Using Phosphogypsum To Create Soil and Combat Climate Change

Connie Nichol
Nutrien, Alberta, Canada

Nutrien

VIRTUAL EVENT

International Conference on
Management of Naturally Occurring Radioactive Material (NORM) in Industry
19–30 October 2020 #NORM2020

Workshop on Phosphates for sustainable development:
Fertilizers and phosphogypsum in the circular economy
22 October 2020

Nutrien PG Stacks in Canada

- Phosphate fertilizer production at Redwater ceased in April 2019
- Phosphogypsum at Fort Saskatchewan is from a predecessor company

Redwater – 55 million tonnes PG

Fort Saskatchewan – 6 million tonnes

Phosphogypsum Research

- The focus has been primarily on reclamation
- the government suggested reclamation plan is to cover with one meter of soil – not science based
- partnered with the University of Alberta in 2005 to do research outlining better ways to close the gypsum stacks
- seven students have already earned Master's degrees studying phosphogypsum reclamation

Research Results

- results indicate that in our semi-arid climate, a soil capping depth of 8 to 15 cm is optimal for plant growth and minimizing water infiltration
- discovered that mixtures of PG and soil had healthier taller plants with greater biomass than PG or soil alone
- no issues with erosion, run-off, gamma, radon or fluoride emissions or trace element uptake with any cover system

Jackson, et al. 2011. Phosphogypsum Capping Depth Affects Revegetation and Hydrology in Western Canada. J. Env. Qual., Vol. 40 No. 4, p. 1122-1129.

Christensen et al., 2013. In situ measurement of snowmelt infiltration under various topsoil cap thicknesses on a reclaimed site. Canadian Journal of Soil Science, 2013, 93(4): 497-510

Turner, E.L 2013. Influence of soil cap depth and vegetation on reclamation of phosphogypsum stacks in Fort Saskatchewan, Alberta. MSc thesis, University of Alberta.

Abou Rizk, Jenna, 2015. Potential Anthroposol development using phosphogypsum as a substrate with soil and organic amendments. MSc thesis, Dept. of Renewable Resources, University of Alberta

Field Testing the Anthrosol Afforestation Concept

Trees grew very quickly

August 2019

August 2020

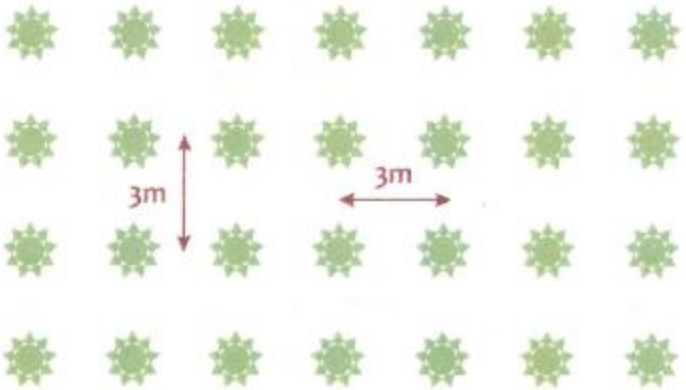
Establishing Forests on Gypsum Stacks

- Based on the success of the cooling pond reclamation and tree trials, Nutrien has closed and forested two gypsum stacks in Fort Saskatchewan
  - 2016 - Gypsum stack #4 – 20 acres - 6000 hybrid poplars and 10,000 willows
  - 2017 – Gypsum Stack #3 – 28 acres - 11,000 hybrid poplars
- Followed Canadian Forest Service guidelines to create high yield afforestation plantations to maximize biomass and carbon accumulation

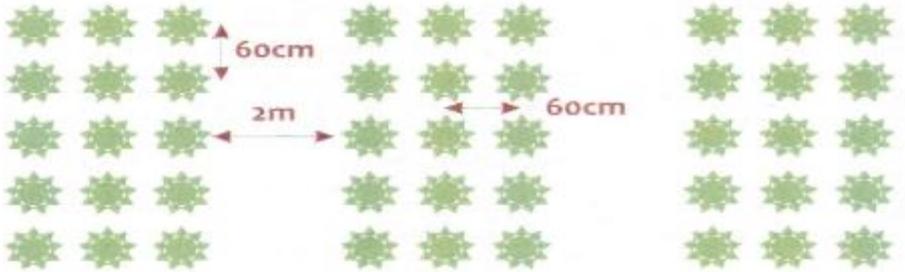



Example Plantation Designs

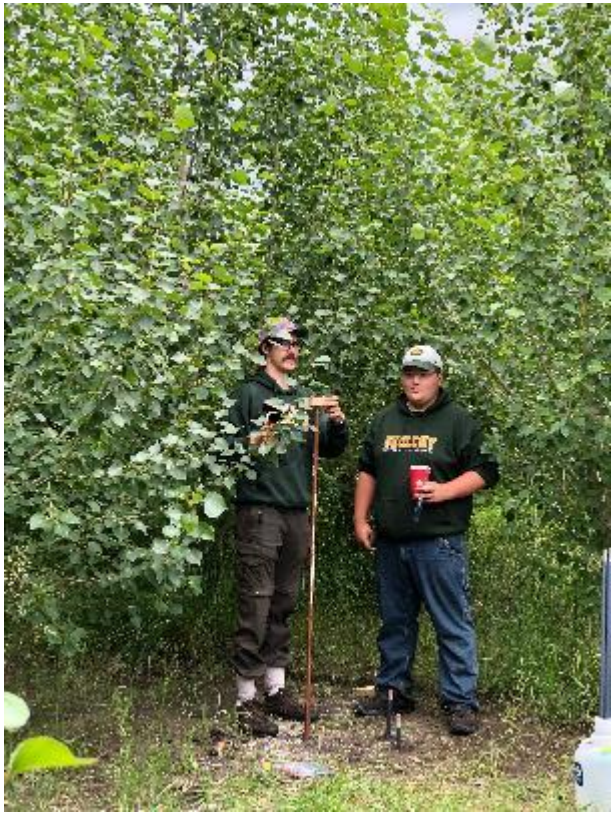
- Species: hybrid poplar; aspen
- Density: 1,100 - 1,600 stems/ha
- Spacing: 3m x 3m (1,100 stems) or
  2.5m x 2.5m (1,600 stems)
- Planting: Manual
- Rotation: 15-20 years
- Yields: 13.6-20.0 m^3/ha/yr or 7.3-10.8 ODT/ha/yr



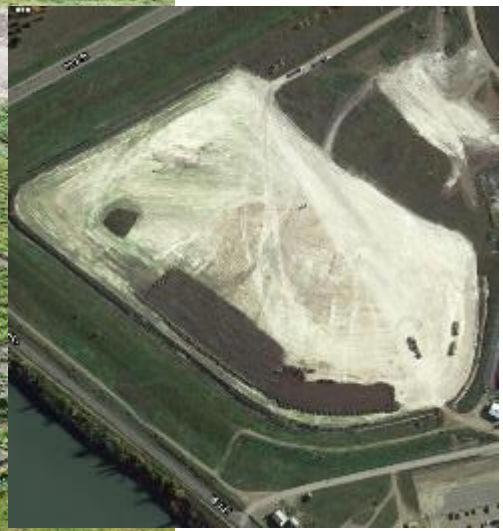
- Species: hybrid willow
- Density: 15,625 stems/ha
- Spacing: 3-row/bed design: 60cm x 60cm between trees, 60cm between rows, 2.0 m between rows.
- Planting: Mechanical
- Rotation: 6-7, 3-year rotations
- Yields: 6.0-12.0 ODT/ha/yr



Gypsum Stack Poplars in 2019/2020

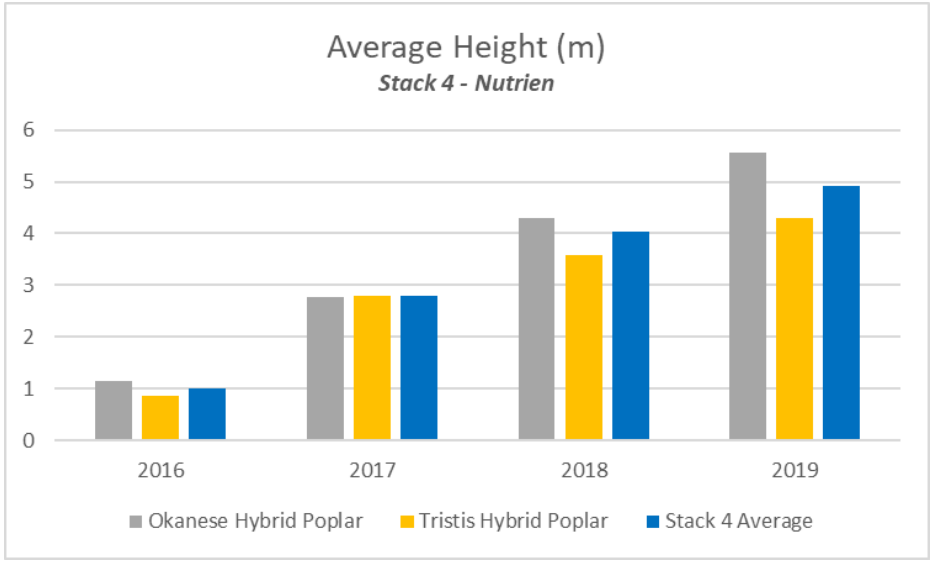


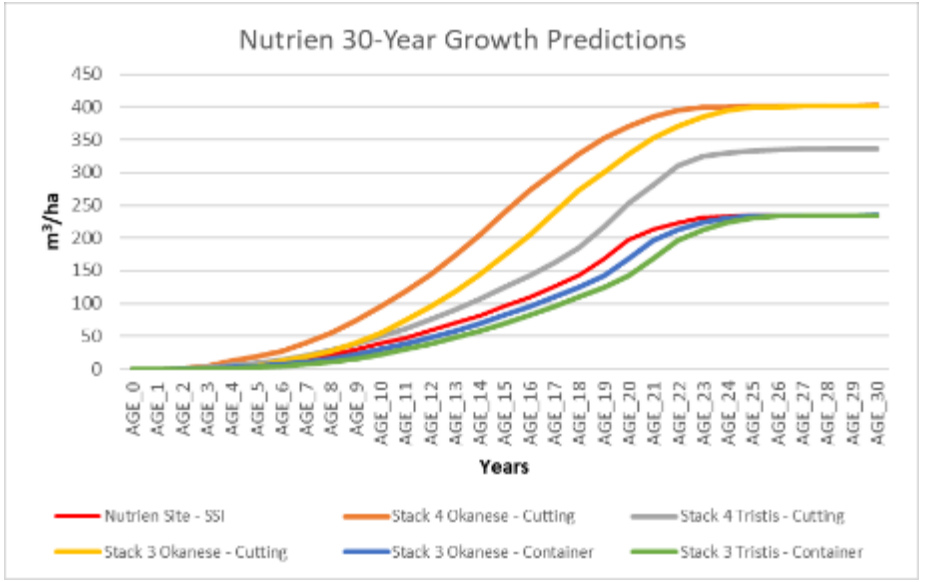
Overhead View August 2020



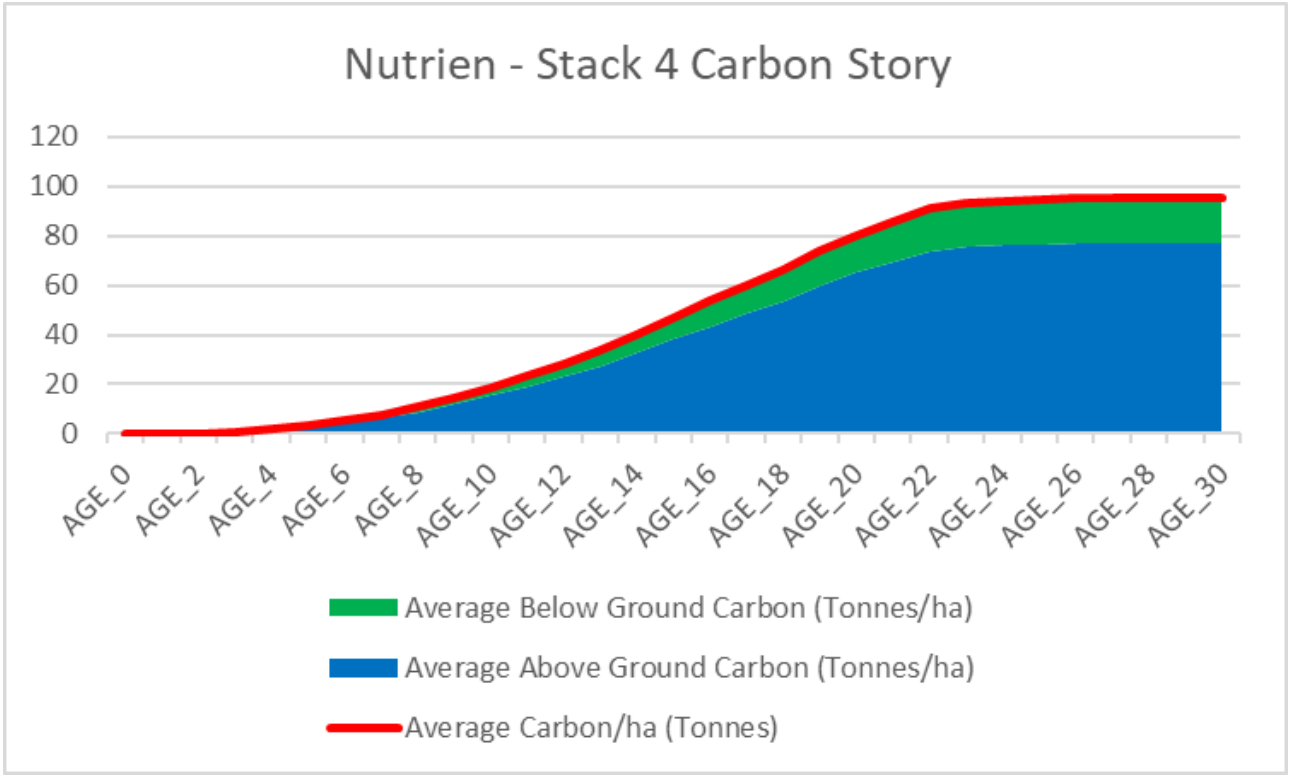
2015 Google Image

Growth Measurement and Predictions





Predicted CO2 Sequestration



Benefits of Trees

- Trees create value and reduce long term maintenance costs
  - High yield afforestation plantations sequester carbon (approximately 30 t CO_2 e ha/year) to combat climate change
  - Potential for use for green energy or wood chips
  - Reduced maintenance once established (trees close canopy after 2-3 growing seasons) - no need for repeated mowing
- Improved aesthetics and ecosystem diversity
  - Establish wildlife and pollinator habitat
  - Improve long term sustainability
  - Help dispel myths regarding toxic radioactive waste
- Can reduce stack closure costs and likely replace the use of synthetic liners in arid and semi-arid environments
  - Research indicates that no rain or snowmelt infiltrates past the tree roots
  - Mixing a small amount of soil into PG to create an Anthrosol is more cost effective than a barrier approach to reclamation

We can grow many things in the Phosphogypsum Anthrosol…









Different Flowers – Establish Pollinator Habitat

Pumpkins are Employee Favourites

- Any amount of soil mixed with weathered PG creates an excellent growth medium that grows larger, healthier biomass than soil alone
- Instead of considering PG a ‘waste’, it can be used *in situ* to create an Anthrosol to grow high value crops
- Concentrated woody plantations can be quickly established to sequester carbon and combat climate change
  - In Alberta, Canada, the afforestation would essentially pay for itself in three years with carbon credits worth $30/tonne and then starts to make money
- The woody plantations also have other benefits such as improved aesthetics, long term sustainability and reduced long term maintenance costs

Thank You for your Attention