

PHYTOREMEDIATION

for the Mature Anthropocene: A Biogeographical Perspective

**Remediation Technologies
(RemTech) Symposium 2017**

Oct 11-13 2017

Fairmont

Banff Springs Hotel

Banff, Alberta







17 years

Phytoremediation over space and time

What is the opportunity we have in phytoremediation to decontaminate soil, water, and air, while increasing ecosystem services, such as carbon sequestration and biodiversity at the site and landscape scale now, and beyond our lifetimes?

What is the Anthropocene?

Marks the era in which earth has gone through novel and dramatic changes of human origin

Mature Anthropocene

The Mature Anthropocene arrives with mass awareness of our role in changing the planet. It differentiates **conscious**, purposeful global change from the inadvertent, random changes that have largely brought us to this point.

David Grinspoon, Astrobiologist

The Case of Alberta Oil over Time and Space

Oil discovered in Alberta in 1914 in Turner Valley

Turner Valley Oilfield Society



- Since 1914, 445,000 wells have been drilled and 450,000 kms of pipeline laid
- By 2014 there were more than 100,000 depleted uncertified wells and 72,000 kms of discontinued or abandoned pipeline



Standards were different across all industries in early years

Contamination issues associated with
oil and gas development are
petroleum hydrocarbons and salt

Turner Valley 1938

Flaring gas

Oilsands mining: Planning for the distant horizon.



Oil Sands

- 48,000 sq kms will be disturbed by surface mining
- With an end of life estimate between 2045 (based on projections of reduced energy market share) to 2106 (based on Reserve Life Index)



Oilsands Reclamation Horizon

First
reclamation
certification
was issued
in 2008 from
a 104 ha site
that began
reclamation
in the early
1980s

Synchrude



**The regulatory standard for reclamation is “equivalent land capability”:
“self-sustaining locally common boreal forest ecosystem integrated with the
surrounding area”.**

With a 25 year reclamation horizon beyond reserve life, the end of reclamation horizon is 2070 at the earliest, to 2131 at the latest – 53-114 years from now.

117 years ago

53-114 years from now

445,000 wells,

445,000 kms of pipeline

48,000 sq kms

We have arrived at this state because of short-sighted vision and piecemeal approaches that are the logic of the Anthropocene

We are now in the middle of the oil development era and are beginning to make the conscious choice going forward to remediate and reclaim according to values consistent with this distant horizon .

This is the Mature Anthropocene

What if all industries in and beyond Alberta were held to the equivalent land capability standard?

Why not design equivalent land use that can be managed to phytoremediate, or at least phytostabilize, over the long-term – fifty to one hundred years. And beyond.

Phytoremediation as Conscious Business

Conscious business enterprises and people are those that choose to follow a business strategy in which they seek to benefit both human beings and the environment. The Conscious Business movement in the US, which emerged from the theory of corporate social responsibility (CSR) pushes for ...social and environmental concerns at both global and local scales.

Fred Kofman 2006

Triple Bottom Line (3BL) opportunities provided by phytoremediation

Profit

- Phytoremediation is cost-competitive on some sites compared to engineered solutions
- Phytoremediation over the long term may make the remediation of some orphan brownfields viable.
- For large or remote sites it may be the only solution
- Phyto reduces exposure to liabilities brought by trucking and transportation of contaminated media through settled areas

People

(individual, neighbourhood, community, and civic)

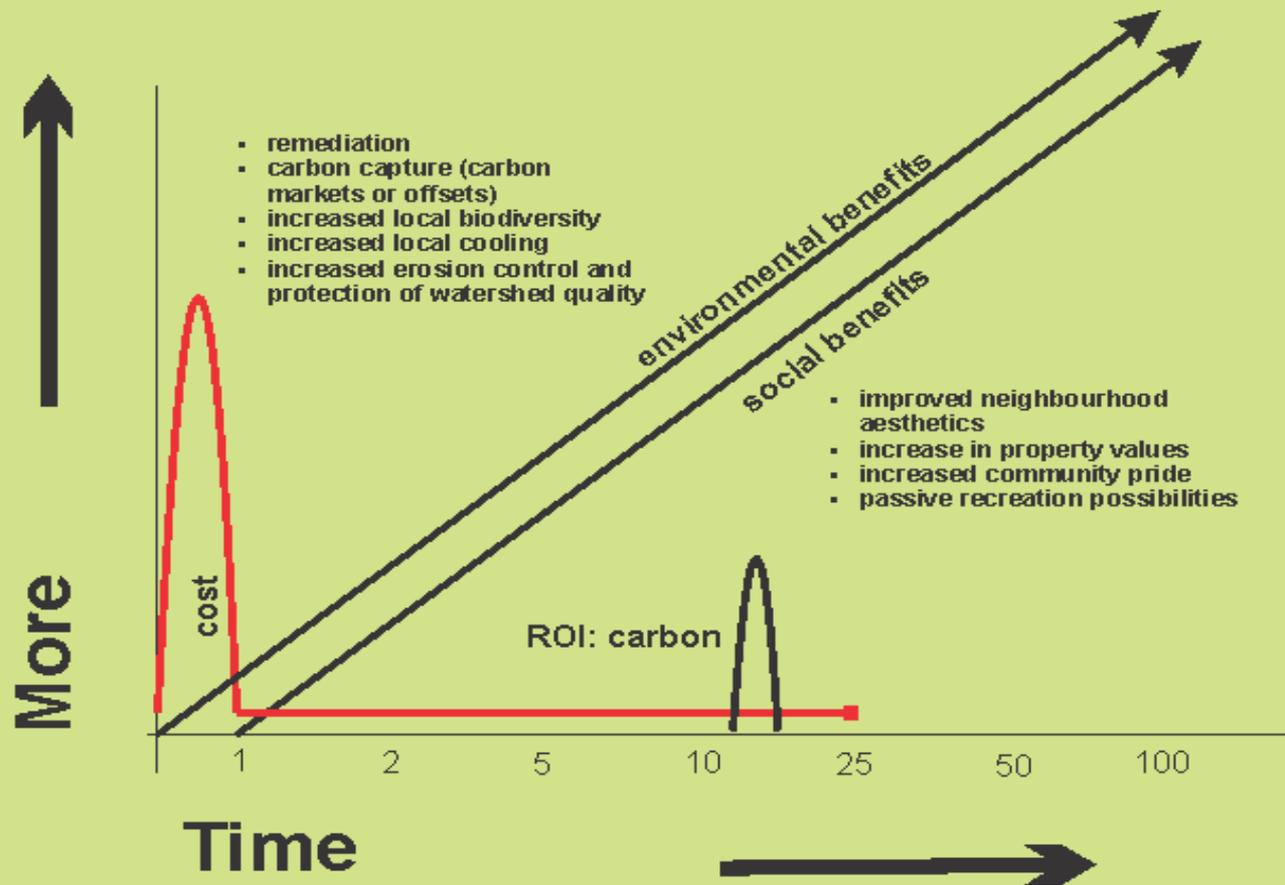
- health,
- aesthetics,
- passive and active recreation,
- increases property values
- contributes to increased community pride and morale
- presents positive image outside the community, contributing to attractiveness to investors, tourists.
- attracts dedicated and inspired staff who feel they are making a positive difference

Planet

(local, community and watershed scale)

- remediates soil and/or groundwater
- provides carbon capture
- carbon emission reduction when replacing dig&dump
- uses less energy for set-up and runs in the long term on solar energy
- protects soil from erosion
- protects groundwater, watersheds and aquatic receptors from siltation and contamination
- provides habitat and increases local diversity
- contributes to improved air quality
- provides local cooling/shading

3BL of Phytoremediation



3BL Examples



Groundwater protection



Environmental benefits of landfill phytostabilization:

- Interception of rainfall on the leaves and stems reducing erosion
- Stabilizing soil with root biomass
- Providing shade that
 - slows snowmelt in spring
 - provides local cooling in summer

Habitat creation, Passive recreation

Ecological benefits:

Increase the diversity of local habitat for animals with mixed tree/shrub planting (11,250 trees and shrubs planted over 2.8 ha)

Human benefits:

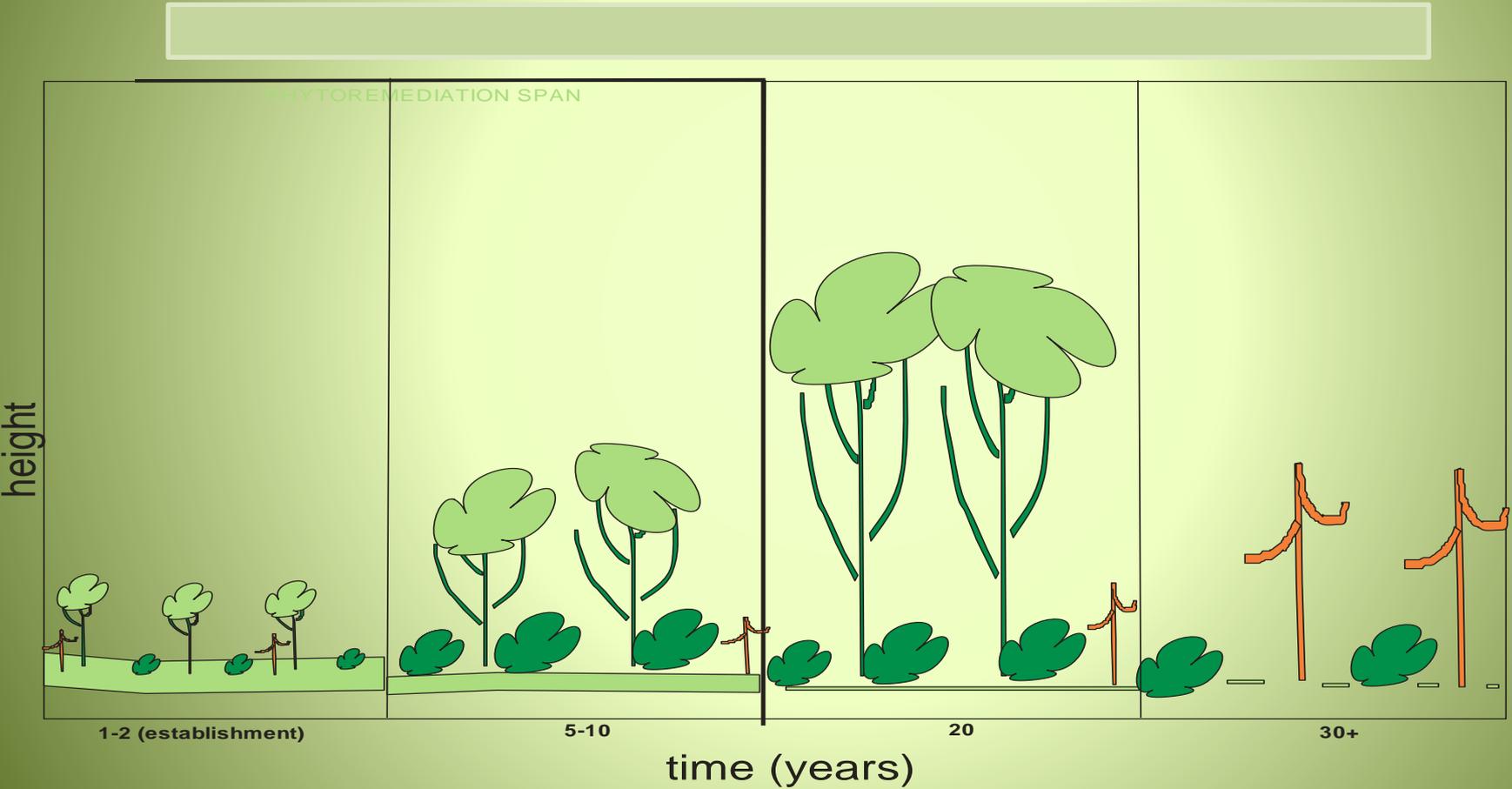
Passive recreation possibilities for the community eg. walking trails which provide an elevated viewscape over surrounding land



Community:

Improved streetscape aesthetics

Phyto-forestry as a nurse crop for native forest restoration





2008



2016

Phyto-forestry:

Carbon capture

1.3 ha site planted in 1999 with 3200 hybrid poplar



Measuring Environmental Benefits of Phytoremediation – carbon capture

•Carbon capture

- Based on OMNR growth tables based on maximum stocking rates of hybrid poplar of 1111/ha, when mature at 20 years carbon sequestered is 188.85 ODkg each, or 209 ODMT/ha

- These estimates predated research (Mugnozza *et al.*FAO n.d.) showing that elevated Co₂ (550 ppm) increased above-ground hybrid poplar biomass from 15-28% and below-ground biomass 22-38%. (Current Co₂ 406 ppm)

•Estimated value of carbon capture

- Based on carbon value forecasts(Synapse Energy Economics, 2016) of low (\$25) medium (\$39) and high (\$62)/MT =

- \$5235; \$8376; and \$12983/ha after 20 years.

Measuring Environmental Benefits of Phytoremediation – other ecosystem services

Local cooling, erosion control, increase in biodiversity and soil carbon capture can be measured through:

- Leaf area index increase (the measure of the ratio of leaf cover to ground) as measure of soil protection
- Baseline and interval measurements of:
 - soil carbon capture (leaf and small twig biomass)
 - summer temperature before planting and as canopy matures.
 - biodiversity inventory of all taxa: vegetation, birds, mammals, herpetofauna

Novel Phyto-ecosystems
Eco-remediation at the Landscape Scale

Embrace complexity



Expertise: International Phytotechnology Conference

- 300 international experts in research and application
- Phytotechnologies for the treatment of:
 - wastewater, ground water, surface water,
 - minerals and trace metals
 - organic contaminants

Expertise: COSIA

Canadian Oilsands Innovation Alliance has funded remediation and reclamation research into:

- Soils profile reconstruction
- Fen, wetland and lake recreation
- Mycorrhizal-dependent ericacious vegetation such as blueberries
- Recreating hydrological features
- Fisheries and wildlife re-establishment
- Many different components of revegetation, including selection for salt-tolerant native species

Eco-remediation



We can combine ecology with phytoremediation technology, reclamation research and design integrated remediating ecological systems: mosses, fungi, lichen, fauna, soil invertebrate, microbes, to create long term novel phyto-ecosystems

Myco-remediation uses fungi to transform PCBs, dioxins, PAHs *inter alia*

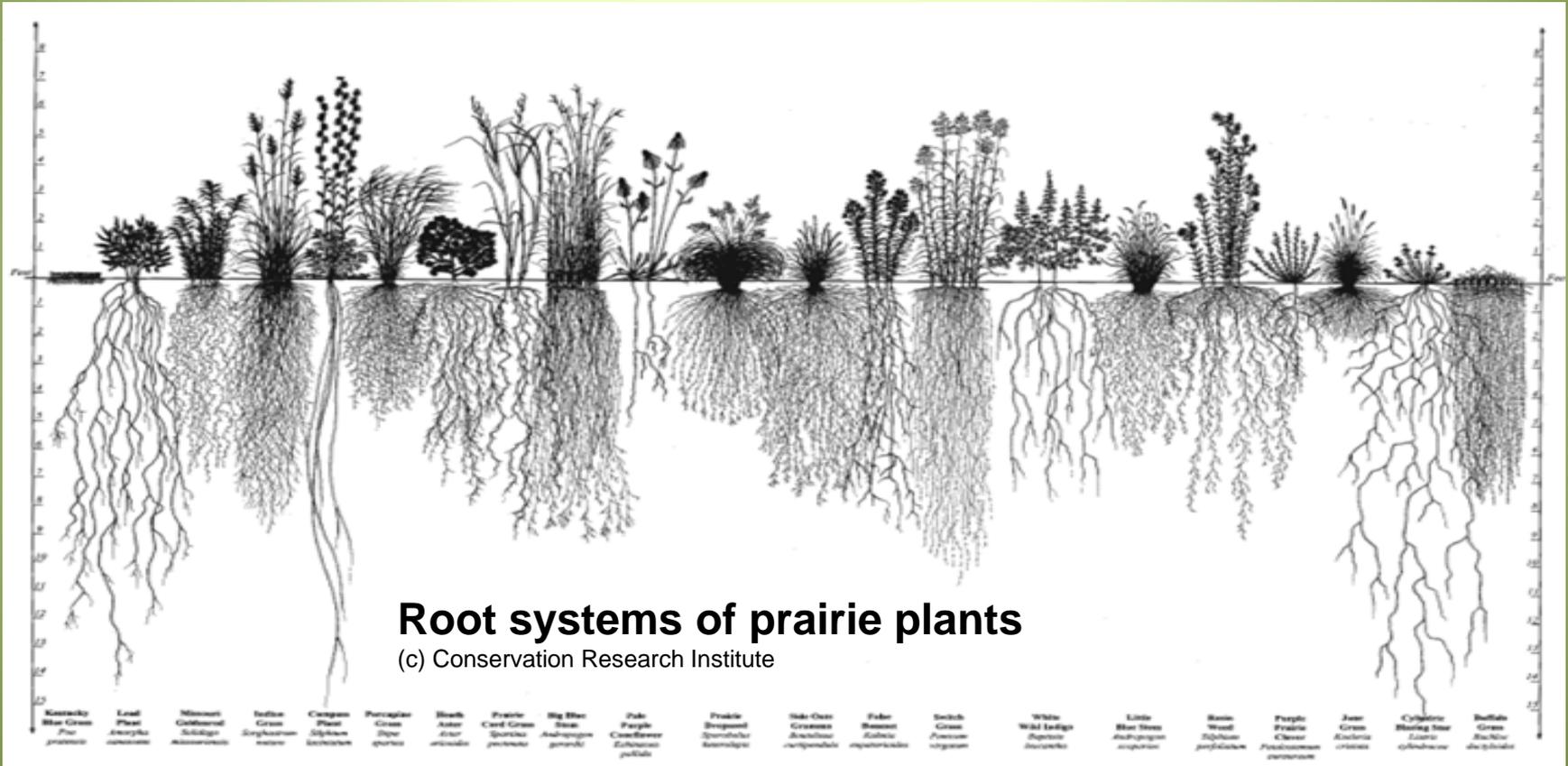


**Lichens accumulate
PoPs, lead and aqueous
uranium**



Novel phyto-ecosystems could transform brownfields and other contaminated sites into the pre-settlement equivalent land capability (such as old growth forests or native grasslands) that remediate over decades or stabilize as they mature over centuries

Grassland novel phyto-ecosystems





9 species of native grasses were screened by the US Army Corps of Engineers (2007) to be candidates for phytoremediation or phytostabilization of TNT and RDX

Treatment wetlands

Supernatant, storm runoff,
inter alia



Landscape-scale Novel Phyto-ecosystems



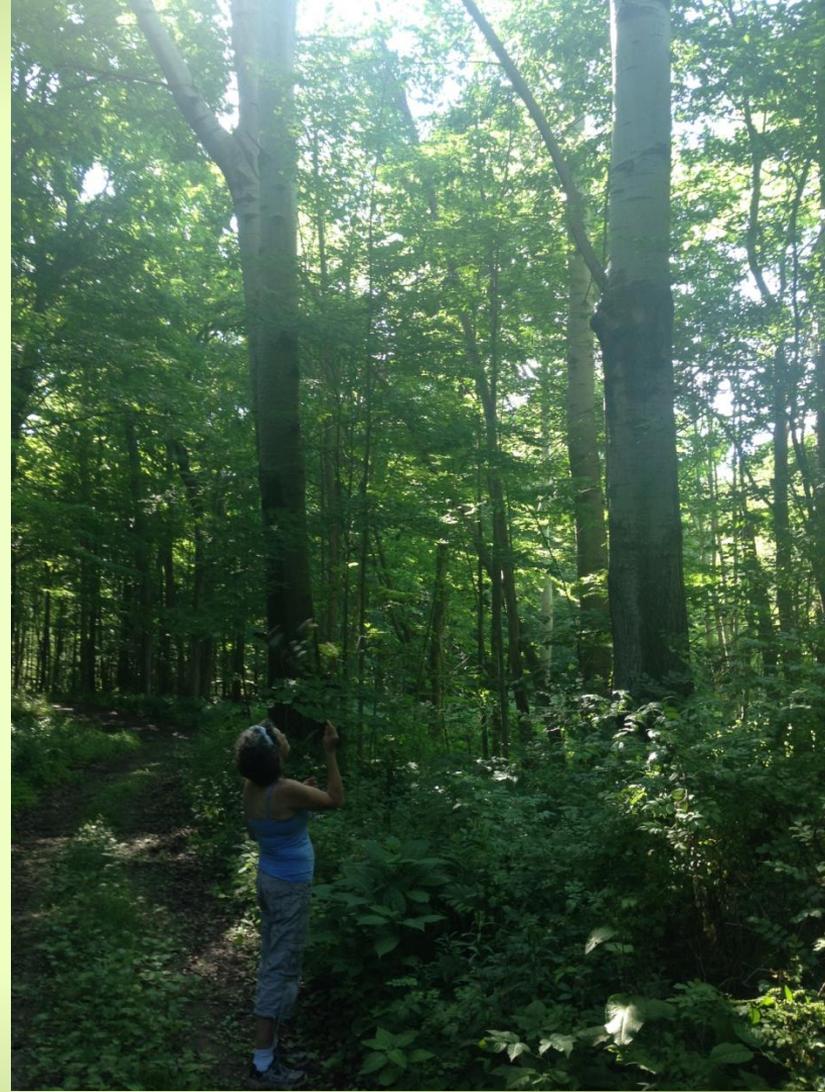
Can integrate different terrestrial and wetland phyto-ecosystems

Long Term Benefits of Landscape-scale Novel Phyto-ecosystems

- Passive solar driven eco-remediation creates new opportunities to remediate orphan and brownfield sites that were cost prohibitive, and new finance possibilities over the long term.
- Provide higher-level ecological open space
- Contribute to community aesthetics, well-being and prosperity
- Provide restored/improved hydrological function at regional and watershed scales
- Positively affect climate change through carbon sequestration
- Professional legacy

Legal frameworks for managing Novel phyto-ecosystems in perpetuity

Land Trusts and Conservation Easements which have traditionally have been used to protect natural landscapes can also be used to manage and protect phyto-remediating ecosystems from development indefinitely.



Professional practice in the Mature Anthropocene

What can you do in your career? For intermediate and seniors professionals, look for ways to apply the benefits of your experience in ways that will last beyond your lifetime, including mentoring juniors.

For students and juniors, look at cumulative impact of your career over its 30 or 40 year potential.

“If your life’s work can be accomplished in your lifetime, you’re not thinking big enough”

Wes Jackson, Founder, The Land Institute



Think
riginally