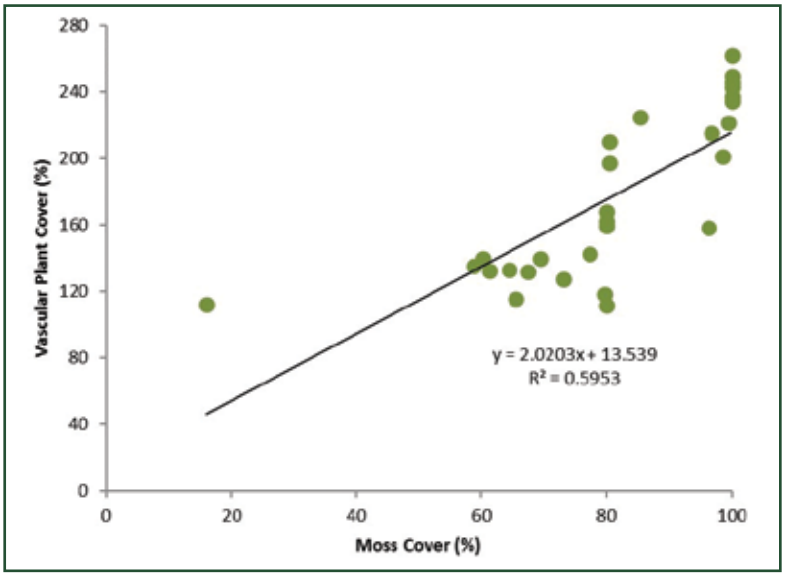



*FIGURE 10: Linear relationship between moss cover and vascular plant cover in the Seeded Bare Tailings and Seeded Moss.*

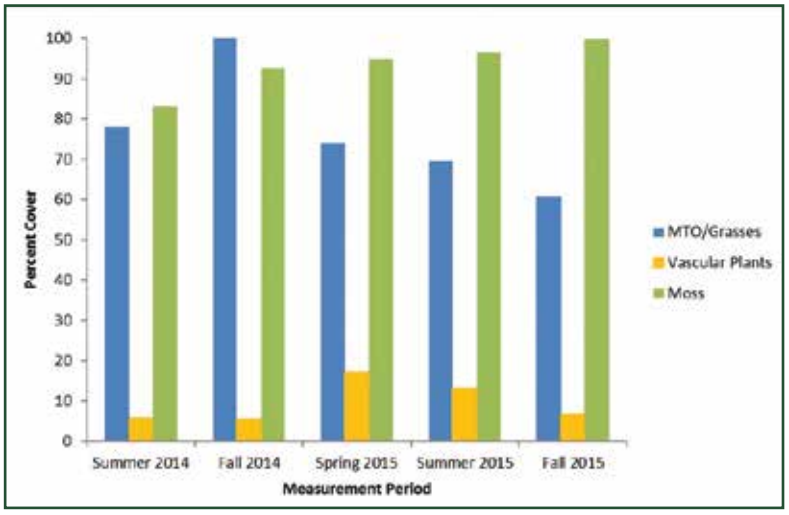
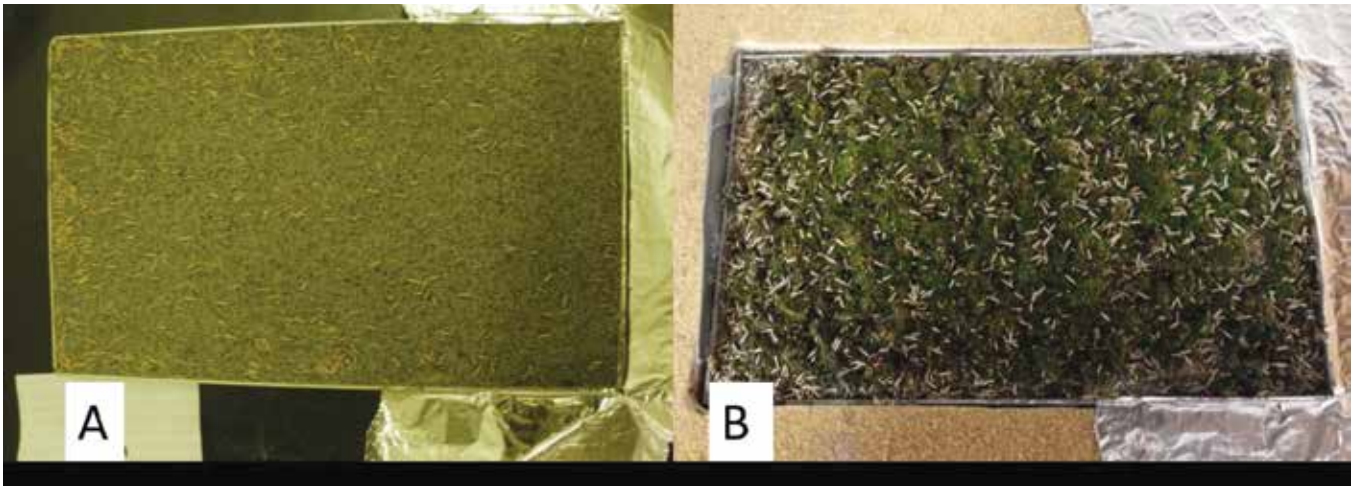



*FIGURE 11: Average vegetation cover in all areas of Tailings Pond 4.*

*FIGURE 12: Trays after wind tunnel experiments: A) bare tailings; B) moss cover. Notice seed collection and distribution differences between tray type.*



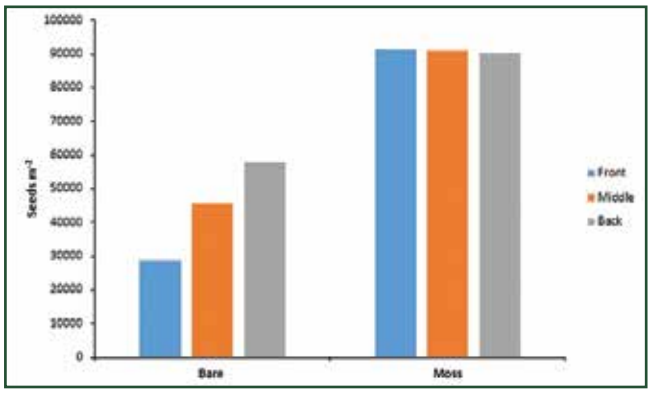




*FIGURE 13: The average density of seeds across the three zones (front, middle and back) of the differing surface treatments in seeds $m^{-2}$.*

and exhibits a cushiony and branchy growth pattern (McKnight et al., 2013; Raven et al., 1999). This surface, upon capture of a seed, would be more successful at retaining the captured seed than the bare tailings, which is devoid of any pronounced surface texture to faciliate seed capture. A study carried out in 1963 by the U.S. Forest Service evaluated the ability of various soil surfaces at seed capture and retention. They determined that seeds moved with ease along dry, flat surfaces by either bouncing, sliding, or rolling; and that surfaces with small depressions or pocks captured and retained more seeds (Haupt et al., 1963). They also determined that the moisture content of the surface influenced seed capture and retainment, as moist surfaces were softer, thereby reducing the chance of seed ejection upon impact. Based on this, it is possible that the bare tailings were intitially capturing a higher number of seeds but were unable to retain them throughout the remainder of the experiment.

Distribution Density: When examining the seed density per zone and treatment, the moss surface treatment exhibited the most even distribution of seeds: front: 91,425 seeds $m^{-2}$, middle: 90,805 seeds $m^{-2}$, back: 90,391 seeds $m^{-2}$. In contrast, the bare tailings exhibited a higher density of seeds in the back zone than the front: front: 28,759 seeds $m^{-2}$, middle: 45,770 seeds $m^{-2}$, back: 57,828 seeds $m^{-2}$ (Fig. 13). As already mentioned, the surface of moss is typically branchy and exhibits a bumpy topography throughout the whole of the tray, allowing for a more even catchment throughout the surface. On the other hand, the flat topography and minimal surface texture of the bare tailings discourages catchment of seeds, while encouraging the movement of seeds towards the back of the tray.

## CONCLUSIONS

- Some species of moss such as *G. caespiticium* are able to establish 100 per cent surface cover in inhospitable environments if sufficient moisture is available. Providing sufficient GMC levels may encourage natural colonization of mosses which can then act as a form of protective vegetation cover on mine tailings.
- The presence of *G. caespiticium* on the Unimin Ltd. nepheline syenite tailings ponds resulted in improved Buckwheat and MTO mix growth and also encouraged a greater rate of encroachment and establishment of native vascular species.
- Once moss is established it has the capacity to capture twice the amount of seeds as bare tailings. This in conjunction with hospitable growing conditions provided by the moss, could speed natural succession.
- The immediate stabilization of tailings with a cover crop can facilitate a more extensive cover of moss in areas where moss is already present.
- The ease and extent of colonization of the moss *G. caespiticium* on the Unimin Ltd. nepheline syenite tailings ponds allowed for a more natural form of stabilization to occur. While this situation may not exist on all tailings ponds, observing natural conditions and working with them can lead to a higher success rate in stabilization and rehabilitation efforts.

## ACKNOWLEDGEMENTS

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*Phaedra is a budding bryologist interested in the use of mosses as a tool. During her undergraduate degree, she studied the use of mosses as a tool to speed the re-vegetation of mine tailings. Now her focus is on the use of mosses as biomonitoring tools of atmospheric pollutants in areas of increased industrial activities in Canada.*

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# Aerial survey innovations with hydrological interpretations, using UAVs

*Figure 1. UAV (DJI Phantom 4) captured 3D image (no glare; color enhanced), leading to a recently forest-cleared strawberry field. UAV flight height was 60 metres above ground level (agl) in reference to a fixed take-off point. Image overlap was > 60 per cent along planned flight path. Flight time was 60 minutes on July 28, 2017, starting at 12:30 p.m. Weather was partly cloudy. Resulting image resolution: 0.02 m. 3D image and DEM producing software: Agisoft Photoscan Professional Version 1.3.2 (64 bit; Agisoft 2017). Latitude 45.369°; Longitude - 66.257°.*

By Mark Castonguay, Jae Ogilvie, Paul A. Arp, Faculty of Forestry and Environmental Management, University of New Brunswick (UNB), Fredericton, NB

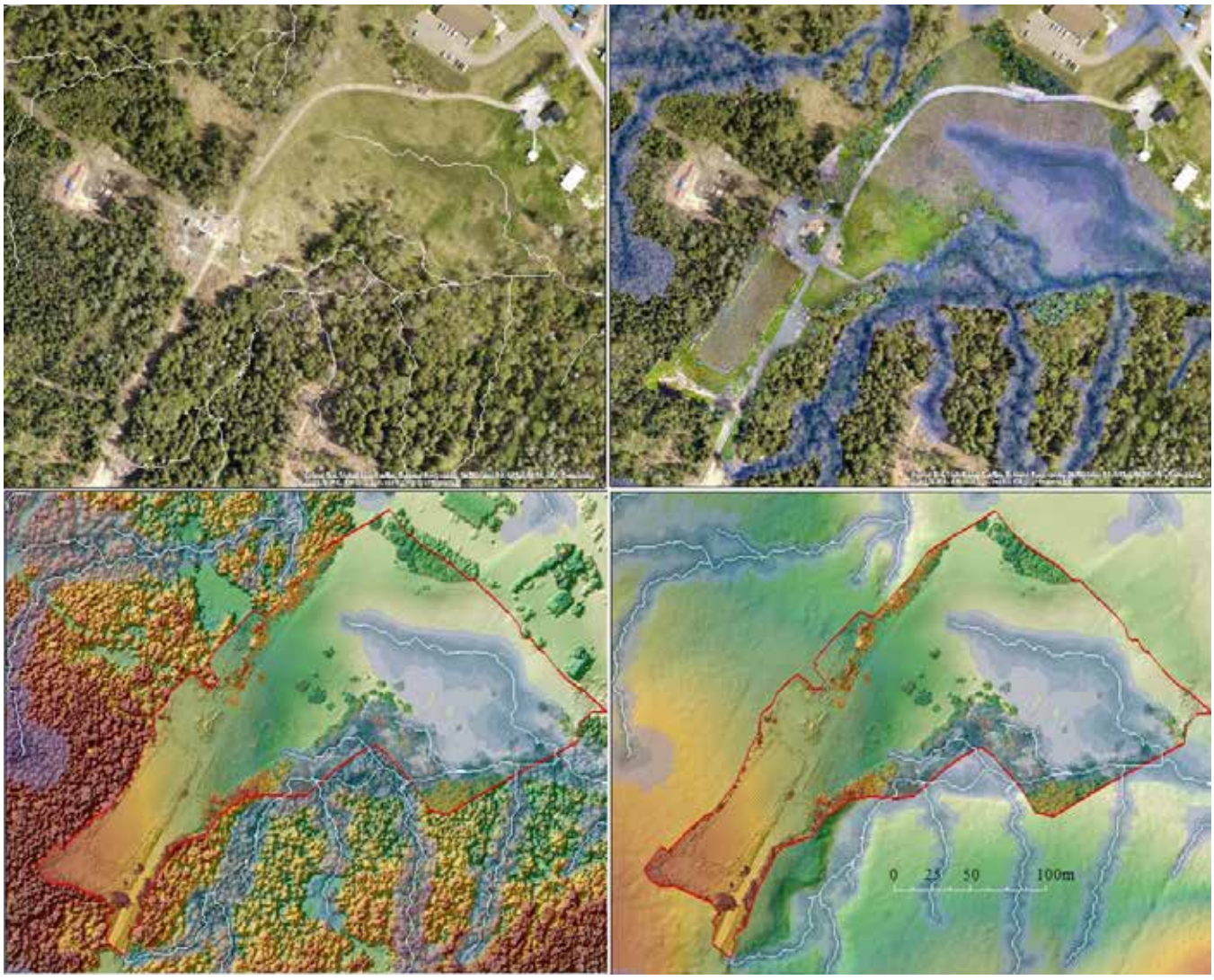
Camera-equipped unmanned aerial vehicles (UAVs) are becoming more available and affordable. At the same time, UAV captured and generated 3D surface images are improving in qualitative and quantitative detail. For example, UAVs can now be used to produce full-feature and bare-earth digital elevation models, which – among other things – also inform about tree height, crown structure and biomass. This article reports about UAV-based 3D survey and interpretation activities at the Forest Watershed Research Centre at UNB, by focusing on a strawberry field in Grand-Bay Westfield, New Brunswick (Figure 1).

Figure 2 presents the same view in two 2D image and DEM presentations, with the strawberry field UAV ortho-mosaicked image located and embedded near the bottom left in the most recent Google Earth image (top row) and GeoNB's full-feature and bare-earth LiDAR digital elevation models (DEMs, bottom row left and right, respectively). Overlaid on three of these images is the blue-shaded DEM-derived flow channels and depth-to-water DTW index (Murphy et al 2011). This index serves to estimate the end-of-summer soil moisture and soil drainage conditions across the scene (dark blue: DTW < 10 centimetres, poorly drained; light blue: 25 < DTW < 50 centimetres, imperfectly drained). Comparing images in the top row reveals that the grassy area is indeed darker where DTW index < 50 centimetres. In addition, the bottom row images illustrate the differences between the full-feature and the bare-earth DEMs, with the bare-earth elevations varying between 30 to 60 metres (right), and the full-feature elevations including height of trees, buildings and other structures, up to 80 metres.

The close-up in Figure 3 focuses on the strawberry field portion of the UAV-captured DEM, with two hydrological interpretations on the right. Top-right shows how water will run along the rills of the mounded strawberry rows in early spring when the field is essentially starting to thaw (i.e., the case when soil permeability is low to absent). After this time, water will start to flow below and across the lines along the southeast elevation gradients (bottom right). Details of the elevation changes across the field are represented by the elevation profiles along the red and purple scan lines (bottom left), with bare-earth elevation dropping from 74 to 66 metres along the field, and from 70 to 67 metres across the field.

While GeoNB's LiDAR-DEMs at one-metre resolution are useful to generate comprehensive area–wide delineations of ephemeral and permanent flow networks, depressions and wet-areas, UAV-generated DEMs at, say, two centimetres resolution can be used to de-

*Figure 2. Top row: Google earth image (left and right), with LiDAR- captured DEM (elevation color green at 10 metres, and dark brown at 80 metres) and wet-to-moist depth-to-water index (DTW) overlaid, all at one metre resolution. The DTW variations are shaded dark to light blue to reflect summer condition, and were generated from GeoNB's bare-earth LiDAR DEM (Government of New Brunswick 2017; one-metre resolution). Bottom row: same DTW index on full-feature and bare-earth GeoNB DEMs, with UAV-generated full-feature DEM at 0.02m resolution overlaid within red outline.*




termine where water puddles and flows in detail. In this way, actual flow channel patterns can be revealed as these would recur during wet to stormy weather events and seasons. In turn, knowing this detail would enable projecting likely areas subject to conditions such as frost heaving, rutting, compaction, and soil displacement due to erosion and down-slope mudflow.

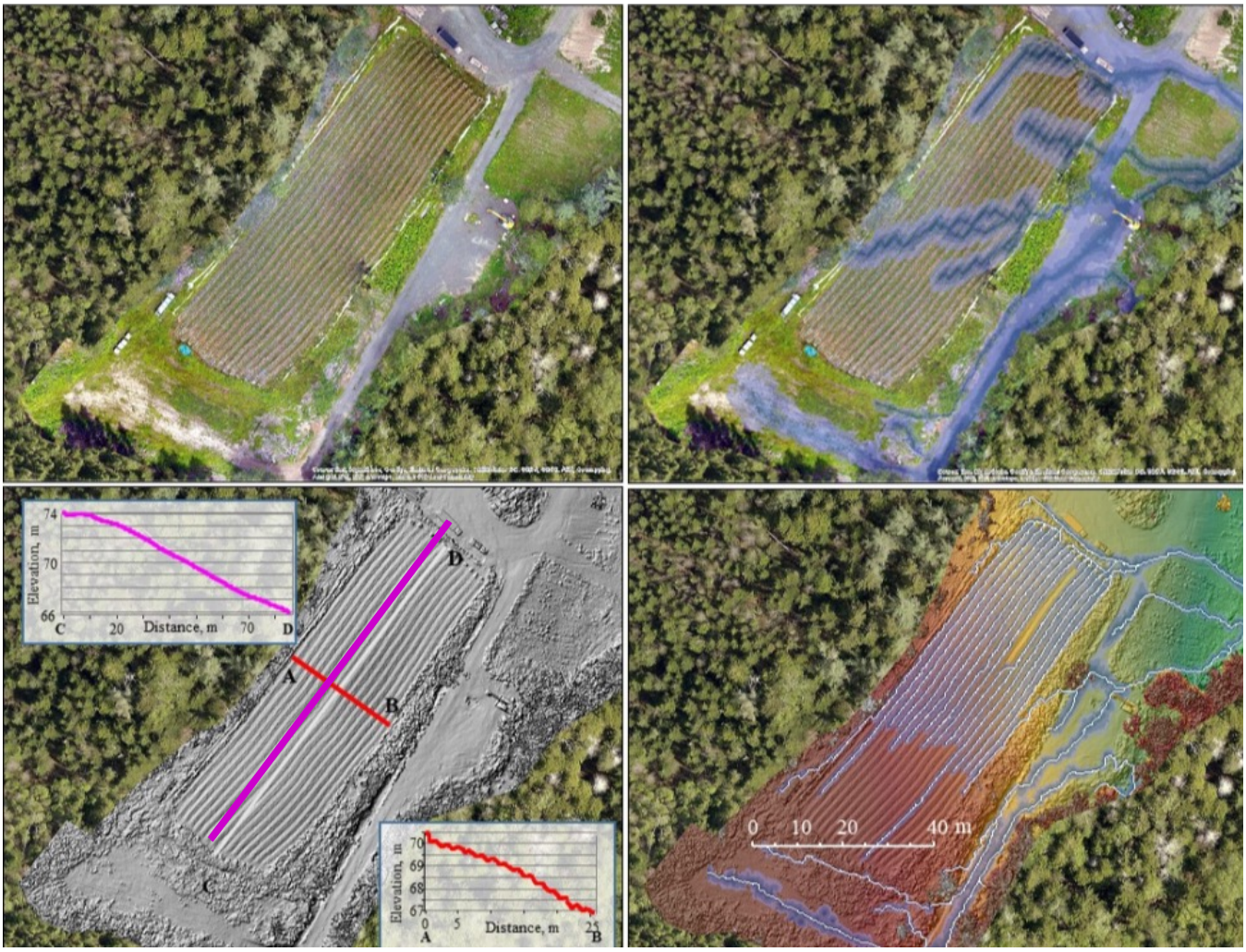
Generating results similar to what is portrayed in Figures 1 through 3 require the following:

- Acquiring or accessing UAV survey capacity and piloting permissions (i.e., Special Flight Operations Certificates: SFOCs) based on developing UAV air-traffic regulations.
- Developing UAV scanning flight plan to ensure full stereo coverage for the project.
- Using UAV-supplied software to develop 3D images, ortho-mosaics, and DEMs.
- Transforming the UAV image in combination with other data layers (traditional surface images, LiDAR DEM or other DEMs) into hydrologically based interpretations.

Experiences gained in doing this has shown that:

- the UAV-generated DEMs can be elevation calibrated using LiDAR DEMs or other DEMs as and where available;
- latest UAV flight control software reduces the work needed to produce slant-free UAV DEMs;
- running available 3D imaging and DEM software (UAV supplied) at high resolution takes time and requires increasingly powerful desktop computing facilities and with adequate memory capacities;
- hydrological interpretations are not yet part of UAV supplied software but can be facilitated through GIS-based processing (e.g., dealing with determining flow direction, flow accumulation, and cartographic depth-to-water mapping, as practiced at the Forest Watershed Research Centre at the University of New Brunswick, Fredericton, NB.)

*Figure 3. Top row: Google Earth image (left and right), with UAV-captured DEM and the wet-to-moist depth-to-water index on the right (DTW, shaded dark to light blue; generated by resampling the UAV DEM from 0.02-metre to one-metre resolution) to reflect rain flow paths along and across field during summer. Bottom row: hill-shaded UAV DEM in grey-tone (left) and with color-graded (right) elevation overlay (10 metres green, 80 metres brown). Also overlaid on the right is the flow pattern generated from the UAV-DEM, at 0.02-metre resolution. This rill-based pattern would exist when the snow melts, and the soil transits from a frozen to an unfrozen state.*




Potential hydrologically based reclamation applications (Arp 2016) would refer to:

- determining and designing project-based flow patterns to avoid flooding, erosion while enhancing water retention elsewhere;
- planning new or re-routing existing roads and trails away from flow channels and wet areas (Campbell et al. 2013);
- routing off-road traffic to avoid soil compaction, erosion, washouts, etc.
- placing infrastructure and foundations on dry ground, year-round;
- mapping soil moisture regimes to optimize selection and placement of planting stock;
- tracing the distribution of soil moisture regimes and moisture obligatory habitats (Hiltz et al. 2012; White et al. 2012; Goguen & Arp, 2017), whether natural or designed.

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## ACRONYMS

*agl – above ground level*

*DEM – Digital Elevation Model, referring to bare-earth or full feature elevations*

*DTW – Depth-To-Water, indexing least elevation rise away from open water sources such as stream channels, lakes, shores, etc.*

*LiDAR – Light Detection and Ranging by way of laser pulse emission and reflection scanning*

*SFOC – Special Flight Operations Certificates*

*UAV – Unmapped Areal Vehicle*

*UNB – University of New Brunswick*

*2D – Two-dimensional*

*3D – Three-dimensional*

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*This relates to the Dennis Wilson/NewGold project : A malaise trap on a reclaimed wetland site at the New Afton gold and copper mine, 10 km west of Kamloops, BC. The trap collected flying insects in 2013 for New Gold's barcoding project.* PHOTO COURTESY OF NEW GOLD INC.

# GENOMICS: an increasingly important part of the environmental toolkit

**Submitted by Genome Atlantic**

Genomics, the unique combination of genetics, biology and computer science, is proving to be a valuable tool for environmental monitoring and remediation.

Three recent examples of genomics applications – to monitor species recovery at a mining site, and to aid in the cleanup of contamination at an abandoned mineral exploration site and in one of Canada's largest ex-military bases – show that genomics can be successfully applied to a range of reclamation challenges.

## ENVIRONMENTAL MONITORING USING DNA BARCODING

In the first example, New Gold is piloting the use of DNA bwwarcoding, a quick, affordable and revolutionary Canadian concept, to identify insect species at its New Afton gold and copper mine near Kamloops, British Columbia. The species information is being gathered to establish performance metrics for the mine's end-of-life phase. The mine, with an estimated 12-year life span, went into production in 2012 and features a pre-existing open pit, underground workings, and a tailing facility.

So new is the barcoding concept that New Afton is believed to be the first and only mine site, worldwide, to adopt it in this way. The growing baseline data is being used to guide biodiversity management, measure the success of current site remediation efforts, compare disturbed and undisturbed sites, and identify significant ecosystems in terms of species richness.

"It's certainly going to be a very important tool going forward," pre-

*This relates to the Dennis Wilson/NewGold project: A malaise trap catching flying insects on a reclaimed grassland site at the New Afton gold and copper mine, 10 km west of Kamloops, B.C. This was part of the 2013 round of insect trapping for New Gold's barcoding project. Photo courtesy of New Gold Inc.*

*This relates to Helen Zhang's and Altius' ROLES project: Installation of DP-BATRAP and site characterization in North Labrador…Team member Zhiwen Zhu.*

dicts Dennis Wilson, director of health, safety, environment and social responsibility for New Gold, headquartered in Toronto. Wilson believes the data could lead to new regulator-accepted key performance indicators for reclamation.

By the time the mine is ready for closure, he says, "I'm pretty sure we'll be able to put a compelling story together. One that provides decision-makers with the information they need to gauge the success of the reclamation." He envisions the DNA-based data set as a new way to bolster credibility for closure and reclamation plans.

As an industry, Wilson says, "we are very, very good at making vegetation re-grow, but I've always wondered about how it's actually used by animal species. How do you know there are any animals that are actually going to return to graze the area, or that it's going to be a fully functioning ecosystem?"

Four or five years ago, Wilson attended a Mining Association of Canada's Implementation Leaders' Meeting in Toronto where a representative from the Barcode of Life Program at the University of Guelph addressed the gathering on activities that piqued Wilson's interest.

The Barcode of Life is a searchable database, the brainchild of the University of Guelph's Dr. Paul Hebert, which is now an international phenomenon. The database inventories minute strings of mitochondrial DNA unique to each species that serve as identifiers. The barcoding technique facilitates large-scale sampling and identifications from a mixture of species. The process is faster, cheaper and more accurate than taxonomy, which relies on visual identification.

After internal company discussions, Wilson conferred with Dr. Lauchlan Fraser, a renowned community and ecosystem ecologist and ecosystem reclamation expert at Thompson Rivers University, and with Scott Davidson, New Afton's manager of environment, social responsibility and tailings. "We came up with this program that could look at the number and type of species we had in our reclaimed area versus a non- disturbed area to see if there is a difference. And if there is a difference, to understand why that would be," Wilson said.

In the initial phase, malaise traps were set up to catch and kill flying

*This relates to the Nordley's project: Helicopter trip to the study site in North Labrador. Pilot from Canadian Helicopters.*

insects on four sites, covering two types of grasslands and wetlands – disturbed and undisturbed. The dead insects were collected in the summer of 2013 and barcode analysis was completed in Guelph in August 2014.

A total of 3,956 distinct species were identified in the 51,246 individuals processed. Findings showed more species in the wetlands than in the grasslands; successful remediation in the disturbed wetland site, based on the rich number of species found there; and a need to boost remediation in the disturbed grassland site, where fewer species were recorded than in the undisturbed control site. The intention is to continue monitoring every three or four years, tweaking the project parameters as needed.

For the next round, the plan is to additionally trap ground dwelling insects, and perhaps soil microbes in the future. The barcoding territory will also expand to provide control data from a nearby portion of the Lac du Bois Grasslands Protected Area, owned by the Nature Conservancy of Canada.

"To get this kind of data for anywhere near $20,000-$25,000 every three or four of years is quite cheap," Wilson says. Conventional data collection to provide similar data would be much more expensive and much less accurate.

At the end of the exercise, Wilson is confident, "we're going to be able to articulate to a regulator that we've got proof that our ecosystem is a functioning ecosystem."

## USING GENOMICS TO CLEAN UP CONTAMINATED SITES

Meanwhile, at Memorial University in Newfoundland, Dr. Helen Zhang, an environmental engineer, and her multi-disciplinary lab team have partnered with Altius Minerals and Nordlys Environmental LP to crack tough remediation problems in Labrador.

The matchups were facilitated by Genome Atlantic because Zhang's lab specializes, among other things, in genomics-enabled remediation. In particular, Zhang integrates genomics with traditional soil remediation solutions and uses various techniques to put naturally occurring organisms to work in pollution cleanups. These microbes, identified using genomics, remove or neutralize pollutants in environmentally friendly ways.

Zhang and her team at Memorial are working with Altius on the Restoration of Labrador Exploration Sites (ROLES) – a project involving a massive clean-up of oil drums and other wastes from multiple abandoned mineral exploration sites. Zhang's lab used DNA sequencing to identify naturally-occurring species of contaminant-degrading bacteria in soil taken from a small sub-surface site polluted by petroleum hydrocarbons near Nain in northern Labrador.

Surprisingly, these microbial strains were found to have adapted to the near polar climate to allow for natural attenuation. Over time, this naturally occurring process reduces the mass and toxicity of contaminants in soil or groundwater. It was the first microbial screening for cold-adaptable oil-degrading microorganisms ever done in Labrador.

Wells are the conventional method of detecting and monitoring microbial sub-surface activity; however, they are prohibitively expensive to drill so far north, due to accessibility and climate restrictions. Zhang came up with a workaround that featured baited cylindrical probes hammered into the soil to attract the specialized microbes that signal the presence of natural attenuation. It was the first time this method of detection had been used in such high northern latitudes. The scientific name for it is BACTRAP or bacterial artificial chromosome translating ribosome affinity purification.

Another of Zhang's collaborators is Nordlys Environmental, one of the contractors working on the $258 million 5 Wing Goose Bay Remediation Project. Zhang says, "We tried to integrate materials called biosurfactants into the remediation process to increase the treatment efficiency because the project had to be completed in a short period."

A Canadian Forces Base in Newfoundland and Labrador, 5 Wing Goose Bay is an important refueling station for Canadian military planes. Over the years, the site has become contaminated with petroleum hydrocarbons that have caused serious contamination of the area's groundwater.

Zhang's project involved a lab study, tied to a large petroleum hydrocarbon contaminated site, considered among the five most heavily polluted areas slated for in situ cleanup.

Using their lab model, Zhang's team found biosurfactants could significantly improve the removal of petroleum hydrocarbons from the soil at the Goose Bay site through soil washing. Biosurfacants are biologically generated surface-active molecules with both oil- and water-soluble properties. These substances, produced extracellularly or as part of the cell membrane by certain bacteria, yeast and fungi, can act as detergents, wetting agents, emulsifiers and dispersants. Unlike chemical surfactants, biosurfactants are less toxic and easily biodegradable – "a kind of green product," says Zhang.

Using DNA sequencing to identify microbes from environmental samples taken along the coast, Zhang's lab developed biosurfactants that could speed up the solubility of oil in the groundwater. This resulted in faster oil deliveries to the oil-degrading microorganisms.

The speed up factor is important in places like Goose Bay where cold area weather and relatively little sunlight compared to the Canadian average slow down microorganism-mediated degradation of contaminants. As a result, traditional remediation techniques will not work as well as in many other places.

The next step for the Goose Bay project, says Zhang, is to "scale it up". That means pilot- and field-testing her lab model findings. If approvals go smoothly, her team could be back on the Goose Bay site, demonstrating a green and economically-viable solution for problematic remediation sites in Newfoundland and Labrador.

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# Regreening with biochar, biofertilizers, liming sludges, and ashes of degraded lands

By Evgeniya Smirnova, GECA Environnement[1]; Suzanne Edith Allaire, GECA Environnement;
Martin Beaudoin Nadeau, Viridis Terra Innovations and SymbioTech Research[2]

## SUMMARY

The importance of adding value to residual wastes has received serious attention over the last years. Waste use in planting substrates represent economic and environmental interests for regreening degraded lands. This paper discusses planting substrates composed of various materials: ash, liming sludge, and biochar, Best results were obtained with a mixture of several materials amplified by biofertilizers.

## INTRODUCTION

Degraded lands usually offer harsh conditions for plant growth such as strong acidity or high pH, contamination, water deficit or bad drainage, and erosion. Thereby, planting substrates should be adapted to environmental conditions of each site and respond to vegetation requirements. In addition, inoculating plants with specific symbiotic microorganisms is known to considerably improve plant survival and growth on degraded lands. To ensure regreening success, we should consider the following: (1) materials composing the planting substrate, (2) selection of resistant plant species, and (3) the right fertilizer-microorganism complement.

A wide range of wastes could be used in regreening operations. Should we choose one or several materials? Should it be transformed or not? Growing substrates composed of industrial wastes found in the proximity of degraded lands may often provide economically effective solutions (Hebert, 2015). However, problems with this approach concern the fact that one residue alone cannot cover all plant requirements and correct all problematic growth conditions (pH, water retention, etc.). A combination of several residues completing each other provides better results.

Cogeneration plants produce tones of ashes. They can be used for soil pH correction because of their high pH (from 8.9 to 13.5) associated to their concentrations in $CaCO_3$, increasing soil water retention, and adding plant nutrients (Adriano et Weber, 1999). However, the ashes do not sustain microorganisms and cannot improve soil drainage and erosion.

Millions of cubic metres of sludge are produced annually in Canada by the mining and pulp and paper industries. The sludges are characterised by alkaline reaction (pH11-13), high concentrations of precipitated metals, and significant amounts of gypsum and unreacted lime (Zinck and Aubé 2000). Furthermore, sludges have silty texture, which promotes water retention; thus, sludges become very hard during drought and impermeable during wet conditions. Regardless, Smirnova et al. (2013) reported that sludge ponds on mining sites support stable vegetation cover. However, physico-chemical properties (particularly pH) of sludges are inappropriate to use alone in planting substrate.

Numerous studies confirmed high efficiency of planting substrates with biochar (Fellet et al., 2011), a solid material obtained from pyrolytic transformation of matter that contains carbon. Physico-chemical properties of biochars vary with feedstocks and technologies. Hence, their impact on plants also varies (Allaire et al. 2015). Biochar is often used to promote better soil structure, water retention and drainage, lower density, fix toxic compounds such as heavy metals, bring nutrients to plants and support microorganisms that promote plant growth. However, biochars cannot support plant growth alone.

Mining materials – waste rocks, tailings, and overburden – have very low levels of beneficial microbial activity compared to well-developed soils (Bois et al. 2005). However, in vivo and in situ selection of the most suitable plant-microsymbiont associations is crucial for the success of regreening activities because not all symbiotic microorganisms are efficient in enhancing plant fitness on these degraded lands. Furthermore, one may combine one or more materials to offer them better growth conditions.

## CASE STUDIES

Several trials were conducted in the laboratory, supervised by Dr. Suzanne Allaire with the collaboration of Dr. Khasa's team at Laval University.

One trial aimed at comparing the effect of limestone sludge, ashes from cogeneration plant, compost, and different biochars on plant growth for greening gold mine residues (waste rocks, tailings and overburden) with two plant species: bluejoint reedgrass and alders introduced into different proportions of sludge, ashes, and biochar. These materials were selected for their complementary properties for plant growth. The mixture of forestry and paper pulp residues was added to all planting substrates.

After four months of growth in greenhouse, alders grew best by 25 to 40 per cent in two substrates amended by different sludge and biochar ratios (Photo 1) compared to substrates containing ashes. The biochars, despite their low nutrient concentrations, improved substrate physical properties. Substrates containing the sludge in combination with biochar also resulted in higher growth. The sludge offered better nutritional support for the plants and optimised bacterial propagation in the substrates.



*Experimental design with planing substrates composed of biochar, liming sludge, and ashes in the greenhouse at Laval University.*

*Plants inoculated with (left two) and without (right two) TreeBoost®.*




Other trials, with similar gold mine residues, different mixtures of residues, biochars and microorganisms, were tested with a variety of plant seedlings for germination and growth (clover, fescue, oats). Some mixtures contained either one or several plant species within the same substrate. One biochar with larger particles and higher nutrient contents greatly improved germination and growth, while the other had a lower effect. After four months, growth of plant mixtures increased by 40 per cent with a consortium of microorganisms mixed and a biochar.

Many our studies have demonstrated that inoculating tree and shrub seedlings with specific mycorrhizal fungi before outplanting on mine spoils may increase their survival, health, and growth (Nadeau et al. 2016). For example, we demonstrated that jack pine and white spruce growth on oil sands spoils increased by up to 60 per cent and 115 per cent, after four seasons, when inoculated with specific mycorrhizal fungi (Photo 2) (Quoreshi 2008). On another site, height growth rate of both pine and spruce seedlings on oil sands spoils was enhanced by 100 per cent and 60 per cent, respectively, after two seasons, and seedling survival by 75 per cent when inoculated with specific mycorrhizal fungi (Onwuchekwa et al. 2014). These results led to the registration of a commercial biofertilizer product named TreeBoost®, which is available in Canada, for accelerating the restoration of degraded boreal ecosystems. Other products and technologies are currently under development.

## CONCLUSIONS

The availability of different types of industrial wastes widen up the possibility to adapt planting substrate composition depending on environmental condition of the site and vegetation requirements, while biofertilizer enhances success. Enhanced regreening success improves cost-effectiveness. Long-term in situ experiments with a wide range of residues, plant species with microbial consortium will allow the development of best solutions for actual and new environmental challenges.

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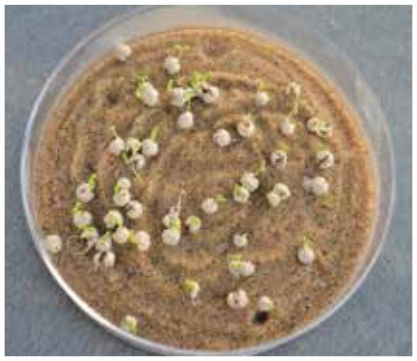
*Native plant salinity tolerance experiment – Paper birch (Betula papyrifera), Autumn willow (Salix serissima), Bebb's willow (Salix bebbiana), Balsam poplar (Populus balsamifera).*



*Petri dish showing pelleted seed germination.*

# NAIT advances plant and seed technologies to accelerate native plant establishment on boreal reclamation sites

Successful reclamation of retired oil & gas sites requires selecting and planting appropriate native plant species. It is a crucial component of returning sites to "equivalent land capability" required by the Environmental Protection and Enhancement Act (EPEA) (Province of Alberta, 2014). Plant species selection depends on the availability of native seeds, seedlings and soil conditions. There are 21 different seed zones in northwest Alberta, each with different dominant native plant species, which affects the availability and use of appropriate seeds and seedlings. Industrial activities change soil's physical and chemical conditions and make plant establishment more complicated regardless of the seed zone.

Re-establishing a functional boreal forest and peatland ecosystem requires timely access to a diversity of native tree, shrub and herbaceous species – over 130 native plants can be recommended for use in reclamation in Alberta. However, only a few are currently commercially available for the reclamation of industrial disturbed sites. There is a significant knowledge gap concerning the propagation methods for the commercial production of many native plants as there is no empirical information regarding nursery standards for most of the species.

Increasing understanding of these issues will help to reduce the cost and improve reclamation success. The Plant and Seed Technologies program at NAIT's Boreal Research Institute strives to answer these questions through applied research projects in collaboration with industry partners.

"Our understanding of how Mother Nature treats native seeds and grow plants in the wild would increase our ability to handle seeds, grow seedlings and successfully deploy them on reclamation sites," says Jean-Marie Sobze, NAIT's Applied Research Chair in Plant and Seed Technologies. Establishing boreal forests takes a considerable amount of time. Sobze's goal is to develop practical methods and technologies to successfully propagate key plant species used in land reclamation. The Plant and Seed Technologies program is assisting commercial nurseries and reclamation enterprises in the development of protocols for the collection, handling, propagation, and use of native boreal seeds and plants to accelerate reclamation of the boreal forest.

The program is also working on seed enhancement to improve plants' tolerance of adverse soil conditions. Major stressors for plants include elevated soil salinity, nutrient-poor soils and drought – conditions that often restrict seed germination and early growth. While conventional planting of seedlings remains the most effective method to re-vegetate disturbed sites due to the relatively quick establishment of target species, it comes at a high cost from nursery production and handling. Sobze and his team are testing new techniques to advance the use of direct seeding for reclamation and help industry to adapt a wider range of effective techniques.

"We are testing methods to enhance seeds to adapt to the harsh conditions found on industrial disturbed sites," Sobze says. While direct seeding has rarely been used due to limited success associated with this practice, Sobze's vision is to improve direct seeding practices of native boreal plant species to reduce time and costs associated with establishing target plant communities.

The need to maximize germination success is essential with limited seed crop supply. In collaboration with industry partners, Sobze is testing a combination of priming and pelleting techniques to enable large-scale direct seeding of boreal plant species in forest reclamation operations. Seed priming is a method where seeds are stimulated to absorb water to encourage germination. Seed pelleting is a technique where seeds are encased in solid particles, such as clay bonded together with an adhesive, to increase their size and improve protection in direct seeding application. Although these techniques are widely used in agriculture, they have not been tested for boreal trees, shrubs and herbaceous species used in reclamation. NAIT's projects combine laboratory and greenhouse studies with field experiments.

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# SMART, EFFICIENT, CAPABLE

## Amphibious (all-terrain) equipment for a changing world

By Mary Bird

PHOTOS COURTESY GREAT EXCAVATIONS INC.

Amphibious, all-terrain vehicles are building a Canadian comeback.

A mainstay of work on wet terrain around the world, from the swamps of Louisiana to the icy terrain of Siberia, these efficient, capable machines were developed for hard-to-access areas. Most impressive? They require minimal infrastructure.

"Our equipment is lighter, faster and more maneuverable than its predecessors," says John Skierka, CEO of Great Excavations Inc., a service provider in environmental remediation and reclamation, as well as the energy, mining, agriculture and construction sectors. "Our pontoon-based undercarriages float, which means they support work on any terrain – they are the ultimate all-access vehicle."

Great Excavations is notable for its use of adaptable equipment.

"We specialize in projects on wet terrain, from mud and muck to muskeg and ice, and everything in between," says Skierka. "Our goal is to make amphibious machinery more accessible – and to prove its capabilities for work in environmentally sensitive areas."

A 2016 Canada's Oil Sands Innovation Alliance (COSIA) study evaluated amphibious vehicles for year-round restoration. The study concluded that "using these vehicles for caribou habitat restoration is a first, and may be a game-changer in improving the pace and cost of restoration with minimal environmental impact."

"Modern amphibious equipment is gaining a reputation for its flexibility on uncertain terrain, as well as its efficiency in linear restoration and deactivation," explains Skierka. "Whereas other equipment may require significant support through building ice roads and using swamp mats – both of which come with their own environmental costs – an amphibious vehicle is able to access remote locations with minimal impact."

Skierka says these machines can reach the boreal forest independently and work largely uninterrupted through the spring, summer and fall, increasing the amount of work done as well as the longevity of that work.

"Shorter, warmer winters are part of the inspiration for our manufacturing system," says Amanda Butala, sales lead at Amphibious Equipment Solutions Inc. (AES), which builds excavators and carrier trucks. "Our machines can work year-round, but the greatest efficiencies are April through November, which basically doubles the work time of more traditional equipment."

AES is known for tailoring machines to specific tasks, such as improving northern habitats through modifications to machines slated for linear deactivation.

"We needed a narrower machine that could traverse cut lines but still do the work of a traditional excavator while also floating, if required," says Skierka. "Working with industry partners, we developed a telescopic undercarriage so the machines can traverse narrow corridors when needed, then expand to their full size while working."

According to Butala, this type of innovation is key to building a market for these remarkable machines.

"Our investment in innovation is about building sensible solutions for industry," says Butala. "The next step is making this equipment a must-have for remediation and restoration work."

Skierka agrees.

"We already know our machines can do the work – and do it well," says Skierka. "We know we have a minimal environmental footprint and excellent biosecurity compared to traditional methods. We know amphibious equipment reduces costs, time and effort. And we know our systems work."

The challenge? Ensuring industry buy-in in a sector built on the winter work cycle.

"It's time for change," says Skierka. "We have a lot of work to do in the environmental sector, which is a key part of our business philosophy. But it's also time to convince traditional industry that reducing environmental impact starts with making simple changes that provide value every day, such as floating machinery."

***For more on the benefits of amphibious equipment, check out:***

http://www.cosia.ca/initiatives/land/amphibious-vehicles

http://www.cenovus.com/news/our-stories/amphibious-vehicles-offer-game-changing-solution-to-restore-land.html


# #wefloat

**Amphibious equipment's low ground pressure significantly reduces environmental impact for reclamation and remediation activities.**

# UPCOMING EVENTS

### SEPTEMBER 18 – 21, 2017
**42nd CLRA/ACRSD Annual National Conference & AGM**
Fort McMurray, Alberta
www.clra.ca

### SEPTEMBER 18 – 21, 2017
**BC Technical and Research Committee on Reclamation – 41st Annual British Columbia Mine Reclamation Symposium**
Williams Lake, British Columbia
www.trcr.bc.ca | @TRCR

### OCTOBER 1 – 4, 2017
**44th Annual Canadian Ecotoxicity Workshop (CEW) – Ecotoxicology in the Great Lakes Basin and Beyond**
Guelph, Ontario
http://ecotoxcan.ca

### OCTOBER 11 – 13, 2017
**Remediation Technologies Symposium 2017 (RemTechTM 2017)**
Banff, Alberta
www.esaa.org/remtech

### OCTOBER 23 – 26, 2017
**12th International Conference on Mine Closure – (Mine Closure 2017)**
Lima, Peru
www.mineclosure2017.com

### NOVEMBER 5 – 8, 2017
**Tailings and Mine Waste '17**
Banff, Alberta
www.tmw2017.com

### NOVEMBER 12 – 14, 2017
**Canadian Aboriginal Minerals Association 25th Anniversary Conference – Water for Life, Mining for Need, Achieving Balance**
Toronto, Ontario
www.aboriginalminerals.com

### NOVEMBER 29 – 30, 2017
**24th Annual BC-MEND Metal Leaching & Acid Rock Drainage Workshop – Challenges & Best Practices in Metal Leaching & Acid Rock Drainage**
Vancouver, British Columbia
Contact: Bill Price, CanmetMINING
(Bill.Price@canada.ca)

### APRIL 11 – 13, 2018
**21st International Seminar on Paste and Thickened Tailings**
Perth, Western Australia
paste2018.com

### JUNE 2 – 7, 2018
**35th Annual Meeting of the American Society of Mining & Reclamation – The Gateway to Land Reclamation**
St. Louis, Missouri
www.asmr.us

### JUNE 16 –21, 2018
**RFG 2018 | Resources for Future Generations Conference**
Vancouver, British Columbia
rfg2018.org

# BULLETIN BOARD

## BrettYoung Joins TWCA as Class-A Member

This Spring, Brett-Young Seeds Limited announce its Certified Partnership with Turfgrass Water Conservation Alliance (TWCA).

BrettYoung knows that water conservation is a primary concern for their customers, and as a Class-A Member of TWCA, they'll will bring to market turfgrass varieties that have been rigorously tested to meet the most stringent criteria of water usage and conservation methods. Currently, BrettYoung is the only TWCA Class-A Member in Canada.

"BrettYoung is a leader in bringing world class genetics to market and ensuring we are meeting our customers' evolving needs," says Wayne Unger, Vice President for BrettYoung's Forage and Turf business unit. "We're confident that partnering with TWCA will allow us to continue to be at the forefront of technology developments in plant breeding. This partnership will ensure BrettYoung turf products are delivering the utmost water conservation benefits."

The main goal of TWCA is to combat the rising concern of depleting water resources. The Turfgrass Water Conservation Alliance qualifies grasses that demonstrate a statistically significant water saving potential over conventional varieties of the same species.

Jack Karlin, the Program Director for TWCA, adds: "BrettYoung's membership in TWCA is a real testament to their commitment to conservation and shows their vision for the future. We're really looking forward to working with them to promote drought tolerant turf and make every drop count."

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CLRA | ACRSD

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and reap the benefits of what this association has to offer! As a dynamic association, the CLRA/ACRSD attracts members from across Canada and beyond. Members come from various backgrounds, each bringing vital knowledge to the field of land reclamation.

### The main objectives of CLRA/ACRSD are:

- To promote education and professionalism in land reclamation.
- To recognize places, products, organizations and people that demonstrate excellence in land reclamation.
- To stimulate the practice of reclamation, encourage investigation of problems, and promote development of technical and regulatory solutions.
- To maintain and develop national and international strategic alliances that support the vision and mission of the CLRA/ACRSD.
- To provide opportunities for members to meet and exchange information, ideas and experiences in land reclamation.
- To collect and publish land reclamation information.
- To do all that is incidental or conducive to the attainment of the above objects and in particular to receive, maintain and use funds to establish and maintain education, research, promotion and publishing activities or to aid in such activities, agencies and institutions already established.

## MEMBER BENEFITS

### Among the benefits of membership are:

- Annual Membership Directory containing contact information for more than 1,100 individual and corporate CLRA members involved in land reclamation across Canada;
- Receive Canadian Reclamation magazine in the mail two (2) times per year – featuring news, project articles, supplier information and much more information pertaining to land reclamation in Canada and around the world;
- Receive notices, calls for papers and discounted registration fees for National Annual Meetings and Conferences as well as Chapter events;
- Tremendous networking opportunities at National and Chapter events;
- Linkages with other professional land reclamation associations in the UK, USA, Australia and China;
- Members are some of the first to learn about new regulatory initiatives; membership provides access to regulatory workshops and lunch and learns (chapter specific);
- Access to discounted rates for Chapter lunch and learns and workshops;
- Fees help support educational awards and scholarships in land reclamation;
- CLRA activities can help you be involved with charitable opportunities (e.g. golf tournaments).

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