LAND CAPABILITY CLASSIFICATION OF RECLAIMED LANDS IN ALBERTA – HISTORY AND FUTURE

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Presentation Outline

- **Pre 1990**
  - The background to land evaluation systems for reclaimed lands for agriculture and forestry
- **1990 to 2015**
  - Development, implementation and review of the reclamation capability systems
- **2015 onward**
  - Continuation of agricultural land capability: discontinuation of forestry land capability
  - Implementation of an ecosystem approach
  - Plot monitoring
  - Research projects
  - New developments for forest land reclamation
  - A vision for the future

The Beginning…

Pre-1990s

Key Provincial Acts

- The *Surface Reclamation Act* was enacted on June 1, 1963 making Alberta the first province to enact legislation on land reclamation

- *The Land Surface Conservation and Reclamation Act, 1973* replaced the *Surface Reclamation Act*

Land Evaluation

- First Environmental Impact Assessment under the new legislation was completed for Syncrude Canada's Mildred Lake Mine and Processing Plant. Operations began in 1978

- The need for procedures became apparent
  - Pre- and post-disturbance land capability evaluation for agriculture and forestry

- Began by modifying the Land Capability Classification used for natural land uses
  - The focus for agriculture was returning land to produce common crops
  - The focus for forest lands was growing the same tree species and similar productivity

The Canada Land Inventory (CLI) 1965

- Federal-provincial project that produced maps indicating the capability of land to sustain:
  - **Agriculture**
  - **Forestry**
  - Recreation
  - Wildlife
- Geographic extent was all of Canada except the North

Land Capability Classification for Agriculture 1965

- Mineral soils are grouped into 7 classes and 13 subclasses based on climate, soils, landforms and potential for production of field crops
- Organic soils are not a part of the classification
- Alberta does not have Class 1 lands due to climatic limitations

Canada Land Inventory (1965)

Canada Land Capability for Forestry 1965

- Mapping of land capability for forestry on natural lands
  - Rated according to 7 classes based on its capability to grow commercial timber
  - Areas stocked with the optimum number and species of trees
- Applies to land in its natural state – no fertilization, drainage, or amelioration practices
- Classes are based on productivity
  - In Alberta classes 1 and 2 were not found – productivity levels > 91 cubic feet per acre per year, were not attainable in our climate
  - Mapped five classes, 3 to 7

Canada Land Inventory (2002)

International Use of Land Capability

Canadian land capability rating systems are similar to others abroad

- New Zealand (1950s) – Agriculture and Forestry
- USA (1950s) – Agriculture
- United Kingdom – Forestry

1963 1965 1973 1990 1995 2015

efotg.sc.egov.usda.gov, Lynn et al. 2009, www.hutton.ac.uk, Image K. Dlusskiy

Alberta: *Soil Quality Criteria Relative to Disturbance and Reclamation*

- A comprehensive guide to assist those involved in soil reclamation
  - A scientific, technical soil manual for use by professionals
  - Published in 1981 and revised in 1987, and continues to be used today
- Focus is on surface and subsurface soil materials and their suitability
  - Based on physical and chemical properties in relation to plant growth
  - Parameters are rated as *Good, Fair, Poor,* or *Unsuitable*
- Soils are rated for three regions
  - Plains
  - Northern forest region
  - Eastern slopes

Alberta Soils Advisory Committee (1987).

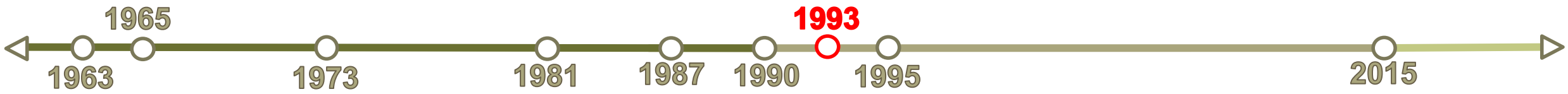
Arrival of Reclamation Capability

1990 to 2015

1990s: Arrival of Reclamation Capability

- Proposals for coal mining on the plains and oil sands mining in the northern forest necessitated development of procedures for evaluating lands pre- and post-disturbance

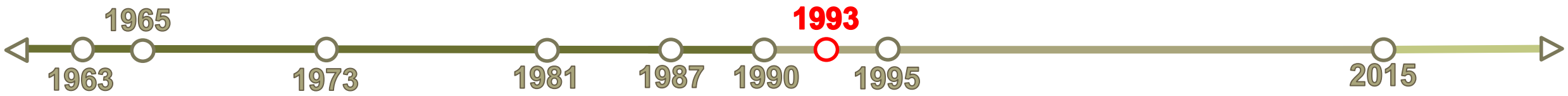
- **Equivalent Land Capability**: The ability of the land to support various land uses after conservation and reclamation is similar to the ability that existed prior to an activity being conducted on the land (Province of Alberta 1993)



CONSERVATION AND RECLAMATION REGULATION, Alberta Regulation 115/1993

Agricultural Capability Classification for Reclamation

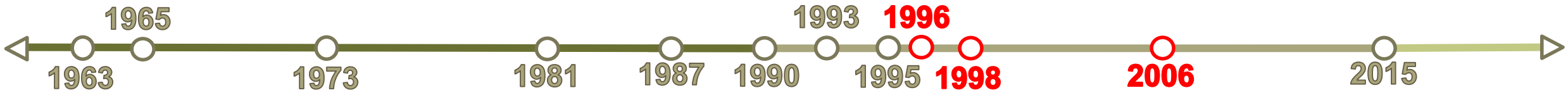
- Developed in 1993 by a team of government, consulting, and industry members
- 5-class system adapted from CLI, with ratings for
  - Moisture regime plus limitations for soil parameters closely related to the soil quality criteria
  - Landscape (slope, stoniness, erosion)
  - Implied ability to support vegetation (composition, cover, health, productivity)
- System was used extensively in prairie coal mines and sand and gravel pits, and it worked very well



Leskiw, L. A. (1993)

Land Capability Classification System for Forest Ecosystems

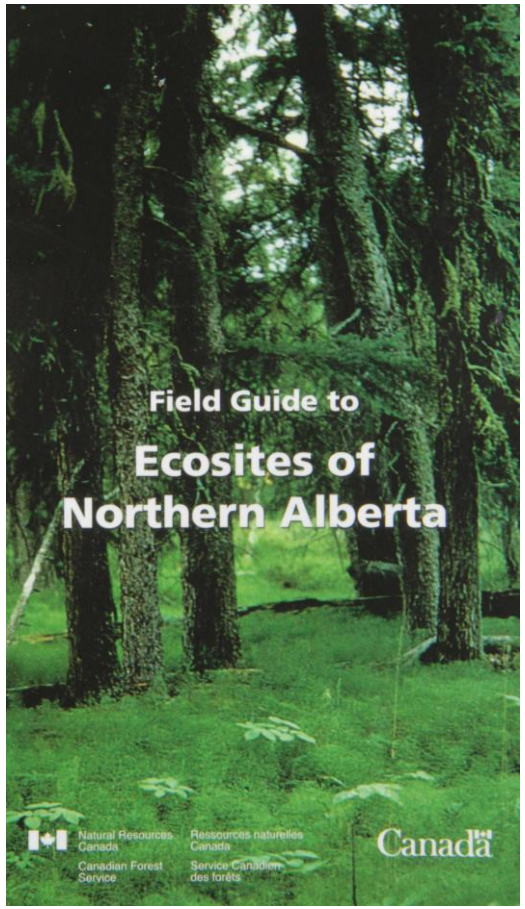
- Three editions: 1996, 1998, and 2006
- 5 classes of land rated according to potential and limitations for productive forest use
  - Classes 1, 2, and 3 support commercial forests: Classes 4 and 5 are non-commercial
  - Productivity, measured by site index, declines 20% per class from Class 1 to 5
- Soil and landscape parameters rated include
  - Soil moisture and nutrient regimes
  - Potentially limiting soil physical and chemical parameters
  - Across three principal horizons (0 to 20, 20 to 50 and 50 to 100 cm)
- The plan was to continue establishing and monitoring plots and refining the system as necessary, but further revisions were not made

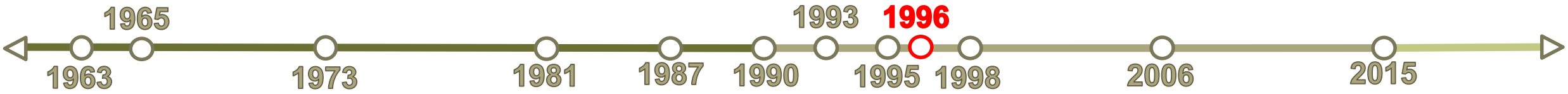


AENV (2006)

Field Guide to Ecosites of Northern Alberta

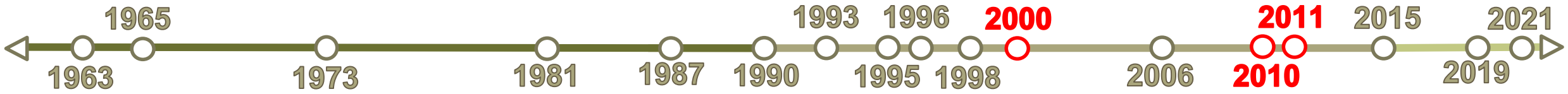
1996 edition by Beckingham provided the first comprehensive characterization of forest ecosites applicable to the oil sands region and was used until 2019





Cumulative Environmental Management Association (CEMA)

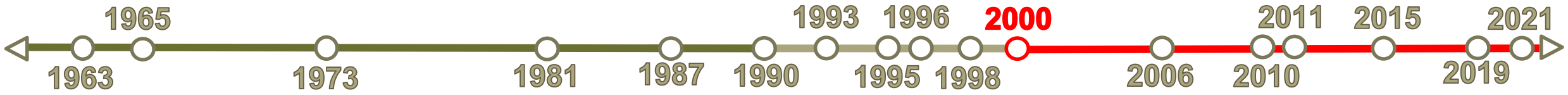
- A long-term plot network (LTPN) program was established in 2000 to measure soil, vegetation, and forest parameters at five-year intervals in natural and reclaimed sites
- The results were used to calibrate and update the capability classification
- After review in 2010 and 2011, the program was modified into an effectiveness monitoring program (EMP), and now discontinued



Paragon (2015)

University of Alberta Research Projects

- Research studies in the oil sands focusing on soils and/or vegetation
  - More than 25 MSc and PhD research studies at U of A, plus more from other Universities
  - Mostly since 2000
- Two examples are presented
- Shaughnessy (2010, 2022) examined natural recovery of vegetation on reclamation stockpiles at Suncor after 26 to 34 years
- Results suggest natural recovery of upland boreal forest on lowland peat substrate is possible and can support evolving plant communities

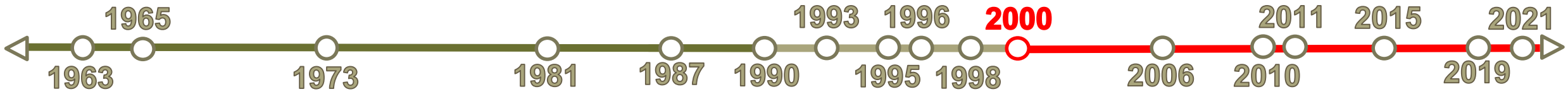


Initial conditions 1976 after winter placement of waterlogged substrate

Plant community growth typical of all sites in 2007

University of Alberta Research Projects Cont'd

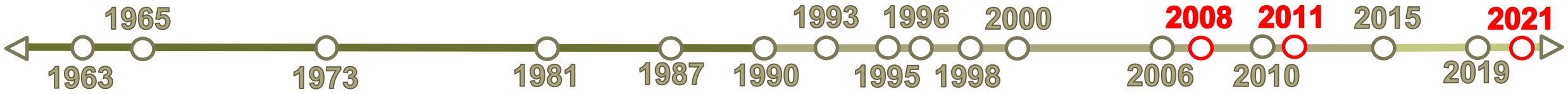
- Ojekanmi (2018) used CEMA natural and reclaimed plot data to clearly define specific relationships among soil parameters in relation to vegetation growth in aspen, pine, spruce and mixed stands
  - Offers an approach to define soil parameters in the edatope in relation to vegetative moisture and nutrient requirements
  - The resolution is greater than in the capability system or the definition of nutrient and moisture regimes in the current ecosite guides
- Soil quality parameters examined
  - AWHC, CEC, EC, N, P, SAR, SOC, SOM, Ca, Na, Mg, Fe, texture
  - Litter, mineral soils, peat, peat-mix, topsoil, upper subsoil, lower subsoil
  - Moisture and nutrient regimes



Ojekanmi (2018)

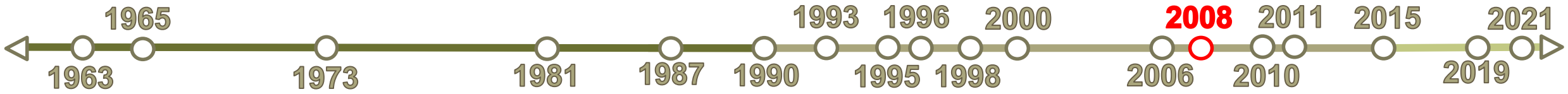
Other Important Reports

- CEMA review by Timberline Natural Resource Group Ltd. 2008
- Oil Sands Research and Information Network (OSRIN) workshop, 2011
- Syncrude Plots, 2021



CEMA Review of Plot Network by Timberline, 2008

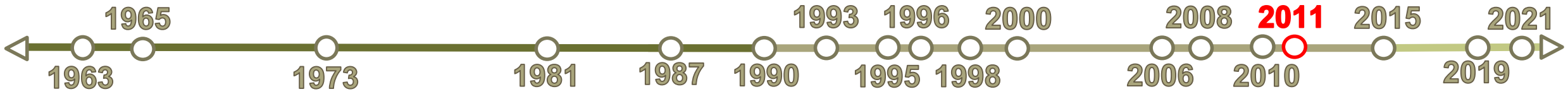
- The land capability rating for **natural sites** works reasonably well, forest productivity is higher on better capability ratings for aspen and white spruce
- On **reclaimed lands** the tree productivity is fairly uniform across capability classes. Productivity of reclaimed sites matches or exceeds productivity on natural sites
- Most reclaimed sites are on the equivalent of *b* and *d* ecosites. To date there are few plots on *a*, *e*, and wetter sites



Timberline (2008)

OSRIN Workshop, 2011

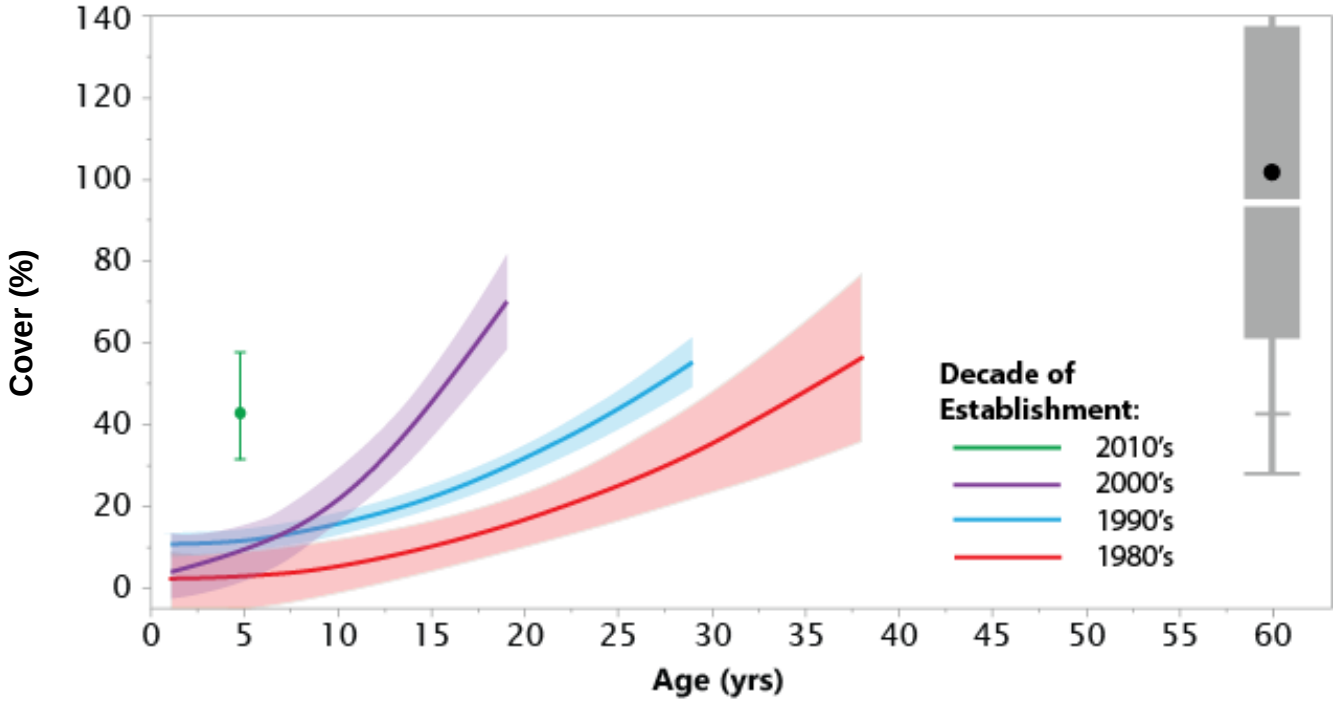
- There was a lot of discussion about what equivalent land capability means. In the early years the focus was return to forest productivity: later it shifted to multiple uses with an emphasis on understory recovery
- The LCCS does not adequately address wetlands
- Poor match of capability to forest productivity on reclaimed soils but good on natural soils
- Studies need to cover a broader range of soil moisture and nutrient regimes
- Need to address traditional land uses
- Reported that agriculture capability system works very well and has been successful on coal mines and other applications



OSRIN (2011)

Syncrude Plots, 2021

- Syncrude reviewed 39 years of plot data from 182 plots on reclaimed lands – mainly *b* and *d* ecosites
- Results are very promising: 58% of **target** species found and 90% of **characteristic** species
- There is not a good differentiation among ecosite types



Trends in cover of understory Target Species by reclamation age

Farnden (2021)

Some Key Findings from the Above Reports

- Agricultural capability works well for natural and reclaimed lands
- Forestry capability works well for natural lands but not for reclaimed lands in terms of forest productivity objectives
- Key capability limitations for reclaimed forest lands are:
  - Ratings do not reflect forest productivity on reclaimed lands, although reclaimed lands are producing equally or better than native lands
  - Does not define ecosite types
  - Does not rate other uses, wetlands, traditional uses, recreation, wildlife

Reclamation has Improved each Decade

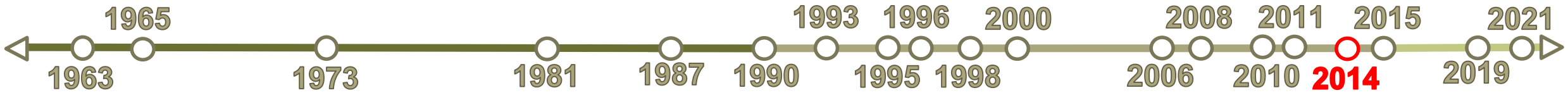
- Discontinued:
  - Domestic grass covers initially planted for erosion control inhibited native species encroachment
  - Exotic tree species, for example, Siberian Larch
  - Soil cultivation, which destroyed propagules and reduced seed bank
  - Widespread fertilization which supported aggressive species

- Introduced:
  - Direct placement of LFH, to enhance seed bank and propagules
  - Mounding and Rough Loose surface, to improve microsites and revegetation
  - Native seed collection programs on surrounding native lands for greenhouse production and planting on reclaimed lands

Termination of LCCS for Oil Sands, 2014

- The Land Capability Classification System (LCCS) was developed as a tool for assisting in the planning process and for evaluation of land capability for forestry/productivity – it is based primarily on soils and landscape features
- It provided a basis for comparing pre- and post-disturbance landscape for oil sands developments
- More recently, limitations with the use of this system have been identified
  - Lack of alignment with current emphasis on targeting natural ecosites in revegetation
  - Correlation of capability classes and site index was poor

AER Bulletin 2014-31



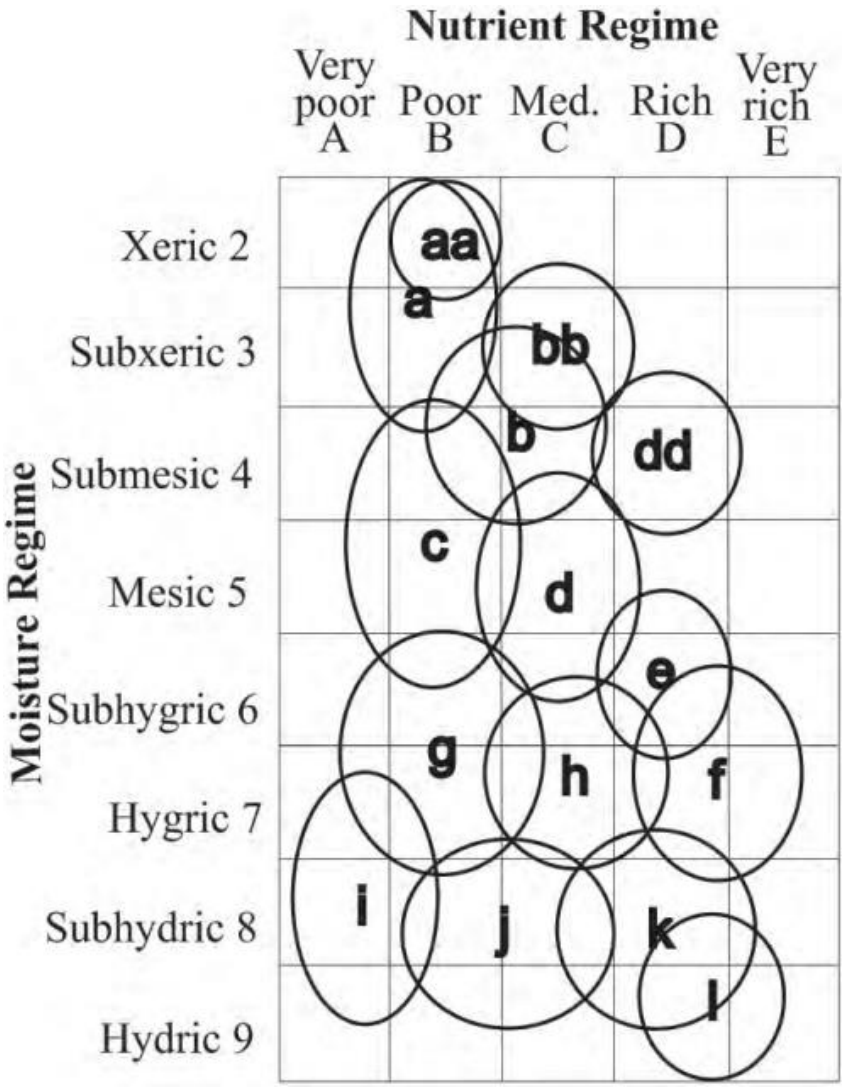
Major Successes

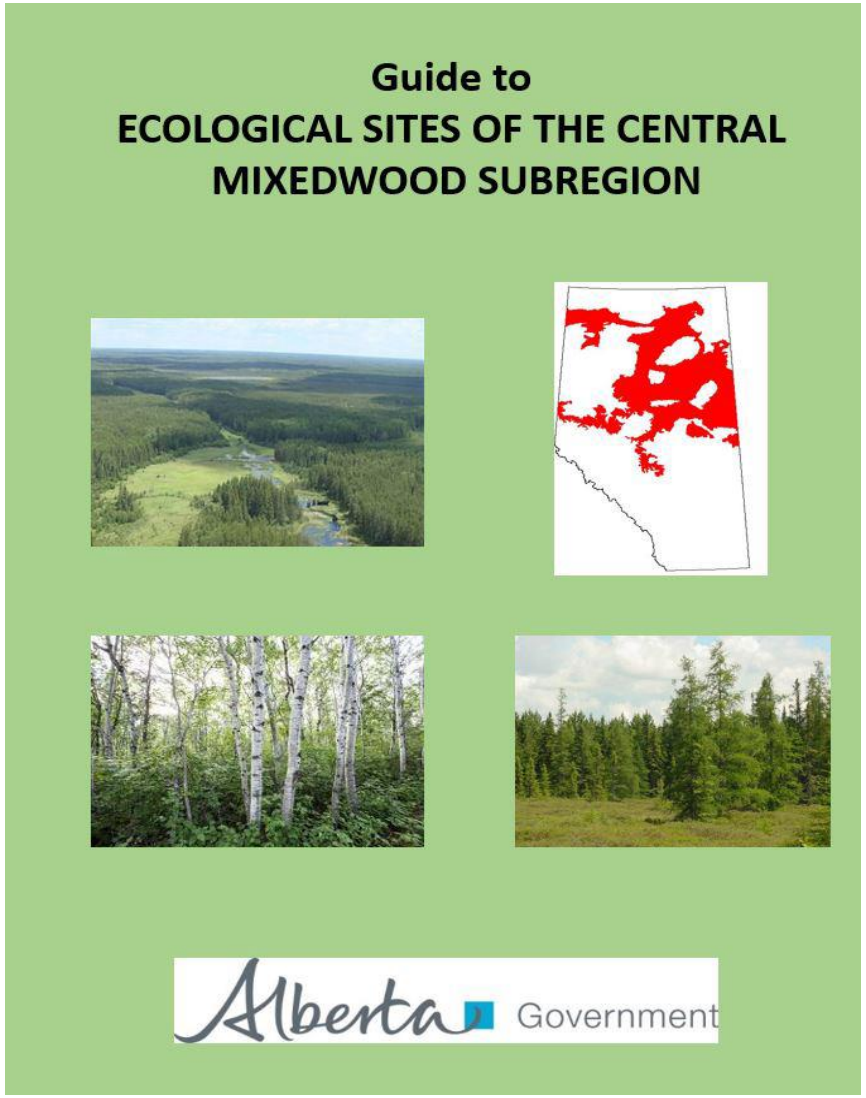
- Excellent erosion control
- Equivalent or better tree productivity
- Diverse vegetative covers with abundance of native species
- Understanding of individual research components
  - Soil moisture
  - Soil nutrients
  - Soil microbiology
  - Vegetation communities
- Build upon these past successes to develop more precision

The Future…

- Land capability for forest lands is discontinued
- Edatope is the focus
- The reclamation goals are now expanded to include:
  1. Commercial forests
  2. Fish and wildlife habitat
  3. Opportunities for traditional uses
  4. Opportunities for recreational uses

Focus is Edatope, 2019





The Challenges in Response to Changing Needs

- **Ecosites**
  - Distinguish *b* and *d*
  - Require *a*
  - Require *e* and wetter ecosites
- **Soils**
  - Require a more definitive characterization of moisture regime and nutrient regime in the edatope
  - Require new prescriptions and new reclamation practices to achieve these additional ecosites
- **How to demonstrate equivalent land capability?**

Target Ecosites

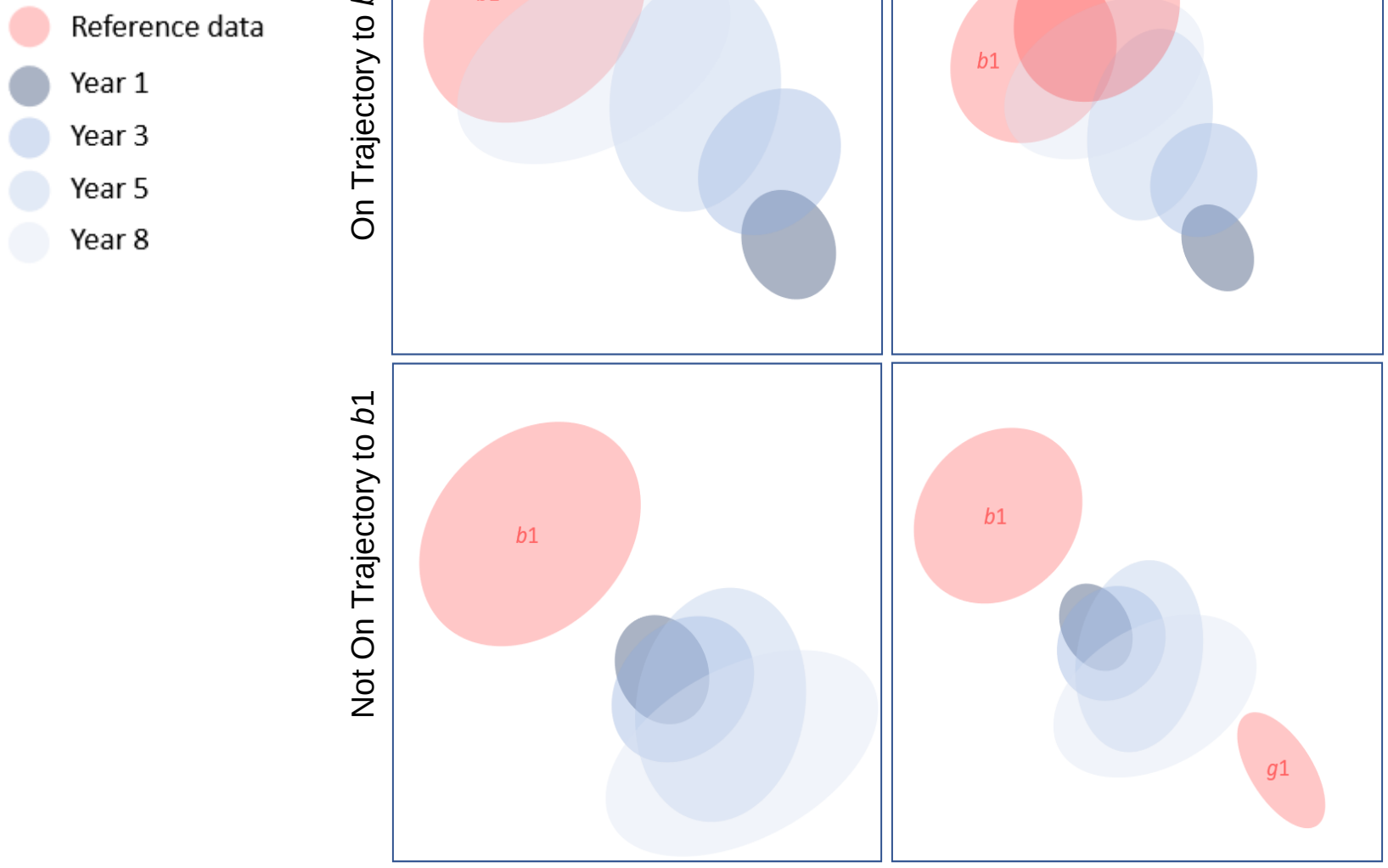
- Compares relevant data collected for the various soil and vegetation parameters to thresholds or guidelines from existing systems

- Considers the collected data and thresholds, in concert, to determine if a site or landform is on trajectory to meet the target ecosite(s) and achieve reclamation success

- Success is a self-sustaining, locally common boreal forest ecosystem integrated with the surrounding area, one that returns an acceptable distribution of upland ecosite phases and wetland types on the post-disturbance landscape

Logan et al. 2019

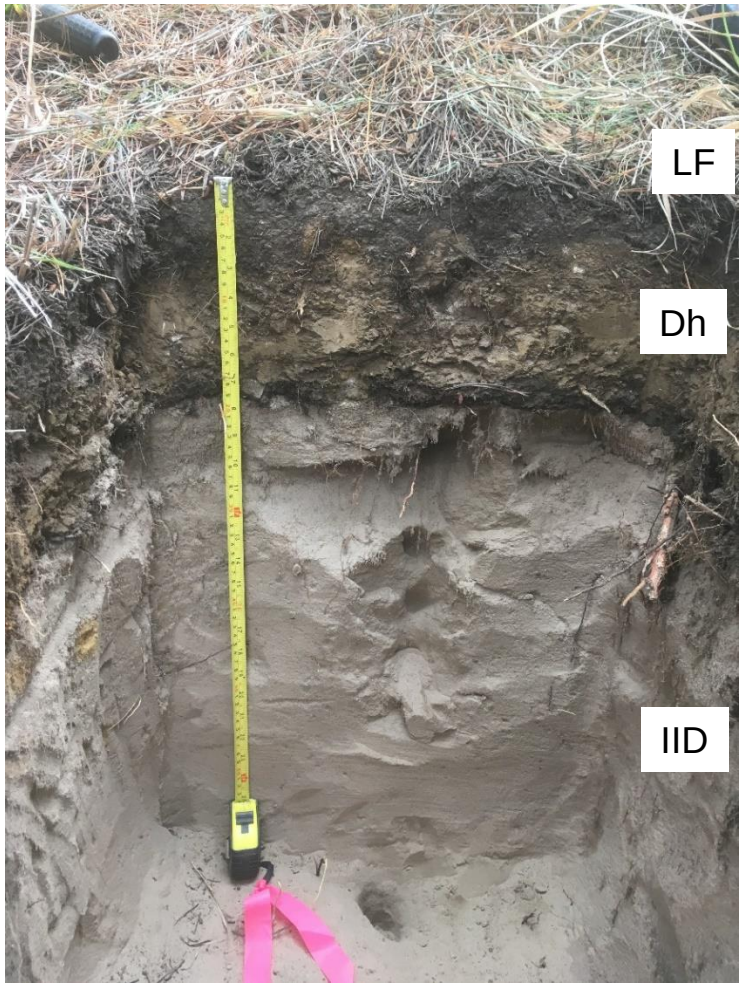
Target Ecosites



Soils and the Edatope

- On reclaimed sites the vegetation community does not necessarily define the soil moisture and nutrient regimes
  - Peat-mineral mix has an overriding influence masking the underlying soil properties
- Will need a more careful look at soil morphology and genesis of reclaimed profiles
- Apply the Anthroposolic classification
- Will need improved measurement techniques, applying new technology, consider adaptations from precision agriculture (e.g., sensors to measure moisture and nutrients)

Soil Morphology: Tailings Pond Dyke



Reclaimed area in the Athabasca oil sands region – peat mineral mix on tailings sand

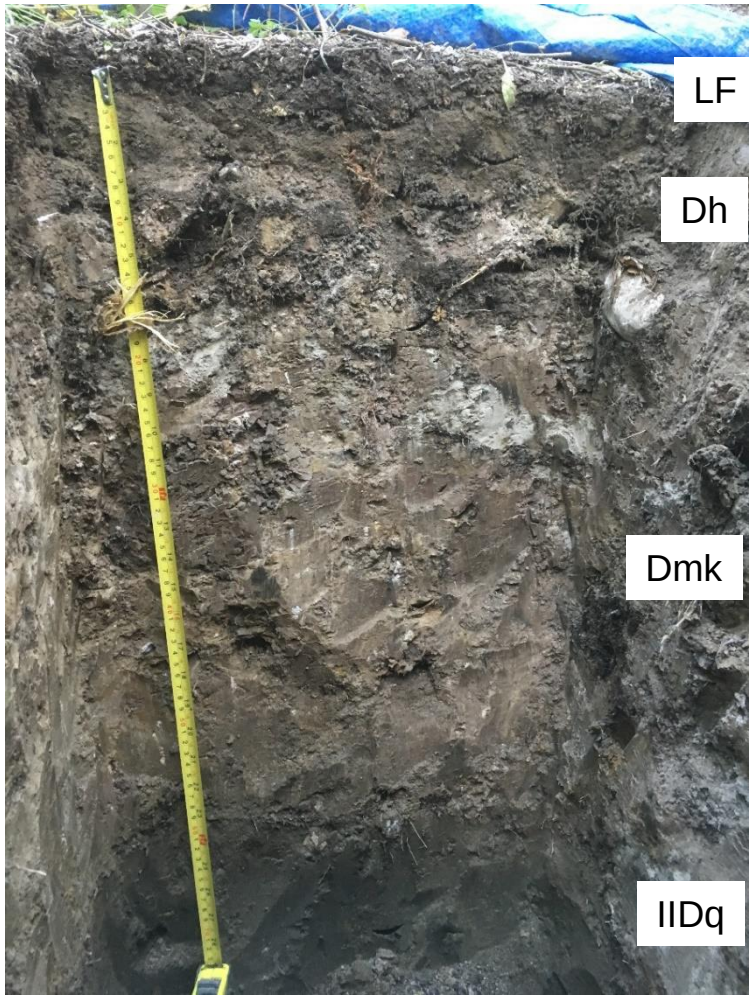
Horizon	Depth	Colour	Texture	Structure
LF	3-0			
Dh	0-18	10YR 3/4	fSL	M-M-SBK
IID	18-100	10YR 4/3	fS	SG

Development of LF indicates beginning of boreal soil formation

Fusco Spolic Anthroposol – dystric phase

Source of the slide: **Dlusskiy K.** 2018. The Anthroposolic Soil Order. In: Governments and people. 2018 Alberta Institute of Agrologists AGM and Conference (Banff, AB)

Morphology: Three Layer Placement on Waste Rock Pile



Reclaimed area in the Athabasca oil sands region – peat mineral mix on fair quality subsoil over unsuitable overburden material

Horizon	Depth	Colour	Texture	Structure
LFH	4-0			
Dh	0-16	10YR 2/2	L	W-M-GR
Dmk	16-64	10YR 3/4	CL	W-M-ABK
IIDq	64-100	10YR 2/2	SL	MA

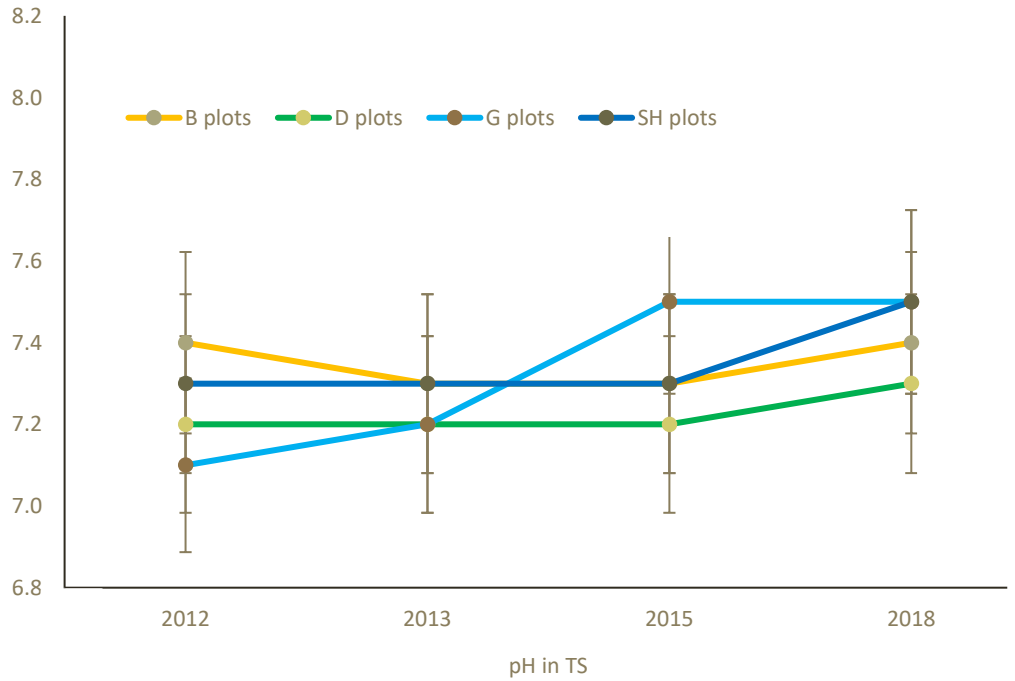
Development of LFH and slight alteration in Dm indicate progress of boreal soil formation

Fusco Spolic Anthroposol – calcareous hydrocarbic phase

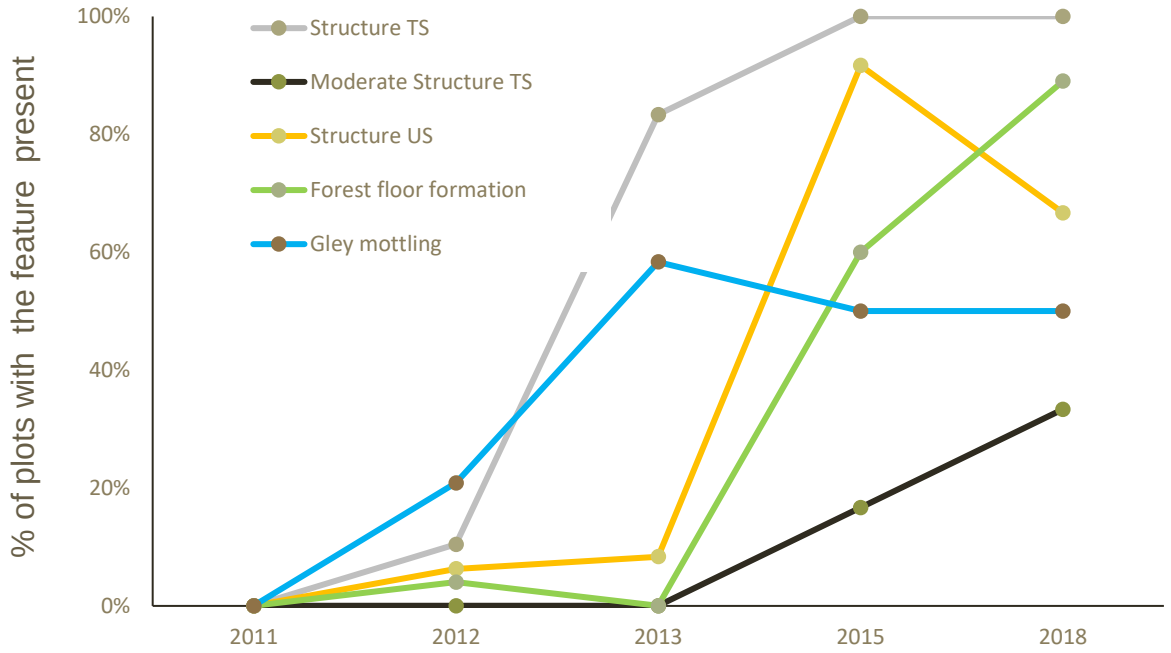
Source of the slide: **Dlusskiy K.** 2018. The Anthroposolic Soil Order. In: Governments and people. 2018 Alberta Institute of Agrologists AGM and Conference (Banff, AB)

Chemical vs. Morphological Changes

pH



Morphology



Dlusskiy K. 2019. Initial soil development on reclaimed land. In: Soil resilience and extreme events. 56th Alberta Soil Science Workshop, Program (Calgary, February 2019) p. 23

8 Year-Old Reconstructed Riparian Areas

- Reconstructed fish habitat compensation lake with surrounding riparian areas at Kearl Oil Sands site
- Materials – slightly stony glacial till, two-lift placement
- Northern Alberta, mixedwood forests

2012 (B2)

2018 (B2)

Dlusskiy K. 2019. Initial soil development on reclaimed land. In: Soil resilience and extreme events. 56th Alberta Soil Science Workshop, Program (Calgary, February 2019) p. 23

Proposed Anthroposolic Order 2022

- Last year an update to the Anthroposolic Order was prepared and this year the *Canadian System of Soil Classification* is being revised and will include the addition of the Anthroposolic Order
- Difficult to find good examples of soil profiles on various reclamation prescriptions and this is true across Canada
- The information is available but it is “confidential”

- **A provincial/national database is needed to allow better communication about and understanding of reclaimed soils**

Naeth et al. (2022)

A New Era: Precision Reclamation

- The Edatope is the focus
- Micro, meso, macro landscape scales
- Vegetation and soil monitoring on natural and reclaimed plots for all target ecosites
- Modify soil prescriptions to meet moisture and nutrient regime requirements
- Identify and manage areas requiring weed control
- Implement technology to apply precision practices

Precision Technologies

- Scanning for weeds and spraying herbicides, use of drones
- Photographic identification of plant communities in plots
  - monitoring trajectories over time
- Soil sensors for moisture and nutrients
- Planting and fertilizing to suit conditions
  - 1 hectare per 6 hours

Goal: Equivalent Land Capability: Fig 1 ≈ Fig 2

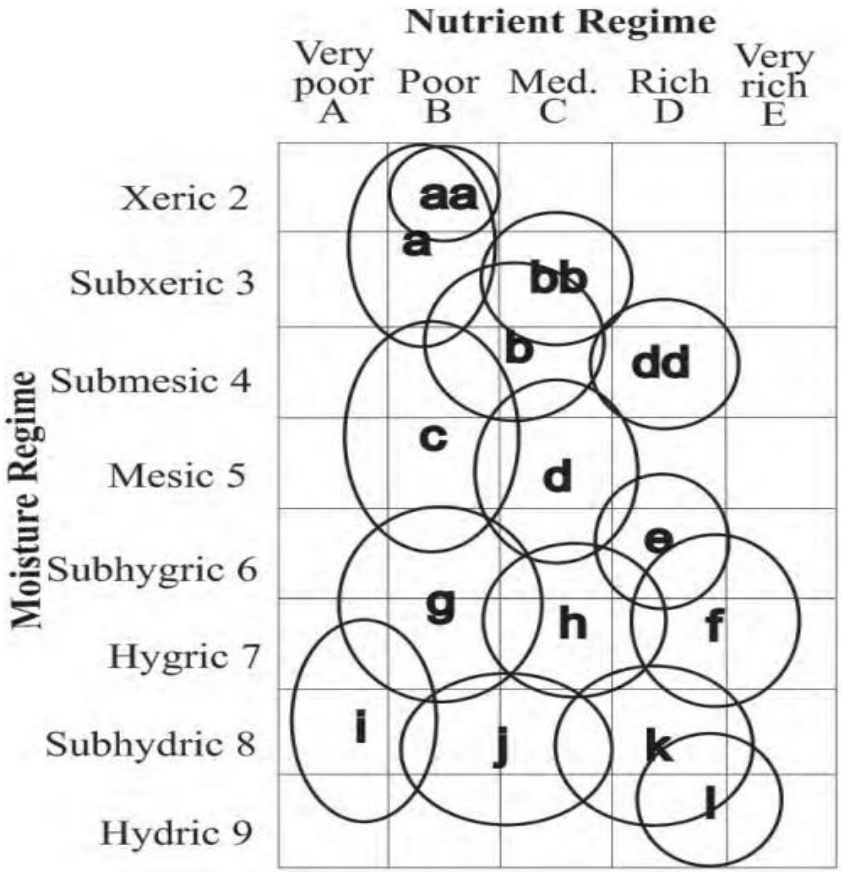


Fig. 1. Natural Edatope

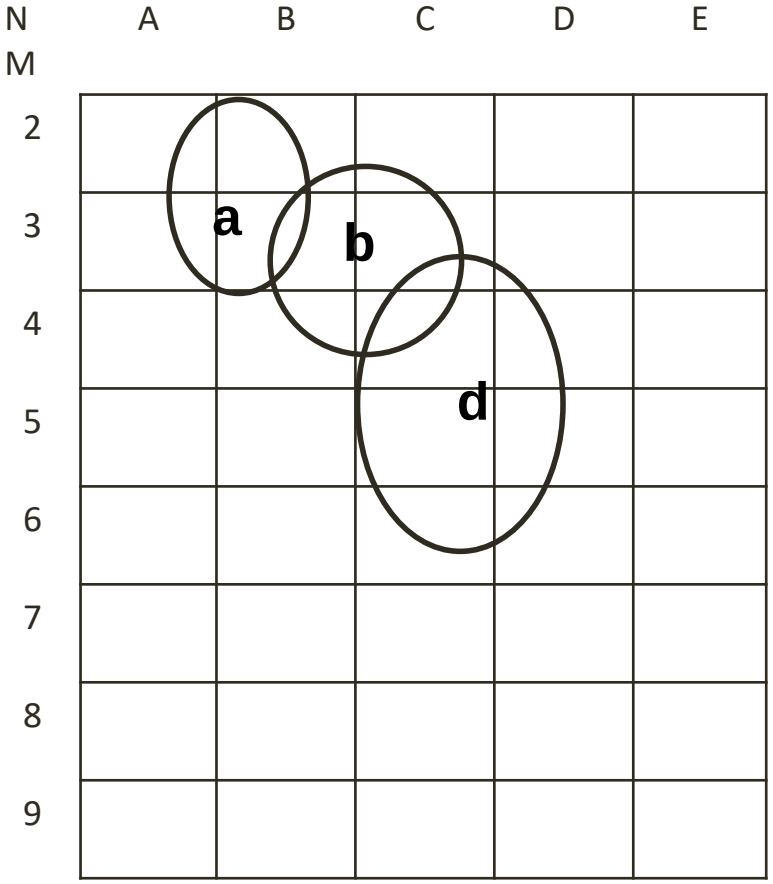


Fig. 2. Anthropogenic Edatope

How Do We Proceed?

- Opportunity for collaboration among companies
- Review of current plot programs (e.g. CEMA, Kearl, Suncor, Syncrude, etc.) and establish a robust monitoring program going forward
- Standardize data collection, storage, interpretation, application
- Test/develop instrumentation to quantify soil and vegetation properties
- Inform the public

Questions?

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