Wisdom and Knowledge Transfer in Restoration; the Cenovus Caribou Habitat Restoration Project

SERWC 2018

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cenovus ENERGY

Outline

- Introduction to Cenovus
- Wisdom and Knowledge Transfer
- Examples in Agriculture, Forestry and Restoration
- Pilots and Demonstrations
- Community is Key

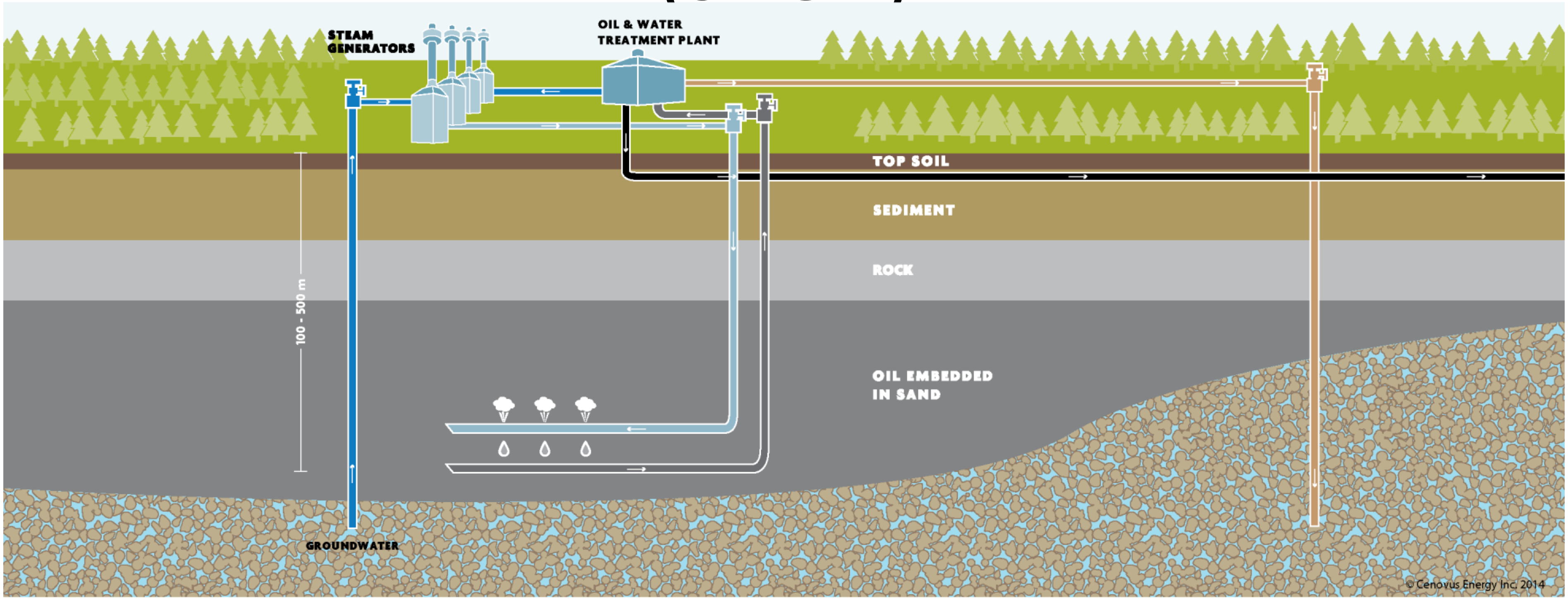
About Cenovus

Oil sands
Oil sands drilling projects in northern Alberta

Deep Basin
Liquids-rich natural gas fairway in Alberta and British Columbia

Refineries
50 percent ownership in two U.S. refineries

Steam-assisted gravity drainage (SAGD)



A typical SAGD oil sands project

Developing the oil sands responsibly

Making safety a priority

Advancing technology

Improving our environmental performance

Investing in communities near our operations

Integrating environment into all we do

Minimizing our land footprint

Reducing our air emissions

Using less water

- *“The status quo isn’t good enough when it comes to environmental performance.”*
- *-Harbir Chhina, Chief Technology Officer*

"As the circle of knowledge increases,
so does the fringe of ignorance."

- *Bill McGill*

Knowledge Transfer

- Discovery ⇨ Communication ⇨ Adoption
- Examples and characteristics
  - Basic research
  - Technical literature & reports
  - Course based teaching
  - Field extension
  - Web-based, virtual media
  - Suited supporting technical change & rapid development
  - May be tailored to audience and learning style

Wisdom

- “the quality of having experience, knowledge and good judgement…”
- Involves complexity, problem resolution, “big picture”
- Interactive, participatory, non-linear
- Involves mentorship, guidance
- Addresses uncertainty & risk
- Often multi-disciplinary, multi-dimensional
- Suited to adaptive management
- “academic humility”

“Everything grew better except the trees…”

- *Kelvin Hirsch*

Synthesis of ammonia – knowledge transfer

- Haber Bosch process – synthesis of ammonia
  - $N_2 + 3H_2 \Rightarrow 2NH_3$
  - high pressure and temperature
  - expensive and energetically demanding
  - rapid deployment and adoption
  - global food supply and population growth
  - significant proportion of global energy demand

Mineral N use - wisdom

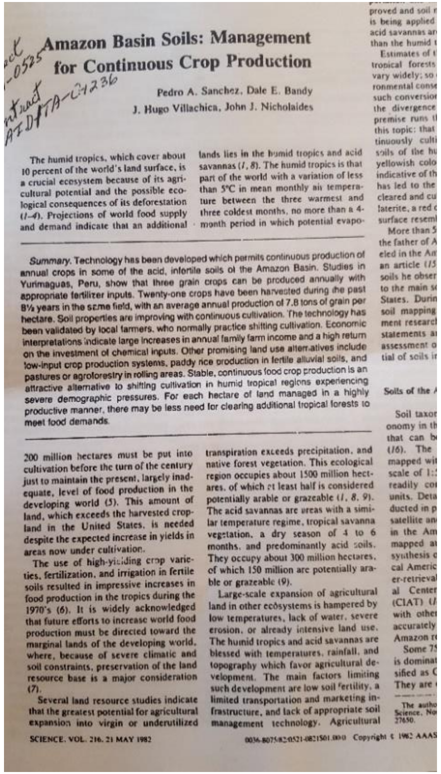
- Oilsands reforestation research
    - Limited success associated with mineral fertilization

- Eutrophication – large scale ecological disruption
    - Gulf of Mexico hypoxic zone; >20,000 km^2
    - Nitrate flux in river, eutrophication, hypoxia
    - Plant diversity loss

“Why are you trying to grow corn on this beach??”

- *peasant farmer – Yurimaguas, Peru*

The Yurimaguas Technology



Amazon Basin Soils: Management for Continuous Crop Production

Pedro A. Sanchez, Dale E. Bandy
J. Hugo Villachica, John J. Nicholaides

The humid tropics, which cover about 10 percent of the world's land surface, is a crucial ecosystem because of its agricultural potential and the possible ecological consequences of its deforestation (1–4). Projections of world food supply and demand indicate that an additional lands lies in the humid tropics and acid savannas (1, 8). The humid tropics is that part of the world with a variation of less than 5°C in mean monthly air temperature between the three warmest and three coldest months, no more than a 4-month period in which potential evapo-

Summary. Technology has been developed which permits continuous production of annual crops in some of the acid, infertile soils of the Amazon Basin. Studies in Yurimaguas, Peru, show that three grain crops can be produced annually with appropriate fertilizer inputs. Twenty-one crops have been harvested during the past 8½ years in the same field, with an average annual production of 7.8 tons of grain per hectare. Soil properties are improving with continuous cultivation. The technology has been validated by local farmers, who normally practice shifting cultivation. Economic interpretations indicate large increases in annual family farm income and a high return on the investment of chemical inputs. Other promising land use alternatives include low-input crop production systems, paddy rice production in fertile alluvial soils, and pastures or agroforestry in rolling areas. Stable, continuous food crop production is an attractive alternative to shifting cultivation in humid tropical regions experiencing severe demographic pressures. For each hectare of land managed in a highly productive manner, there may be less need for clearing additional tropical forests to meet food demands.

200 million hectares must be put into cultivation before the turn of the century just to maintain the present, largely inadequate, level of food production in the developing world (5). This amount of land, which exceeds the harvested cropland in the United States, is needed despite the expected increase in yields in areas now under cultivation.

The use of high-yielding crop varieties, fertilization, and irrigation in fertile soils resulted in impressive increases in food production in the tropics during the 1970's (6). It is widely acknowledged that future efforts to increase world food production must be directed toward the marginal lands of the developing world, where, because of severe climatic and soil constraints, preservation of the land resource base is a major consideration (7).

Several land resource studies indicate that the greatest potential for agricultural expansion into virgin or underutilized

transpiration exceeds precipitation, and native forest vegetation. This ecological region occupies about 1500 million hectares, of which at least half is considered potentially arable or grazeable (1, 8, 9). The acid savannas are areas with a similar temperature regime, tropical savanna vegetation, a dry season of 4 to 6 months, and predominantly acid soils. They occupy about 300 million hectares, of which 150 million are potentially arable or grazeable (9).

Large-scale expansion of agricultural land in other ecosystems is hampered by low temperatures, lack of water, severe erosion, or already intensive land use. The humid tropics and acid savannas are blessed with temperatures, rainfall, and topography which favor agricultural development. The main factors limiting such development are low soil fertility, limited transportation and marketing infrastructure, and lack of appropriate soil management technology. Agricultural

Sanchez et al. (1982) Science

"Why are you trying to grow corn on this beach?!"

“It’s a poor carpenter that blames his tools”

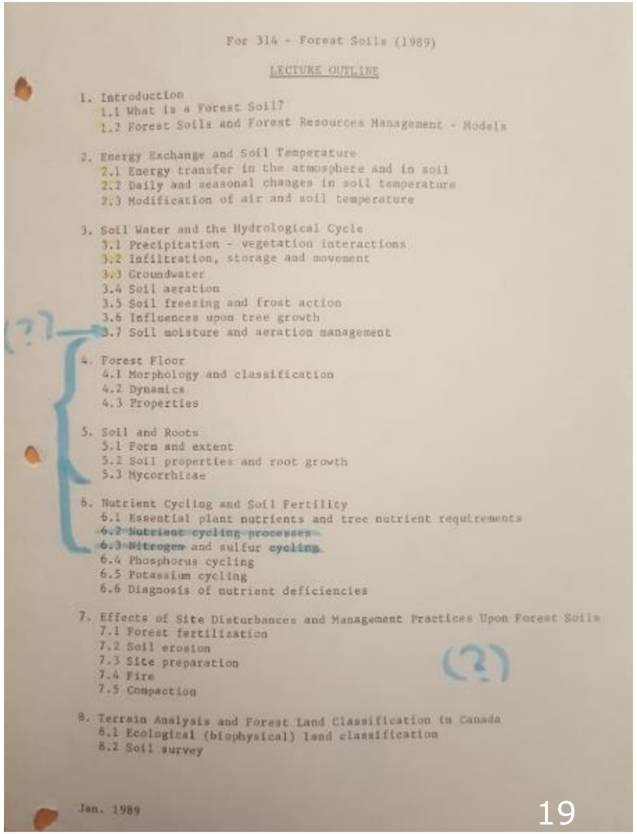
- *Tim Vinge*

Lessons in failure

Intro to Forest Soils - 1988

Emphasis

- soil physical properties & energy exchange
  - albedo, thermal conductivity, etc.
- properties of forest floor & litter
  - C/N ratio, particle size, etc.



For 314 - Forest Soils (1989)

LECTURE OUTLINE

1. Introduction
   1.1 What is a Forest Soil?
   1.2 Forest Soils and Forest Resources Management - Models

2. Energy Exchange and Soil Temperature
   2.1 Energy transfer in the atmosphere and in soil
   2.2 Daily and seasonal changes in soil temperature
   2.3 Modification of air and soil temperature

3. Soil Water and the Hydrological Cycle
   3.1 Precipitation - vegetation interactions
   3.2 Infiltration, storage and movement
   3.3 Groundwater
   3.4 Soil aeration
   3.5 Soil freezing and frost action
   3.6 Influences upon tree growth
   (?) 3.7 Soil moisture and aeration management

4. Forest Floor
   4.1 Morphology and classification
   4.2 Dynamics
   4.3 Properties

5. Soil and Roots
   5.1 Form and extent
   5.2 Soil properties and root growth
   5.3 Mycorrhizae

6. Nutrient Cycling and Soil Fertility
   6.1 Essential plant nutrients and tree nutrient requirements
   6.2 Nutrient cycling processes
   6.3 Nitrogen and sulfur cycling
   6.4 Phosphorus cycling
   6.5 Potassium cycling
   6.6 Diagnosis of nutrient deficiencies

7. Effects of Site Disturbances and Management Practices Upon Forest Soils
   7.1 Forest fertilization
   7.2 Soil erosion
   7.3 Site preparation
   7.4 Fire
   7.5 Compaction
   (?)

8. Terrain Analysis and Forest Land Classification in Canada
   8.1 Ecological (biophysical) land classification
   8.2 Soil survey

Jan. 1989

"Forestry is not rocket science…
it is way more complicated"
Katalijn MacAfee

Silviculture Toolkit

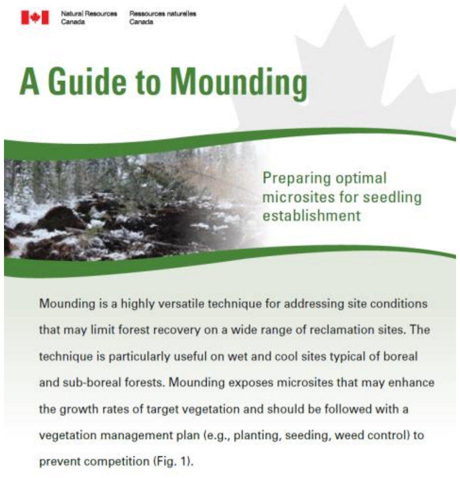
- Performance gap - adoption or technology?
- Recognition of need for active restoration and knowledge transfer
- Boreal reclamation and restoration in oil and gas
  - Often/usually no formal forest science background
  - Workforce intensive (#field workers/ha disturbed)

- Emphasizes capacity building and practice adoption
- Range in media and sophistication
  - Guidebooks (4)
  - Fact sheets (14)
  - Videos (12)

- Collaboration
  - COSIA – NRCan-CFS funding
  - COSIA, CFS, NAIT, Innotech

Fact Sheet

- Portable, instructional, visual
- Moderate detail



Natural Resources Canada   Ressources naturelles Canada

A Guide to Mounding

Preparing optimal microsites for seedling establishment

Mounding is a highly versatile technique for addressing site conditions that may limit forest recovery on a wide range of reclamation sites. The technique is particularly useful on wet and cool sites typical of boreal and sub-boreal forests. Mounding exposes microsites that may enhance the growth rates of target vegetation and should be followed with a vegetation management plan (e.g., planting, seeding, weed control) to prevent competition (Fig. 1).

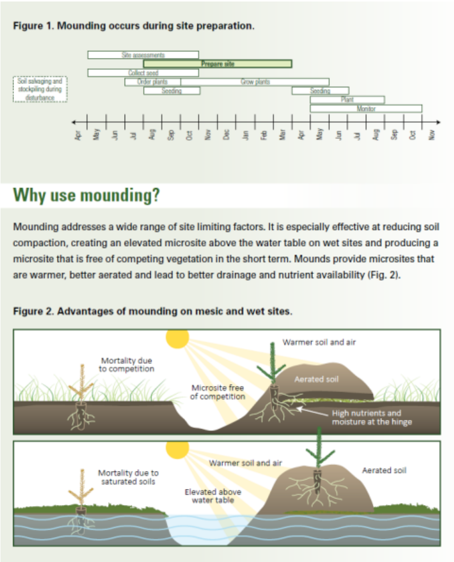
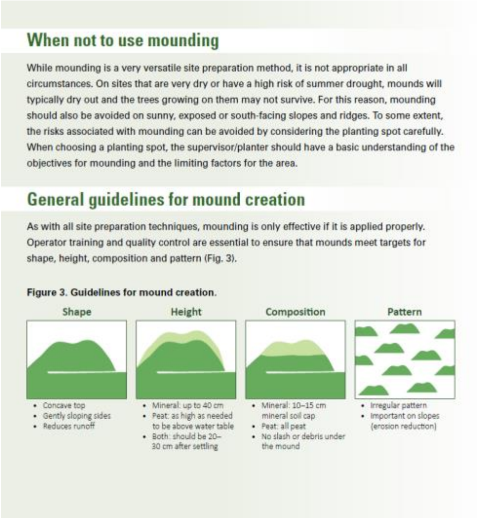


Figure 1. Mounding occurs during site preparation.

Why use mounding?

Mounding addresses a wide range of site limiting factors. It is especially effective at reducing soil compaction, creating an elevated microsite above the water table on wet sites and producing a microsite that is free of competing vegetation in the short term. Mounds provide microsites that are warmer, better aerated and lead to better drainage and nutrient availability (Fig. 2).

Figure 2. Advantages of mounding on mesic and wet sites.



When not to use mounding

While mounding is a very versatile site preparation method, it is not appropriate in all circumstances. On sites that are very dry or have a high risk of summer drought, mounds will typically dry out and the trees growing on them may not survive. For this reason, mounding should also be avoided on sunny, exposed or south-facing slopes and ridges. To some extent, the risks associated with mounding can be avoided by considering the planting spot carefully. When choosing a planting spot, the supervisor/planter should have a basic understanding of the objectives for mounding and the limiting factors for the area.

General guidelines for mound creation

As with all site preparation techniques, mounding is only effective if it is applied properly. Operator training and quality control are essential to ensure that mounds meet targets for shape, height, composition and pattern (Fig. 3).

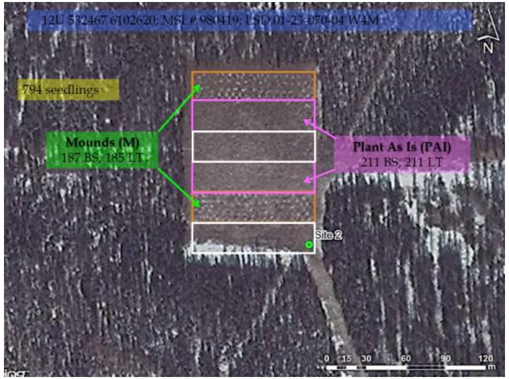
Figure 3. Guidelines for mound creation.

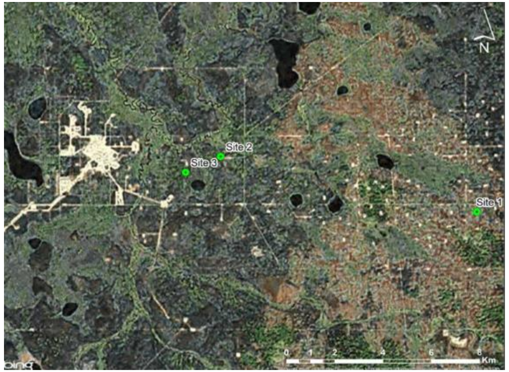
Silviculture video…

- *https://www.kollaborate.tv/player?id=387186&link=5a68c8f92667c

Pilots and Demonstration

- Est. 2008
- Test basic silviculture
- Wet, low productivity forest





Mounding for restoration of treed peatlands; a quantitative evaluation and comparison of treatments

Authors: Javed Iqbal[1], Geoff Sherman[1], Michael Cody[2]*

Introduction:

- Restoration is required for caribou recovery and a key management priority (Boutin 2011; Environment Canada 2012)
- Former seismic lines and wellsites are restoration candidates
- Under passive management, some industry footprint in Northeast Alberta is not returning to tree cover in predictable or adequately rapid successional trajectory (Fig.1)
- Confounding factors such as heavy moss cover (Cogbill 1985), herbaceous competition (Temperton et al. 2004) and high water table (Lieffers 2014) may be causing arrested succession (Kenkel et al. 1997).
- We test intensive silviculture to resolve stagnation and accelerate return to tree cover.
- We hypothesize that seedling growth rate and survival, and volunteer woody ingress, will improve with mounding.

Methods:

- Three wellsites with characteristics of arrested succession approximately 10 years after disturbance were selected
- A block design with a control (no treatment), plant as is (PAI), and mound and plant (M) were established (Fig.2)
- Treatments were established in 2008; plots were planted with 1+0 larch (*Larix laricina*) and black spruce (*Picea mariana*) seedlings
- Sites were revisited and measured for tree growth (height and root-collar diameter) as well as ingress of volunteer woody species
- Statistics were conducted using a T test for difference between planting treatments. Mann-Whitney Rank Sum Test was performed and U statistic used due to unequal sample sizes

Figure 1: recovery stagnant decades after disturbance

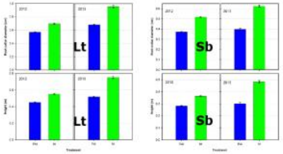


Figure 3: larch (Lt) and black spruce (Sb) growth 4 and 5 years following plant-as-is (PAI) and mound/plant (M)

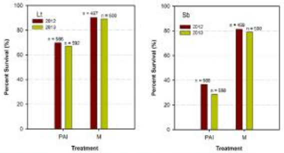


Figure 4: larch (Lt) and black spruce (Sb) survival 4 and 5 years following plant-as-is (PAI) and mound/plant (M)

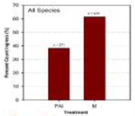


Figure 5: ingress on plant-as-is (PAI) and mound/plant (M) after 5 growing seasons

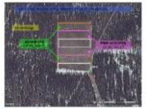


Figure 2: treatment block design established on 3 well sites

Figure 6: restoration with silviculture

Results and Discussion:

- Growth and survival of larch and black spruce significantly better on mounded micro-site (Fig. 3 & 4)
- Ingress of volunteer woody species significantly better on mounded micro-site (Fig. 5)
- Minimal disturbance and passive management assume that with sufficient time and intact soils, forest recovery will occur. This chronosequence view of forest dynamics assumes a single successional trajectory, ignores confounding factors, and results in misleading and oversimplified predictions of vegetation trajectory and future state (Kenkel et al. 1997)
- Restoration of stagnated footprint likely requires intensive silviculture if confounding filters (Polster 2011) are to be resolved within a timeframe that may support caribou recovery efforts (Fig. 6)
- Minimal disturbance approach conceptually appealing but evidence shows inconsistency with desired ecological condition (Kimmins 1999)
- An evidence-based approach to disturbance and recovery, and a more adequate successional model are required

References:

Boutin S 2011 Quoted in the Edmonton Journal article "Senseless slaughter of wolves: Alberta has a policy of killing wolves to protect caribou. It's not working" By Ed Struzik, edmontonjournal.com June 11, 2011

Cogbill CV 1985 Dynamics of the boreal forests of the Laurentian Highlands. Can. J. For. Res. 15:252-261

Lieffers VJ. Personal communication, Feb 25, 2014

Kenkel NC, Walker DJ, Watson PR, Caners RT, Lastra RA 1997 Vegetation dynamics in boreal forest ecosystems. COENOSES 12(2-3): 97-108

Kimmins JP 1999 Biodiversity, Beauty and the "Beast": Are beautiful forests sustainable, are sustainable forest beautiful, and is "small" always ecologically desirable? The Forestry Chronicle 75(6): 955-960

Polster DF 2011 Effective reclamation: Understanding the ecology of recovery. 2011 Mine Closure Conference and BC Technical and Research Committee on Reclamation, BC Mine Reclamation Symposium. Lake Louise, AB Sept. 18-21.

Temperton VM, Hobbs TN and Halle S 2004 Assembly Rules and Restoration Ecology. Island Press. Washington, DC 439 pp.

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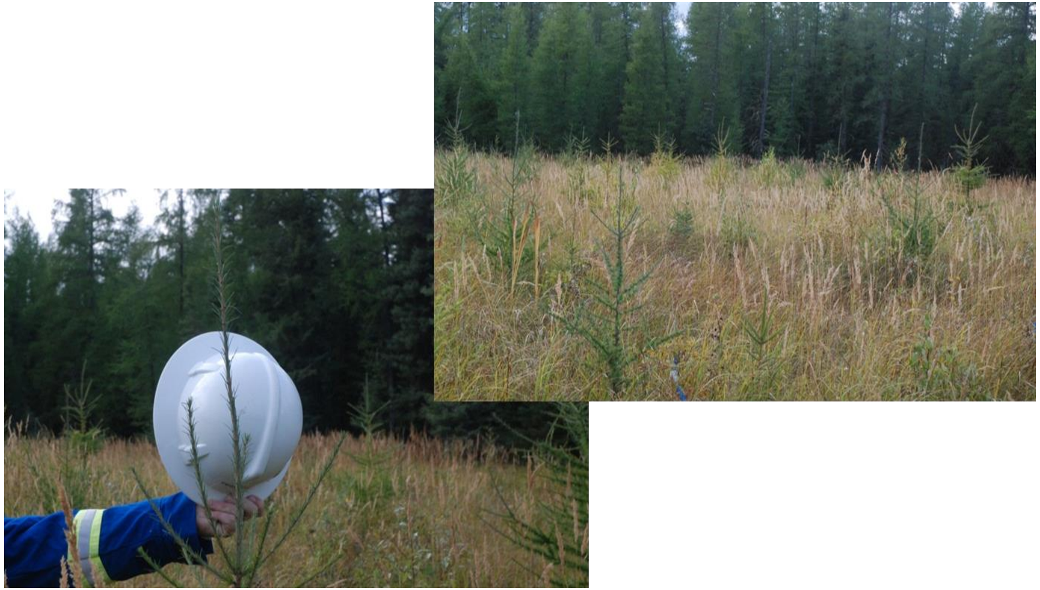
Active restoration (silviculture) works!

Control stagnant under passive revegetation since 1997



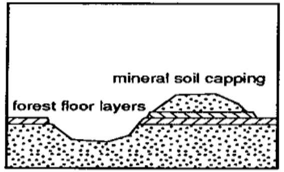
Treated with silviculture in 2008

Active restoration works

Mounding literature

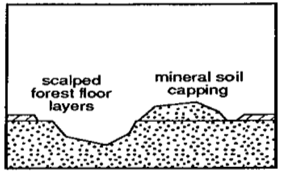
SUMMARY

Inverted humus mounds



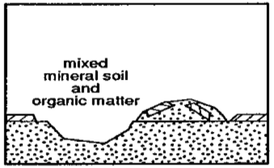
- good on nutritionally poor sites;
- good for rich sites with fine textured soil;
- not recommended for drought-prone sites or sites with deep, loose duff.

Mineral mounds



- best for cold, but slightly drought-prone sites.
- not recommended for nutritionally poor sites.

Mixed mounds



- best for slightly drought-prone, nutrient-poor sites,
- not recommended for sites with abundant competing vegetation;
- avoid creating large chunks of organic matter that cause air pockets.

NOTE: None of these mound types is recommended for sites with a significant risk of summer drought.

Reference: Mounding for Site Preparation, FRDA Memo No. 100, **July 1989**;
http://www.for.gov.bc.ca/hfd/pubs/docs/Frm/frm100.pdf

Applied investigation in restoration

Historical Mounding

Est. 2008

Compare active vs. passive approach

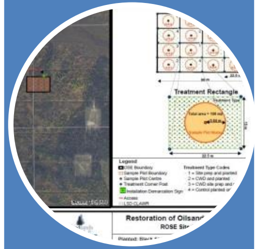
Test basic silvicultre for application in oil and gas

LiDea I

Est. 2011

Pilot linear deactivation

Test linear restoration techniques & monitor at site level



ROSE

Est. 2012

Restoration of OSE* sites

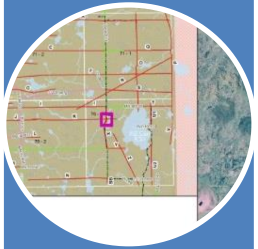
Test a range of silviculture tools

LiDea II

Est. 2013

Forest Habitat Restoration

Test plant and animal response at site, individual and population levels



South LiDea

Est. 2016

Forest Habitat Restoration

Operational and multi-party

Extension of LiDea

CLARA

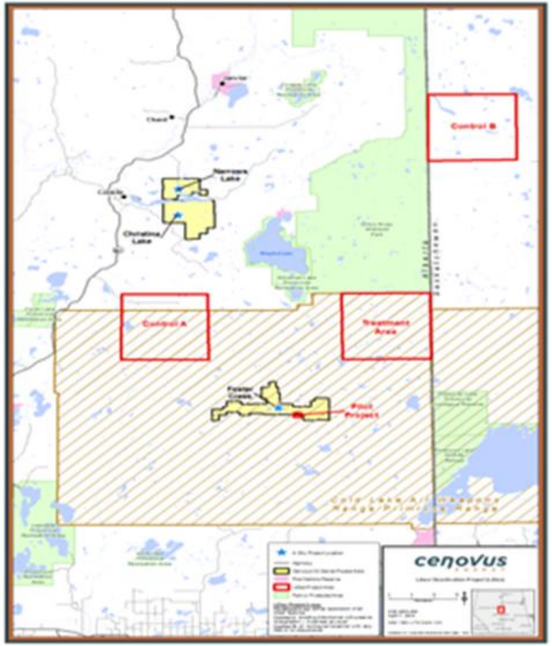
Est. 2016

Forest Landscape Restoration

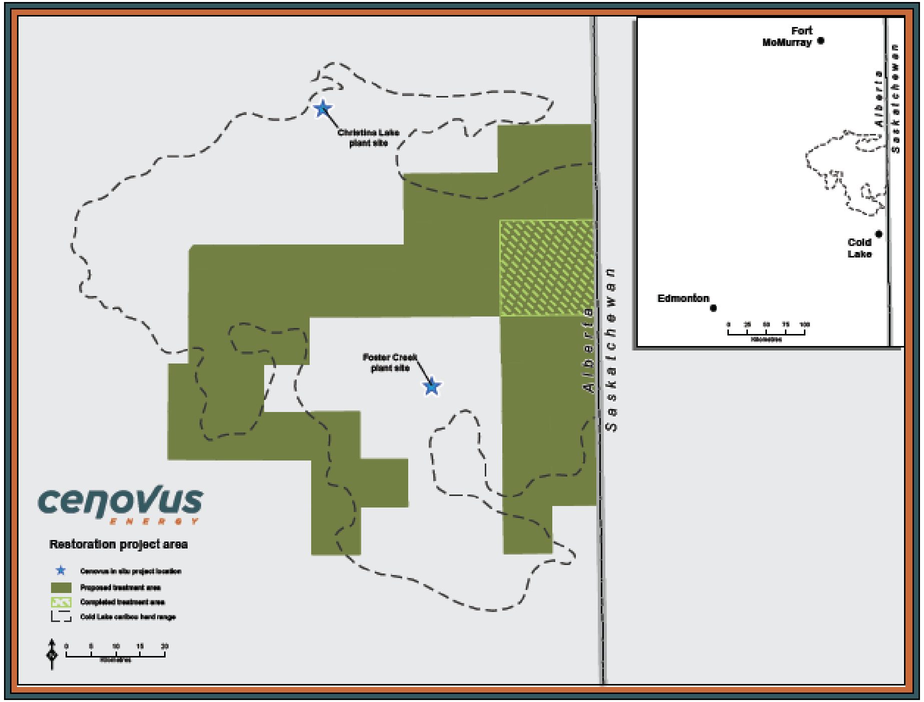
Apply LiDea techniques to range

Linear deactivation (LiDea) project

- Forest habitat treatment for restoration
- Mounding, planting and stem bending
- Objectives:
    - ↑ conifer abundance/growth
    - ↓ trafficability/sightlines
    - restore species distribution
    - adaptive, operationally viable methods
    - controlled design – measured/monitored
    - https://www.youtube.com/watch?v=7rzqMvc4-w0

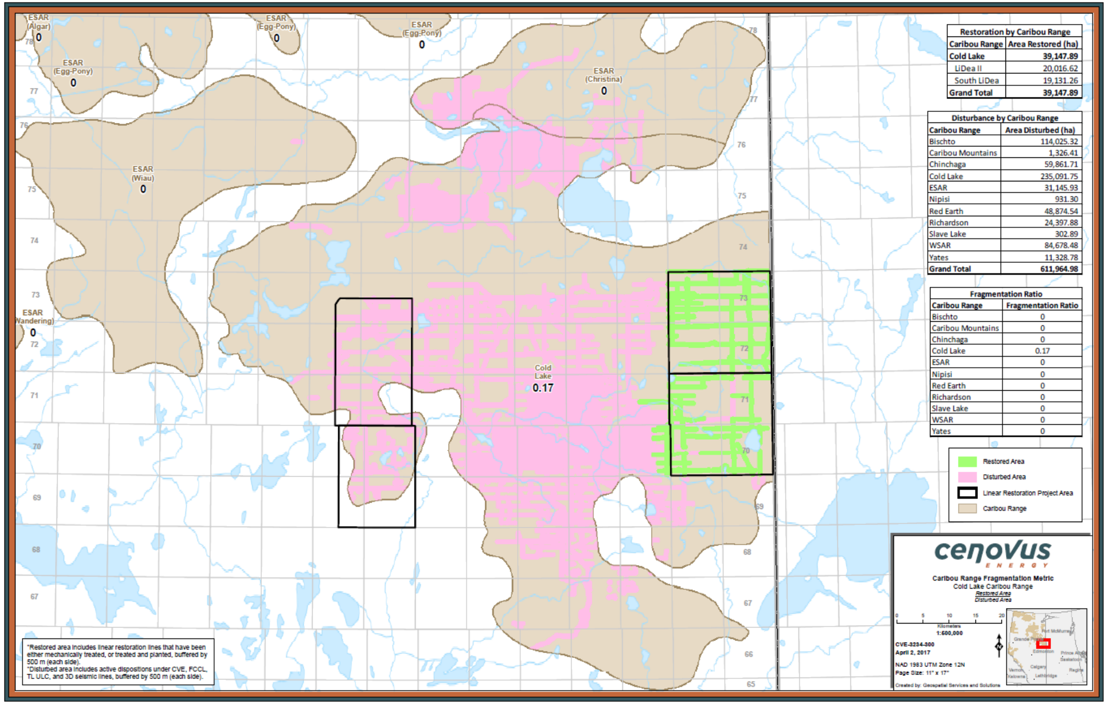


Cenovus Caribou Habitat Restoration Project



Herd Range:	672,422 ha
LiDea:	36,864 ha
CCHRP :	≈ 390,000 ha
Spend:	$32MM

How is restoration proceeding?



Restoration by Caribou Range

Caribou Range	Area Restored (ha)
Cold Lake	**39,147.89**
LiDea II	20,016.62
South LiDea	19,131.26
Grand Total	**39,147.89**

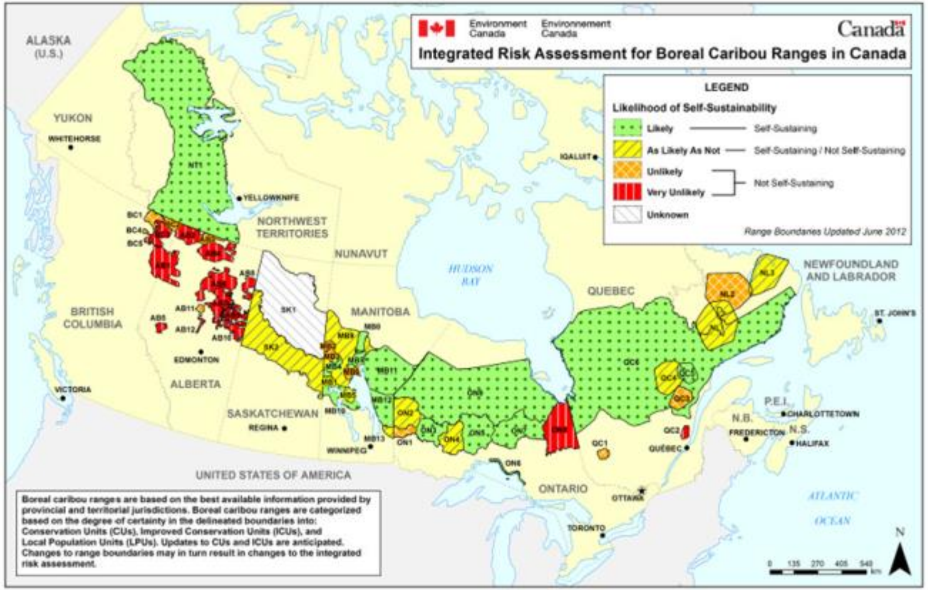
Disturbance by Caribou Range

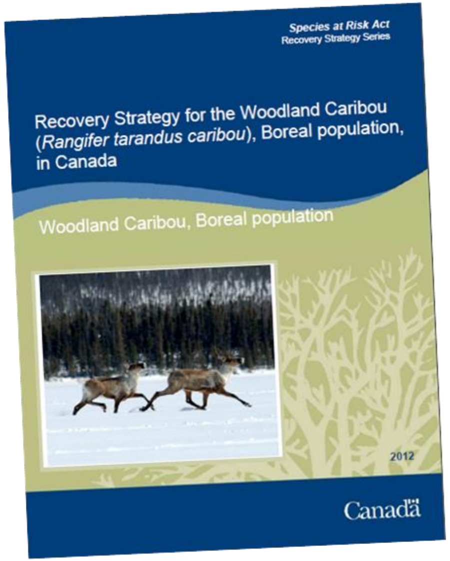
Caribou Range	Area Disturbed (ha)
Bischto	114,025.32
Caribou Mountains	1,326.41
Chinchaga	59,861.71
Cold Lake	235,091.75
ESAR	31,145.93
Nipisi	931.30
Red Earth	48,874.54
Richardson	24,397.88
Slave Lake	302.89
WSAR	84,678.48
Yates	11,328.78
Grand Total	**611,964.98**

Fragmentation Ratio

Caribou Range	Fragmentation Ratio
Bischto	0
Caribou Mountains	0
Chinchaga	0
Cold Lake	0.17
ESAR	0
Nipisi	0
Red Earth	0
Richardson	0
Slave Lake	0
WSAR	0
Yates	0

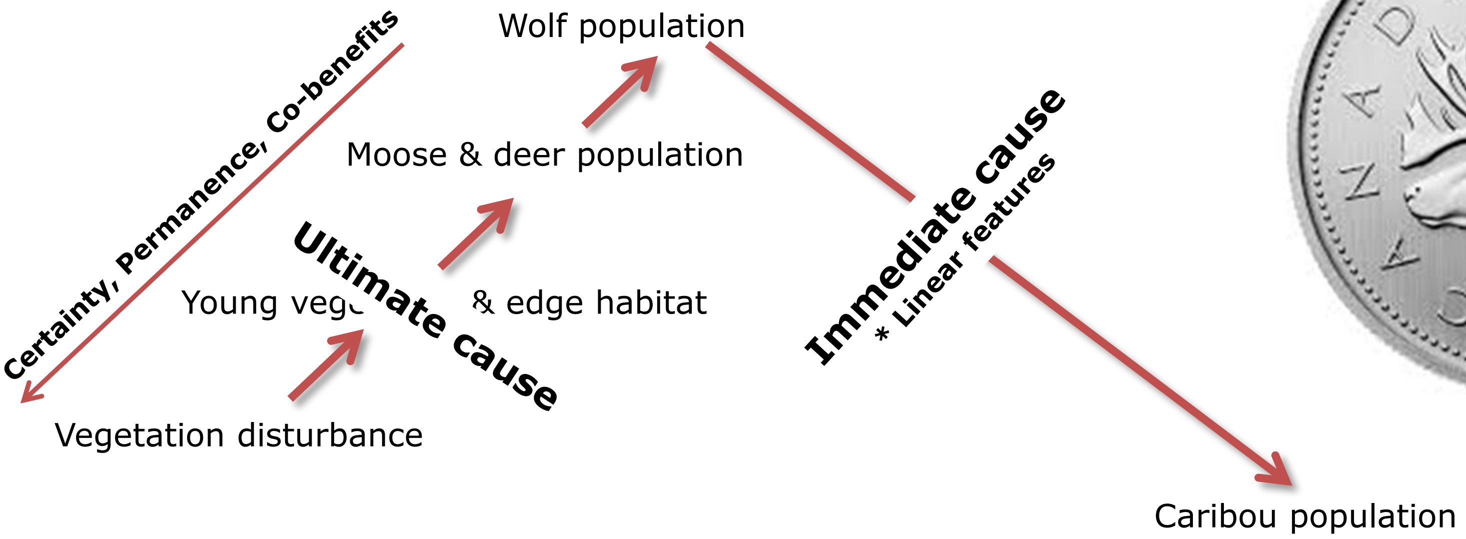
Caribou population decline





Woodland Caribou

- Decline related to habitat disturbance



We attempt to address both immediate and ultimate causes

A rare success story…

- West Moberly and Saulteau First Nations
- Mountain Caribou Recovery Project
- Integrated approach
- * predator control
- * maternal penning
- * restoration
- Reversal of population trend
- Community engagement is key

"…a great training program and I gained valuable knowledge that I still use today."

- *Dan Piche*

Coaching, Mentorship, Apprenticeship

- Interactive and experiential
- Formal and informal approaches
- Capacity growth
- Transcends learning styles, backgrounds and abilities
- Can be delivered anywhere
- Applied learning

Imagine…

Source: “Trees are not enough; accelerated reclamation of our land footprint”.
Michael Cody, Cenovus Innovation Summit, April, 2011