Sudbury, Canada – 40 years of a Community Regreening on a Smelter-Impacted Landscape

Regreening Reverdissement

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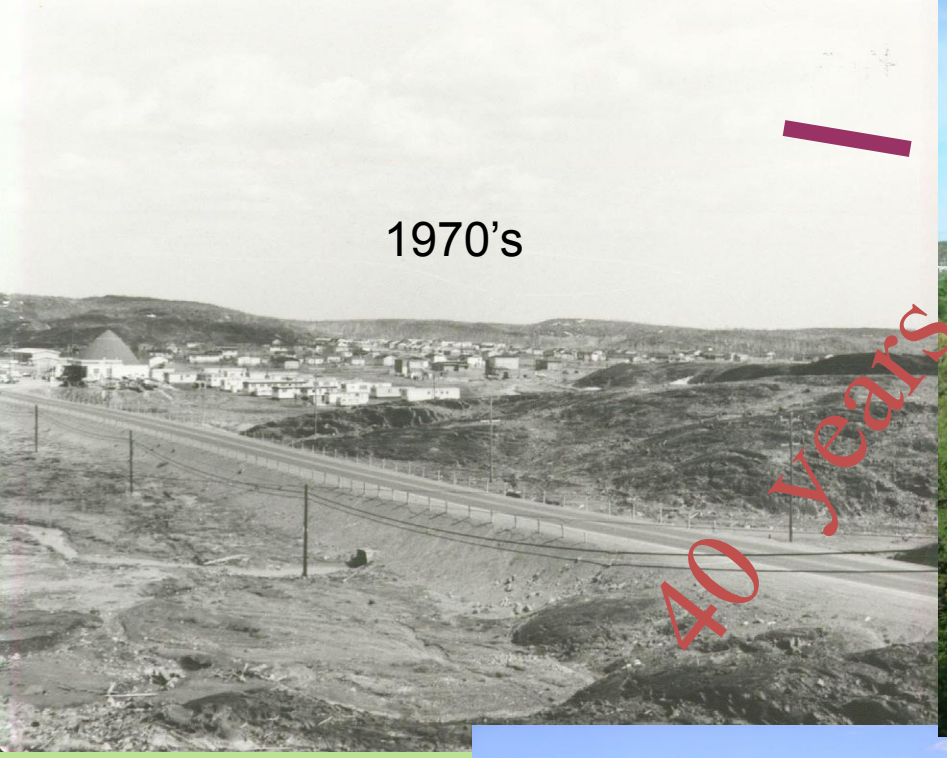
After

Vancouver, BC, Canada
CANADA
Sudbury, ON, Canada
Toronto, ON, Canada
New York, NY, USA
USA

Now a very green city!



40 years

Wahnapitae

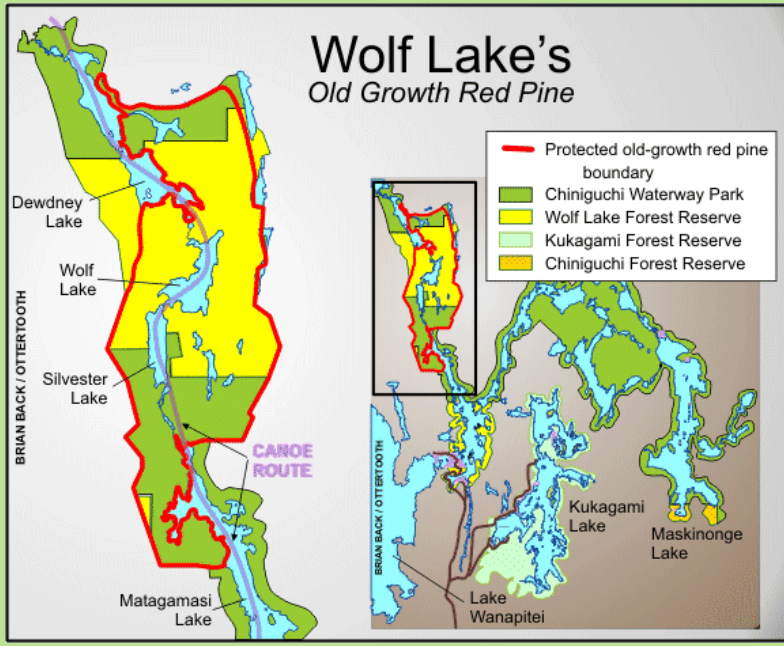
A story of landscape change though community action

VETAC goal - Development of a Sustainable Community

The VETAC Advisory Committee (Panel) has members of the Sudbury community, industry, academia and government working together for ONE common purpose – landscape and ecosystem improvement in the Sudbury community

Land Reclamation
City of Greater Sudbury
Réhabilitation des sols
Ville du Grand Sudbury

Original Sudbury forest: Mixed wood forest of pine, spruce, oak, maple and many more



Soils

A) Forested landscapes
Podzolic and Brunisolic soils on uplands
Well developed Ae and B horizons,
acidic LFH and Ae/Bm/Bh/Bg horizons
Acidic parent materials

b) Gleysols in glaciolacustrine basins
Well developed Ahg, Aeg and Bg horizons,
acidic LFH and Ae/Bm/Bh/Bg horizons
Circumneutral parent materials

c) Organic soils in depressional areas - wetlands

Early Environmental History To 1972

Late 19th Century
- Commercial forestry

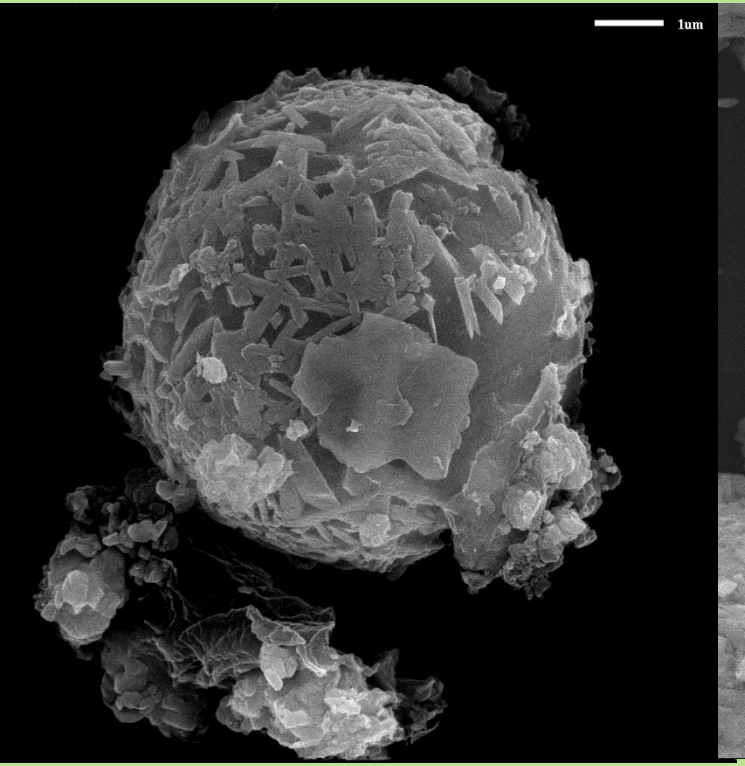
1886-1928
- open air roasting
13 roastyards

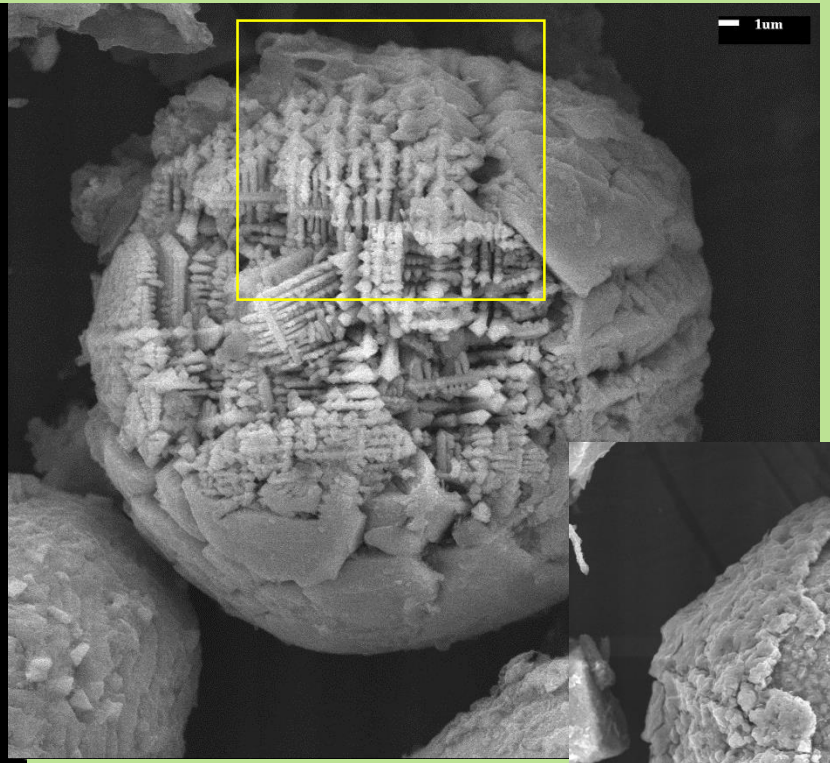
Mining, Smelting for Cu, Ni

Major 3 smelters from 1928 to 1972

Source of Metal Enrichment:

Fugitive Aerosol Particles from Smelter

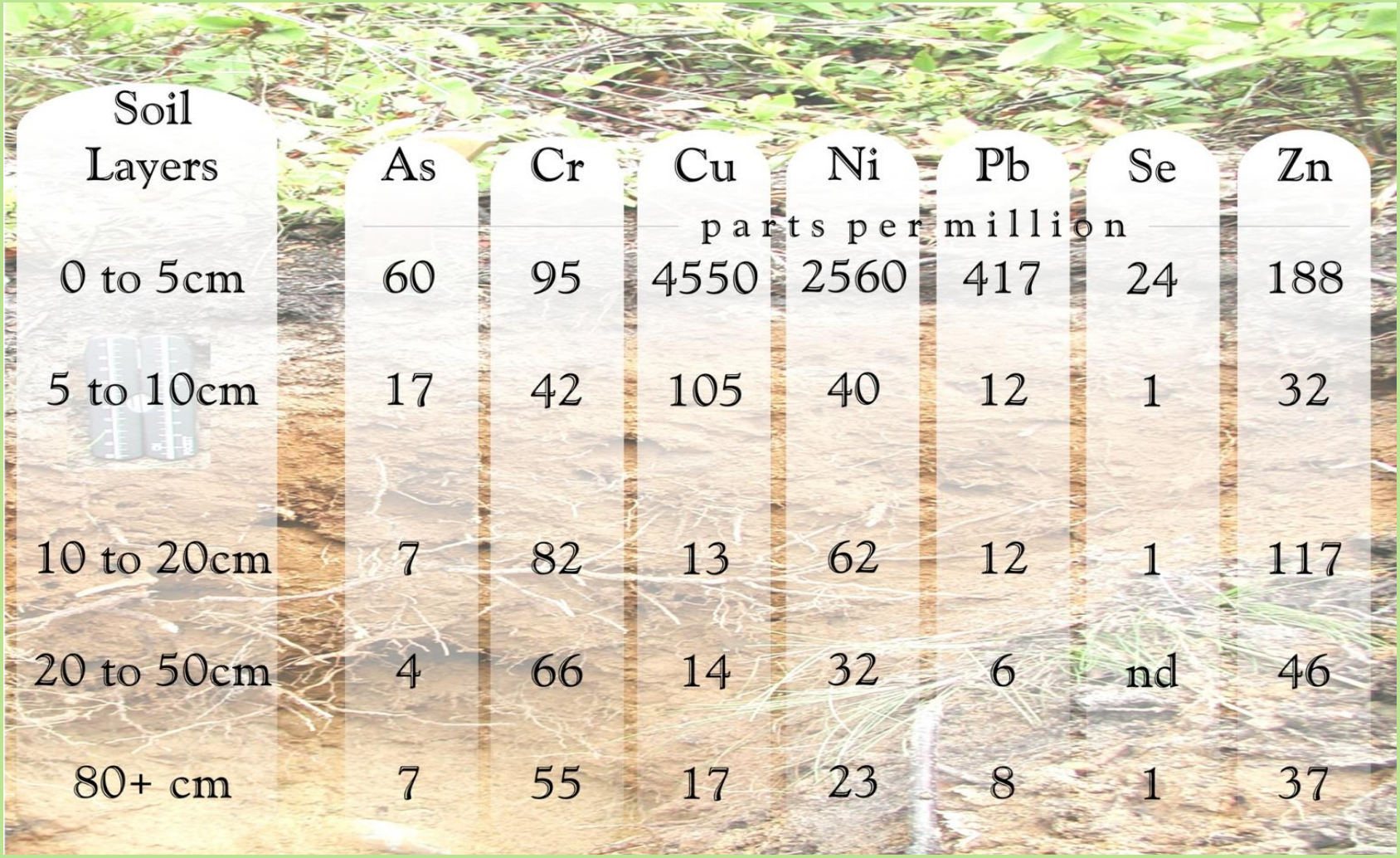




Graeme Spiers

Slow dissolution by soil acids

Effects on Sudbury soils



Soil Layers	As	Cr	Cu	Ni	Pb	Se	Zn
	parts per million						
0 to 5cm	60	95	4550	2560	417	24	188
5 to 10cm	17	42	105	40	12	1	32
10 to 20cm	7	82	13	62	12	1	117
20 to 50cm	4	66	14	32	6	nd	46
80+ cm	7	55	17	23	8	1	37

pH < 3.5

Damaged Landscape – paysage dénudé

Soil eroded away

The soil was acidic (<4), contaminated with metals
No nutrients
No organic matter.

Sudbury Barrens

Conditions retarded plant growth

Greater Grand Sudbury

Mining Fire Logging

How have all the environmental factors and interactions contributed to the barren and highly disturbed birch woods?

Synopsis of Ecological Effects

Open conditions

PROSPECTING

Enhanced
frost action

SO_2

FIRE

Plant death

slash

erosion

leaching

Loss of
seed source

Acid soil
pH<4

Metal toxicity
Cu & Ni

Loss of
Ca & Mg

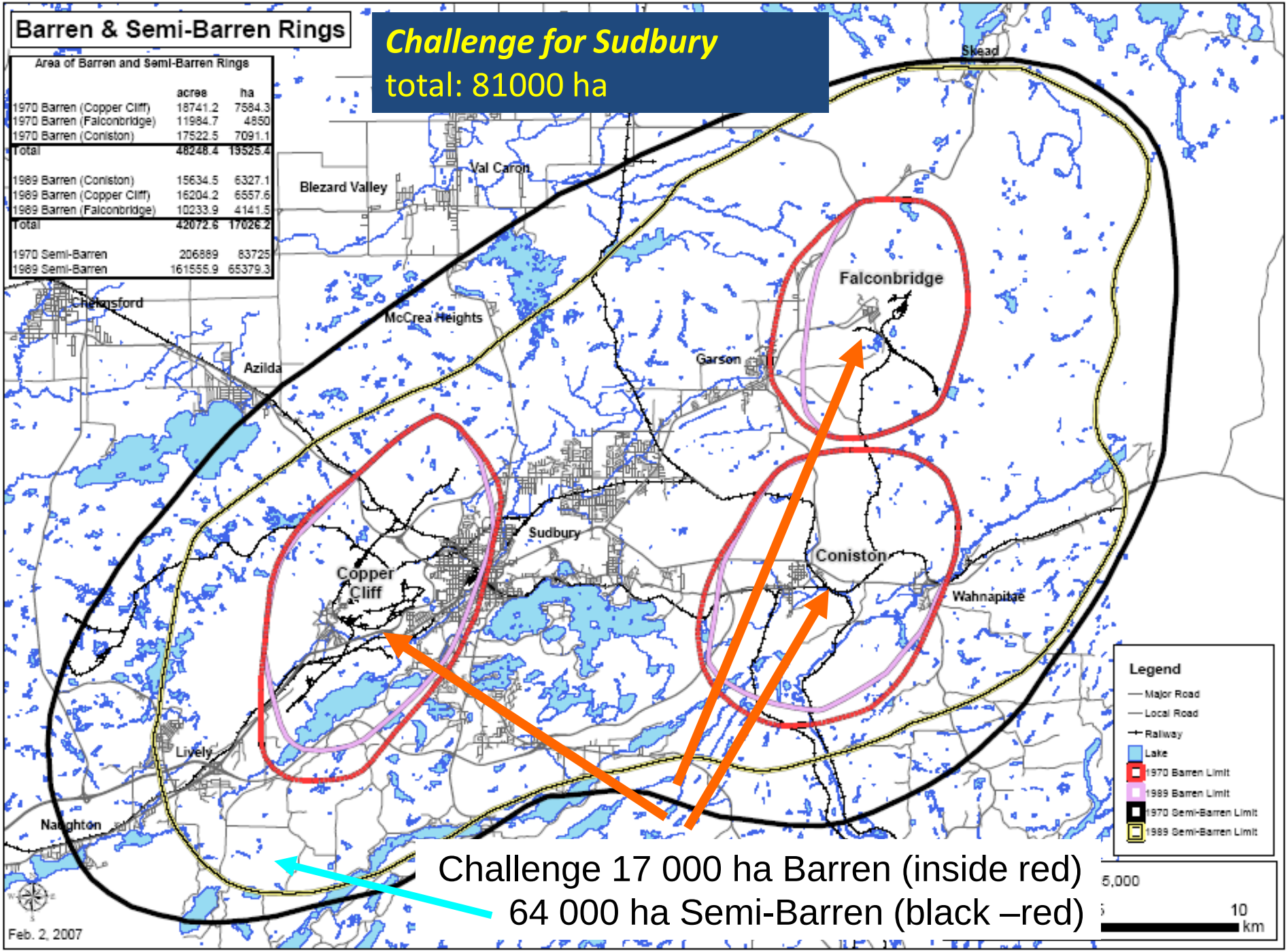
Al toxicity

Loss of soil

Loss of colloids,
(organic material)

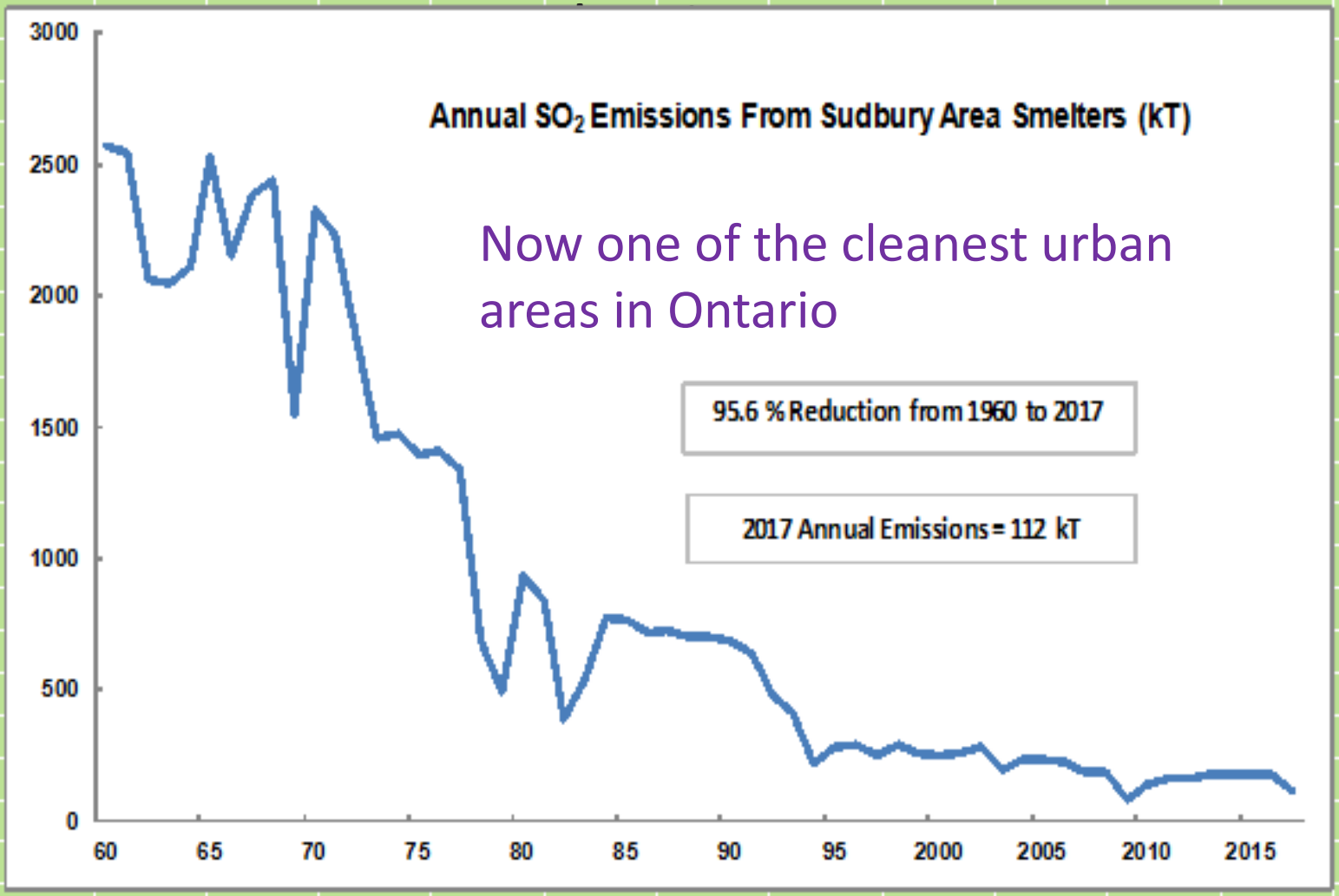
Loss of P & N

Reduction in moisture
& nutrient retention


Barren & Semi-Barren Rings
Challenge for Sudbury
total: 81000 ha
Area of Barren and Semi-Barren Rings
acres ha
1970 Barren (Copper Cliff) 18741.2 7584.3
1970 Barren (Falconbridge) 11984.7 4850
1970 Barren (Coniston) 17522.5 7091.1
Total 48248.4 19525.4
1989 Barren (Coniston) 15634.5 6327.1
1989 Barren (Copper Cliff) 16204.2 6557.6
1989 Barren (Falconbridge) 10233.9 4141.5
Total 42072.6 17026.2
1970 Semi-Barren 206889 83725
1989 Semi-Barren 161555.9 65379.3
Skead
Val Caron
Blezard Valley
Chelmsford
McCrea Heights
Azilda
Garson
Falconbridge
Sudbury
Copper Cliff
Coniston
Wahnapitae
Lively
Naughton
Legend
Major Road
Local Road
Railway
Lake
1970 Barren Limit
1989 Barren Limit
1970 Semi-Barren Limit
1989 Semi-Barren Limit
Challenge 17 000 ha Barren (inside red)
64 000 ha Semi-Barren (black –red)
5,000
10
km
Feb. 2, 2007

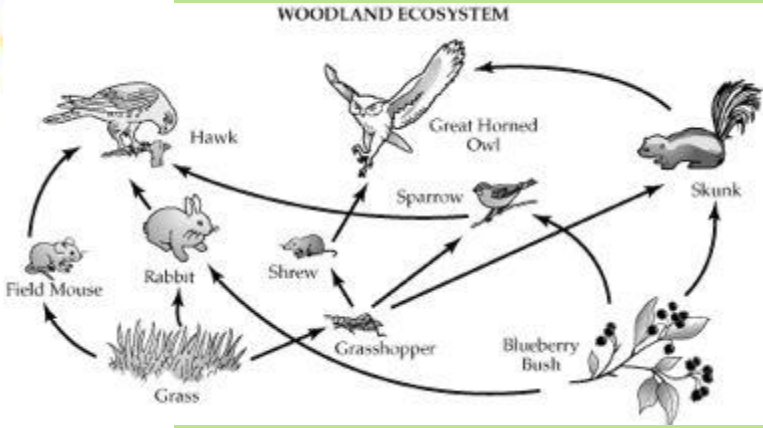
Reduce Contaminant Input

The Sudbury Industrial Solution:
SO_2 emission reduction 1970's – 2017 : >95%



Decreases in SO_2 emissions allow vegetation recovery and growth

Re-establish ecosystem



Key – vegetation and substrate amendment

Why restore the landscape?

- Aesthetics & quality of life.
- Returning ecological services: water quality, soil retention, biodiversity.
- Economic diversity and social benefits

Stages in reclamation/restoration studies

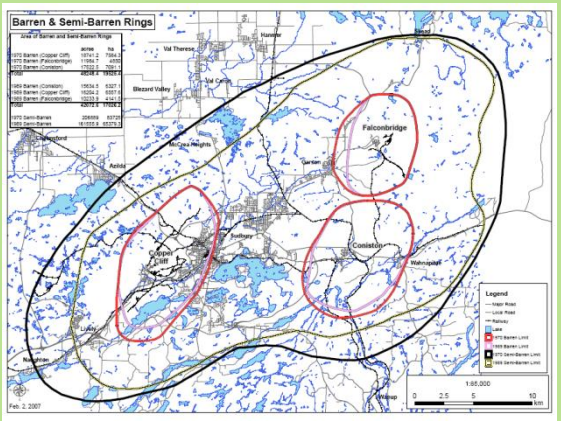
Small scale pot experiments in greenhouse or growth chambers

Field Plot Research - 1970's

Research & Experiments showed:

1. Addition of limestone could reduce metal toxicity (pH alteration, metabolic Ca role)
2. P more limiting than N
3. Trees would not survive on barrens without grass cover – microsite changes

Programme Strategy 1978-2009



Barren zone

1: Limestone, fertilizer, grass-legume seed mixture

2: Tree planting

Semi-barren zone

1: Tree and shrub planting only

Land Reclamation
City of Greater Sudbury
Réhabilitation des sols
Ville du Grand Sudbury

The ‘Original” Regreening Recipe

Amount of lime added: 10 t / ha

Amount of fertilizer added: 400 kg / ha

Seed mixture: 40 kg / ha

Grasses (75%):

1. Red Top (*Agrostis gigantea*)
2. Red Fescue (*Festuca rubra*)
3. Timothy (*Phleum pratense*)
4. Canada Blue Grass (*Poa compressa*)
5. Kentucky Bluegrass (*Poa pratensis*)

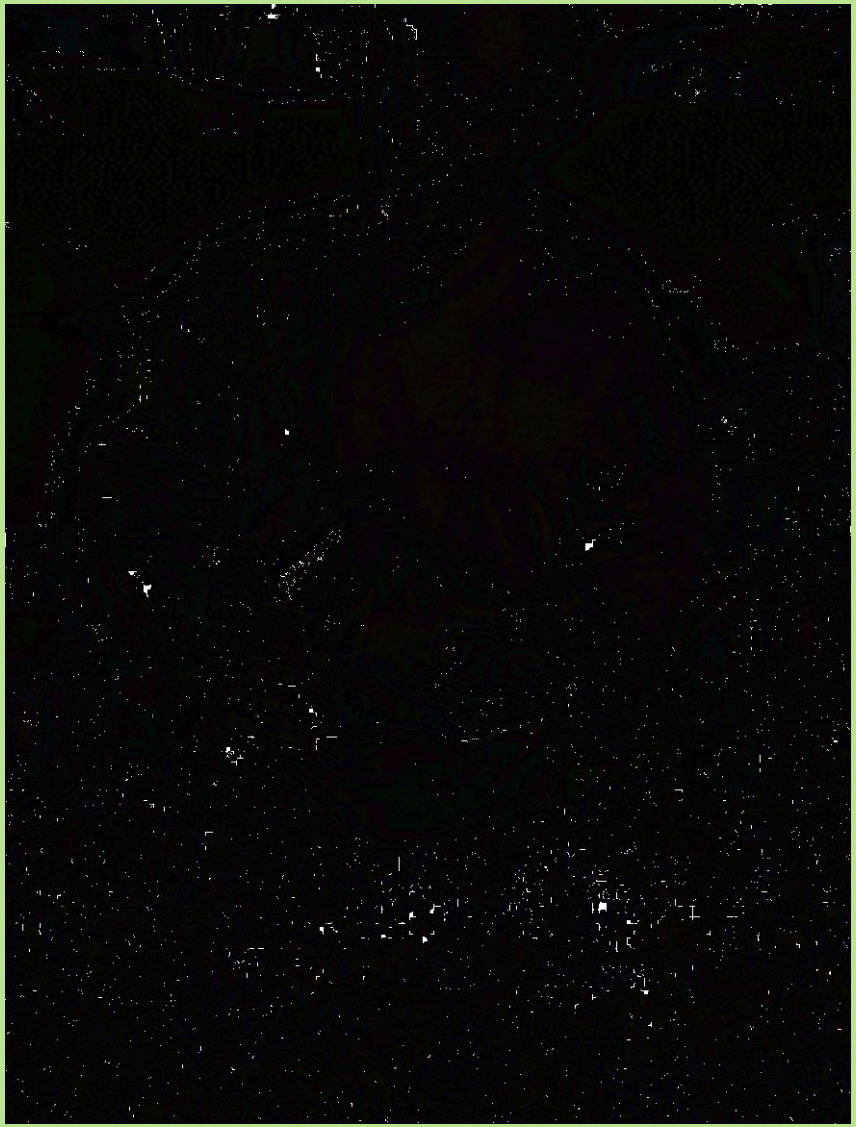
.

Legumes (25%)

1. Bird’s foot Trefoil (*Lotus corniculatus*)
2. Alsike Clover (*Trifolium hybridum*)

Trees Planted (major species): [+10 other]

1. Jack Pine (*Pinus banksiana*)
2. Red Pine (*Pinus resinoasa*)
3. White Pine (*Pinus strobus*)
4. White Spruce (*Picea glauca*)
5. Black Spruce (*Picea mariana*)
6. White Cedar (*Thuja occidentalis*)



Greater Grand Sudbury

Limestone
10 tonnes/ha
dolostone, dolomite
(Ca:Mg 55:45)

Need to raise pH > 4.85

Fertilizing – épandre l'engrais

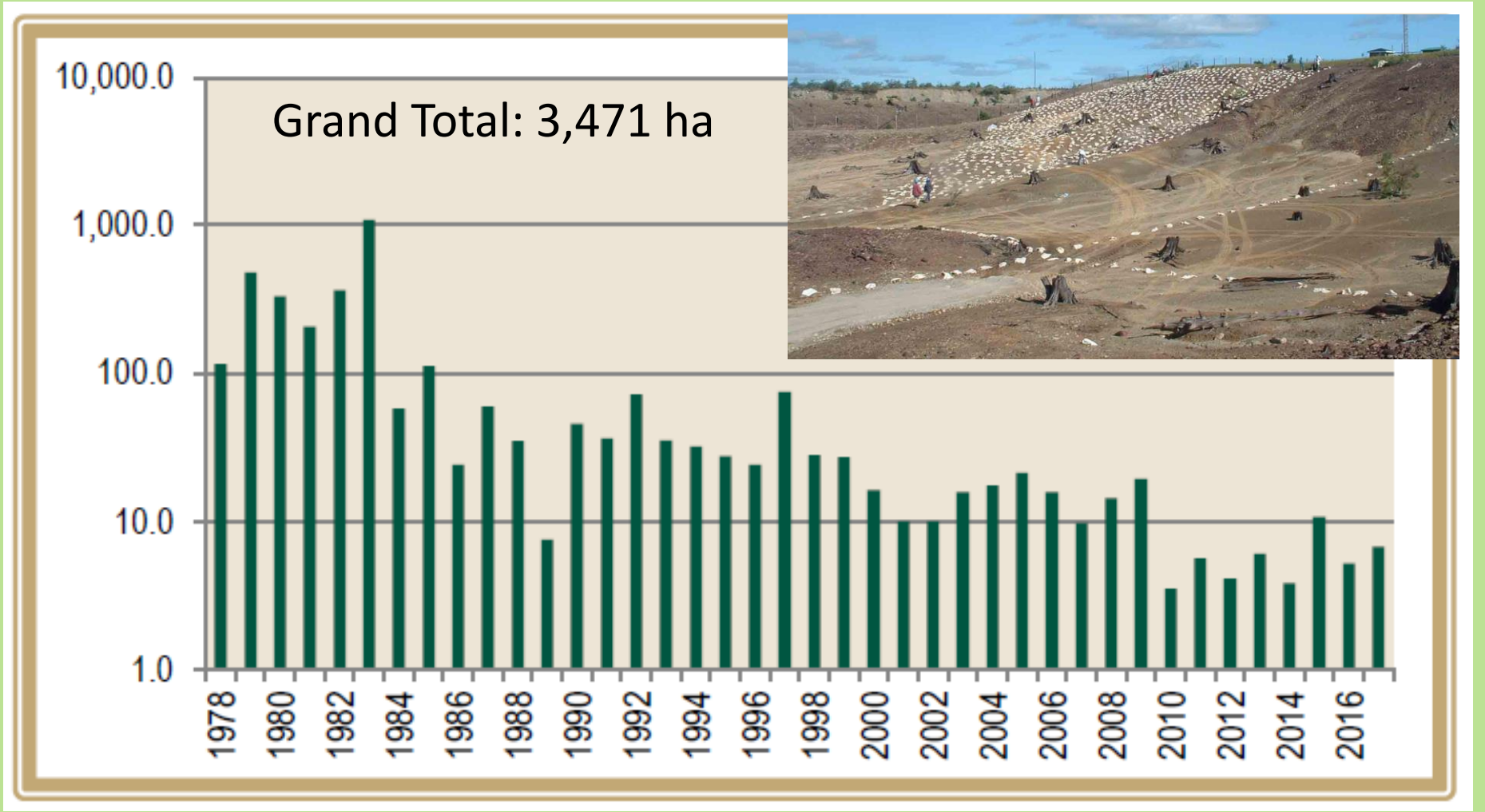
- 400 kg /ha
- 6-20-20

Seeding - semence

- 40 kg/ ha
- grass-legume mix

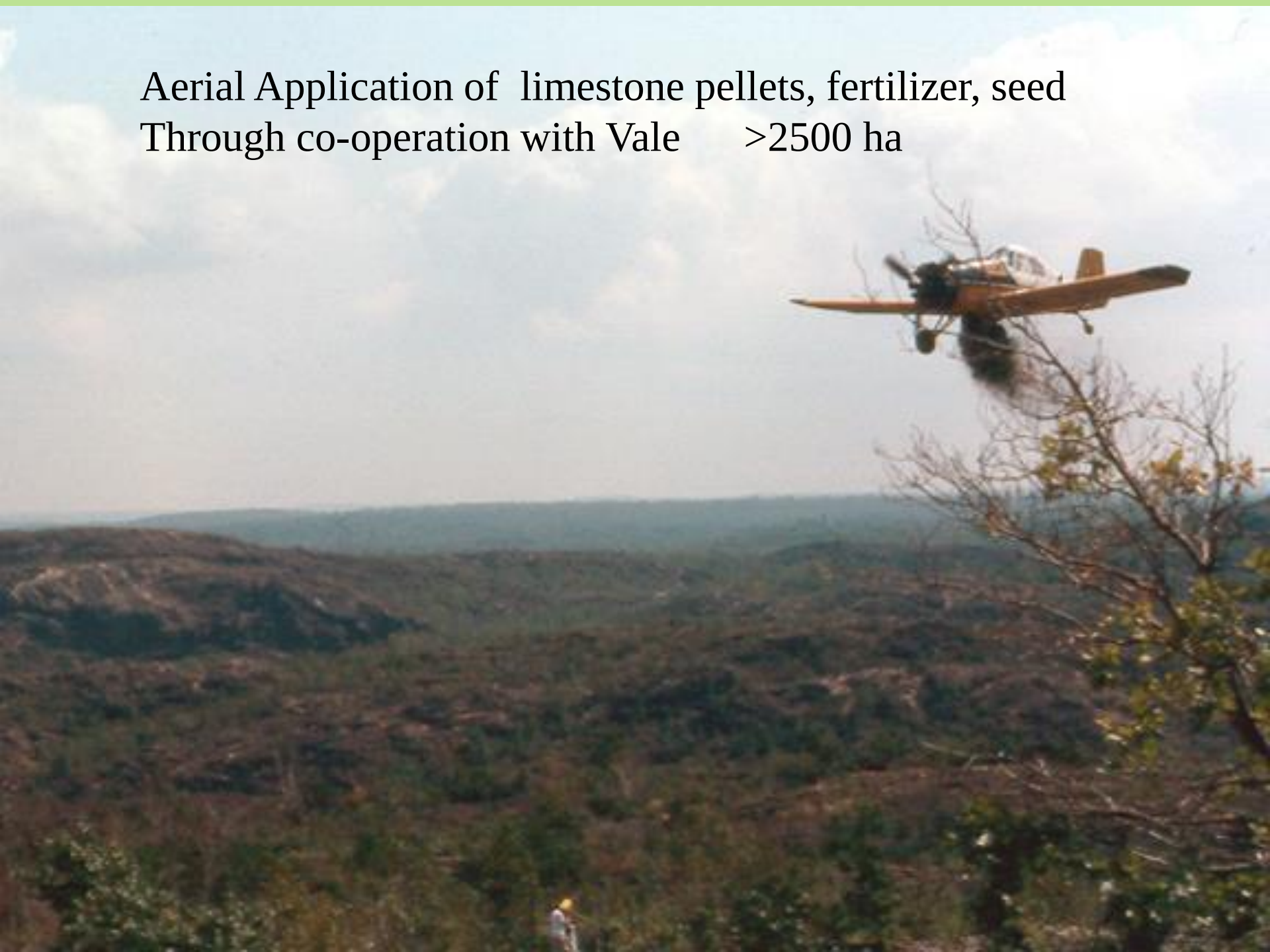
Greater Grand Sudbury

Hectares receiving limestone 1978-2017



[total area to treat is *ca* 7000 ha]

Aerial Application of limestone pellets, fertilizer, seed
Through co-operation with Vale >2500 ha

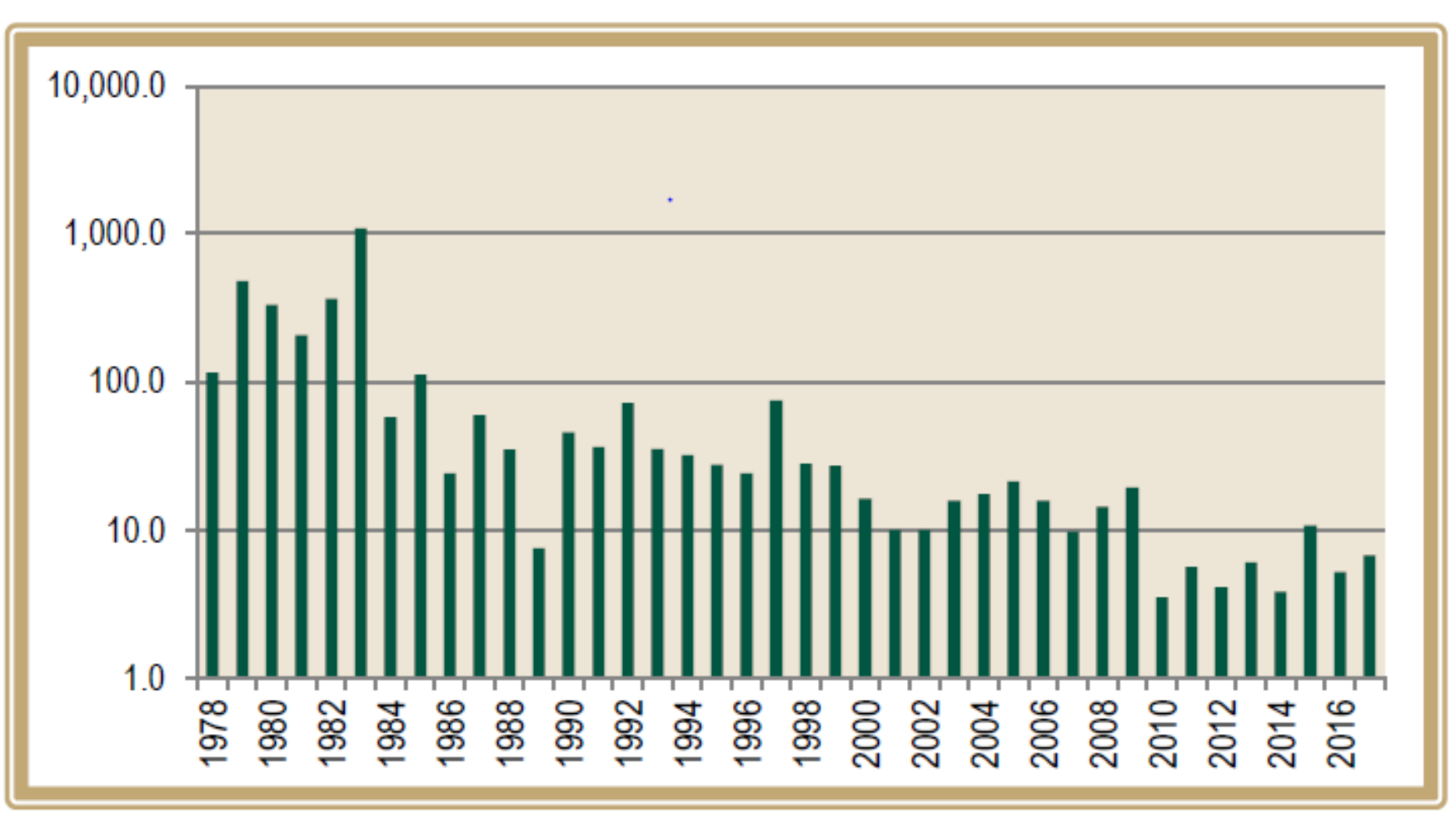


TREE & SHRUB INTRODUCTION

Regreening crew

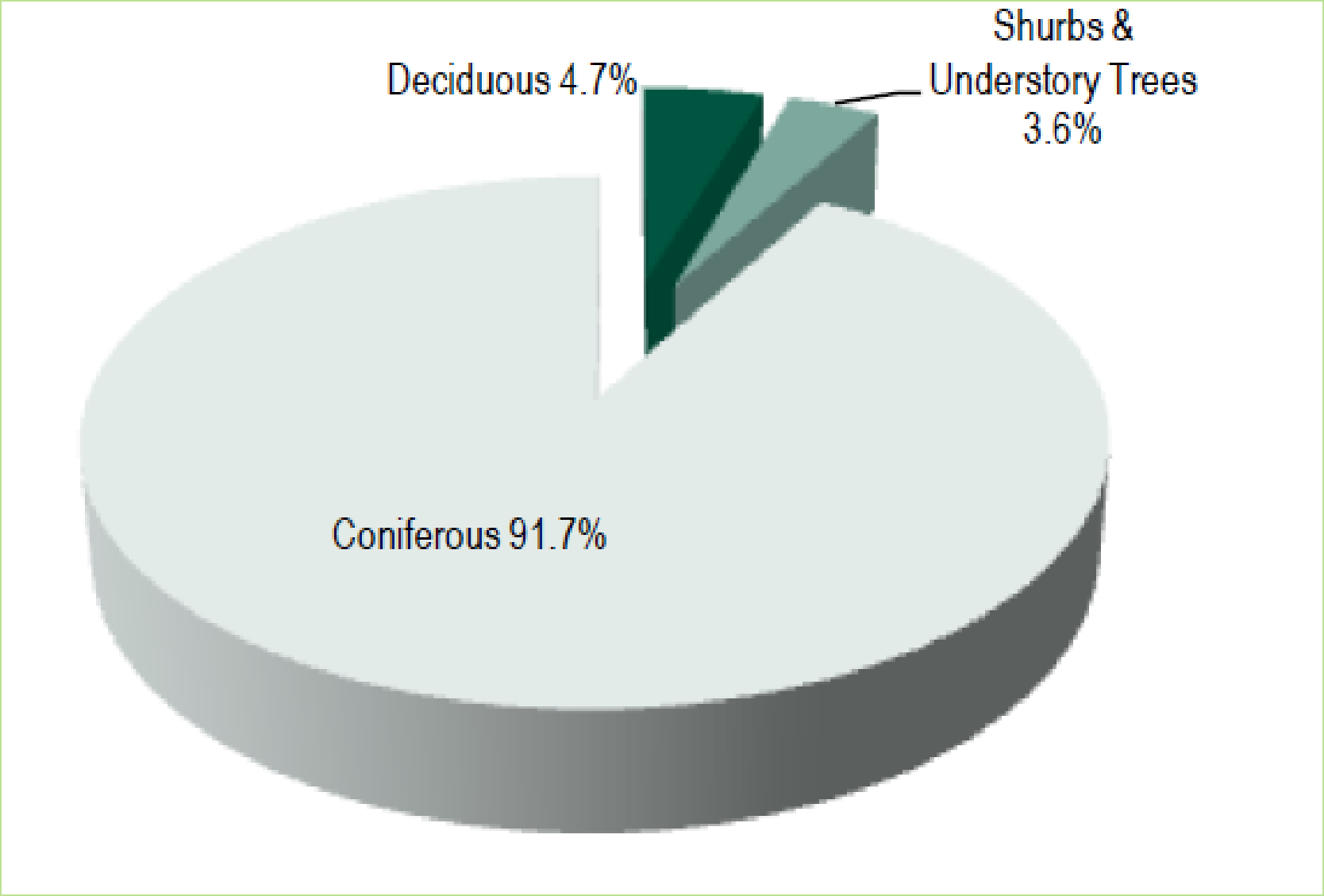
community volunteers (schools,service clubs, citizens etc)

Number of Trees Planted 1979 to 2017 – 9,723,172 (trees and shrubs – 10,033,730

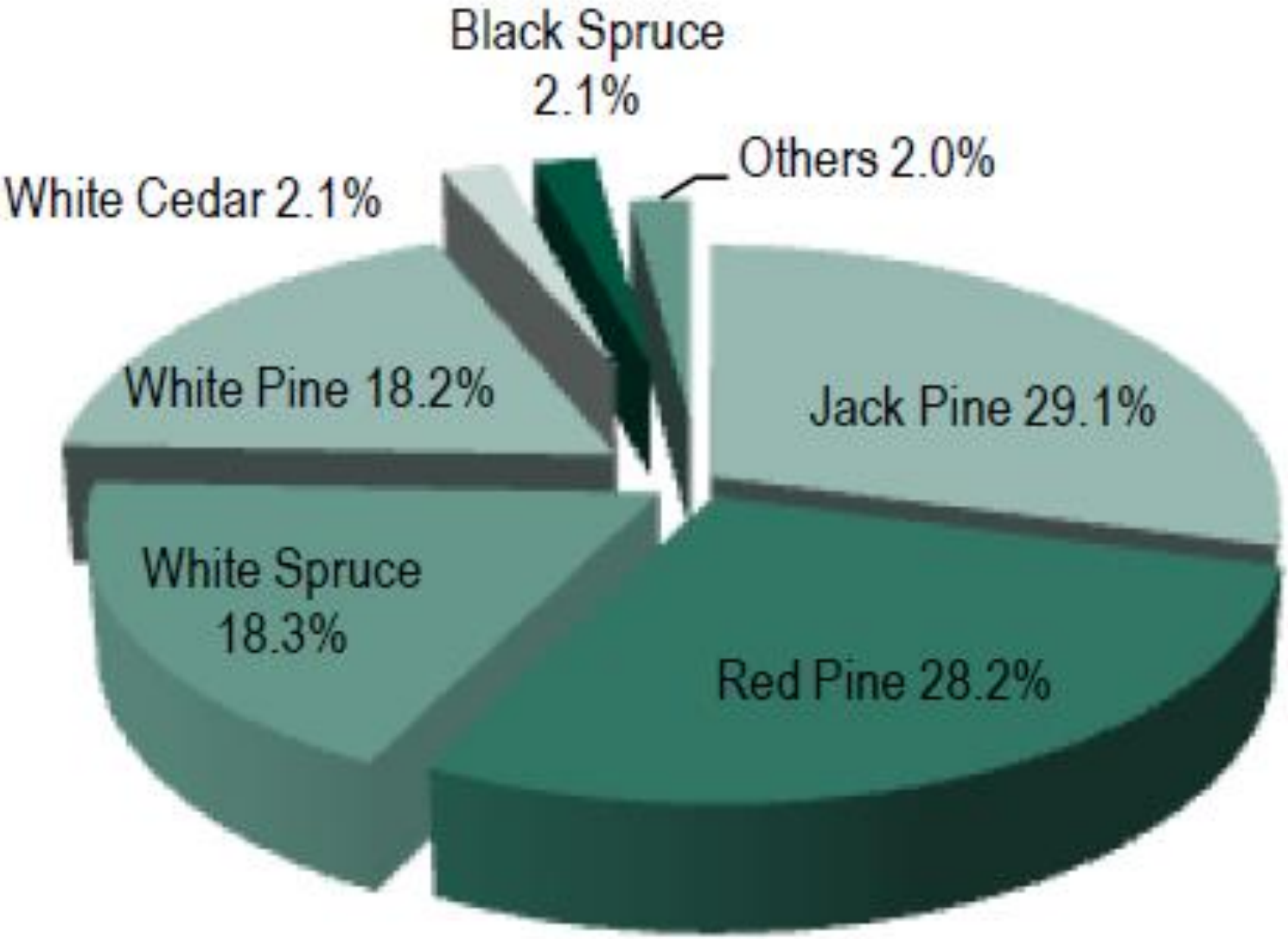


Tree density 100 – 500 trees ha^{-1} Forest replant 2500 ha^{-1}

Percent of Species Planted 1979 to 2017 – 10,033,172

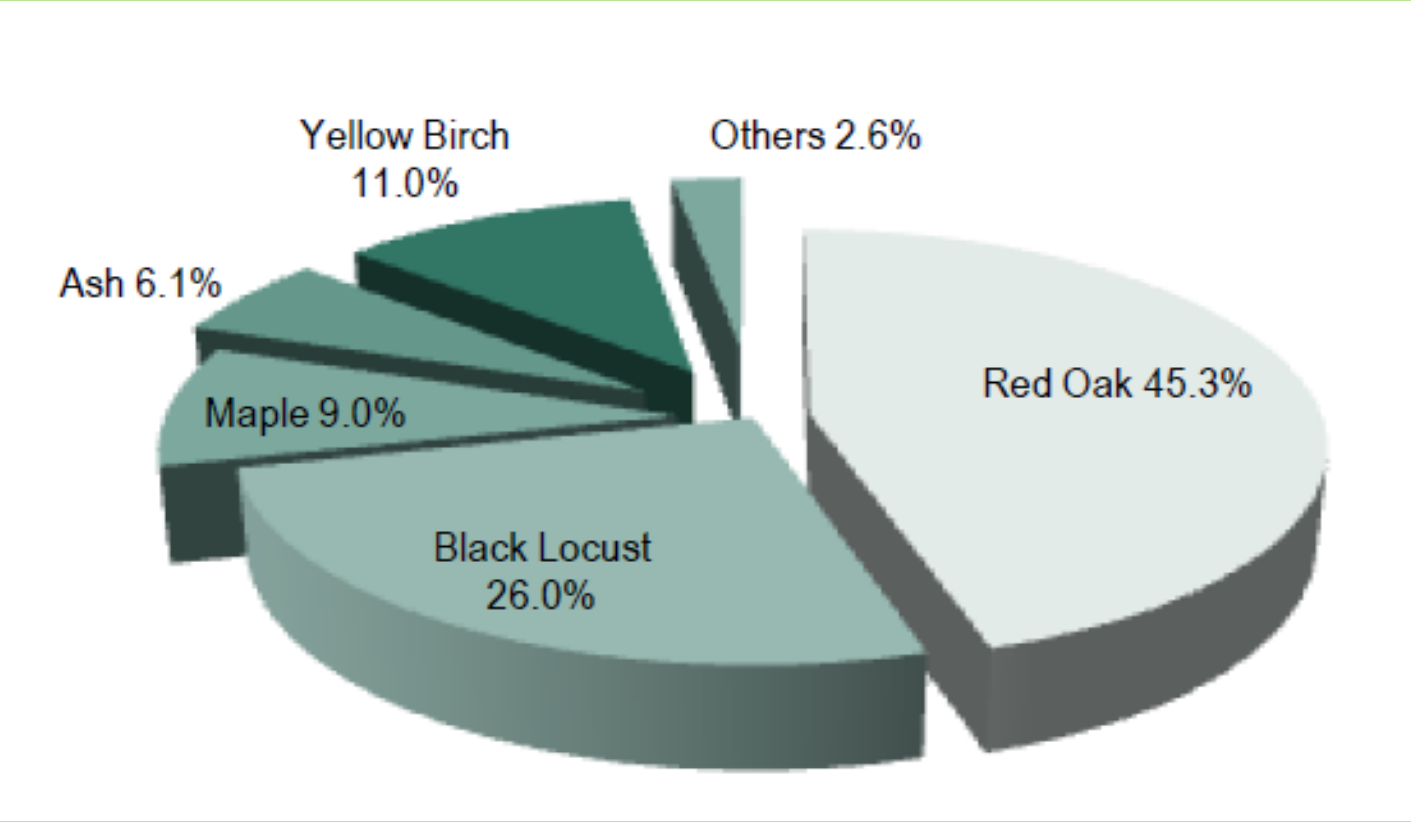


Percent Coniferous Species Planted 1979 to 2017 – 9,723,172

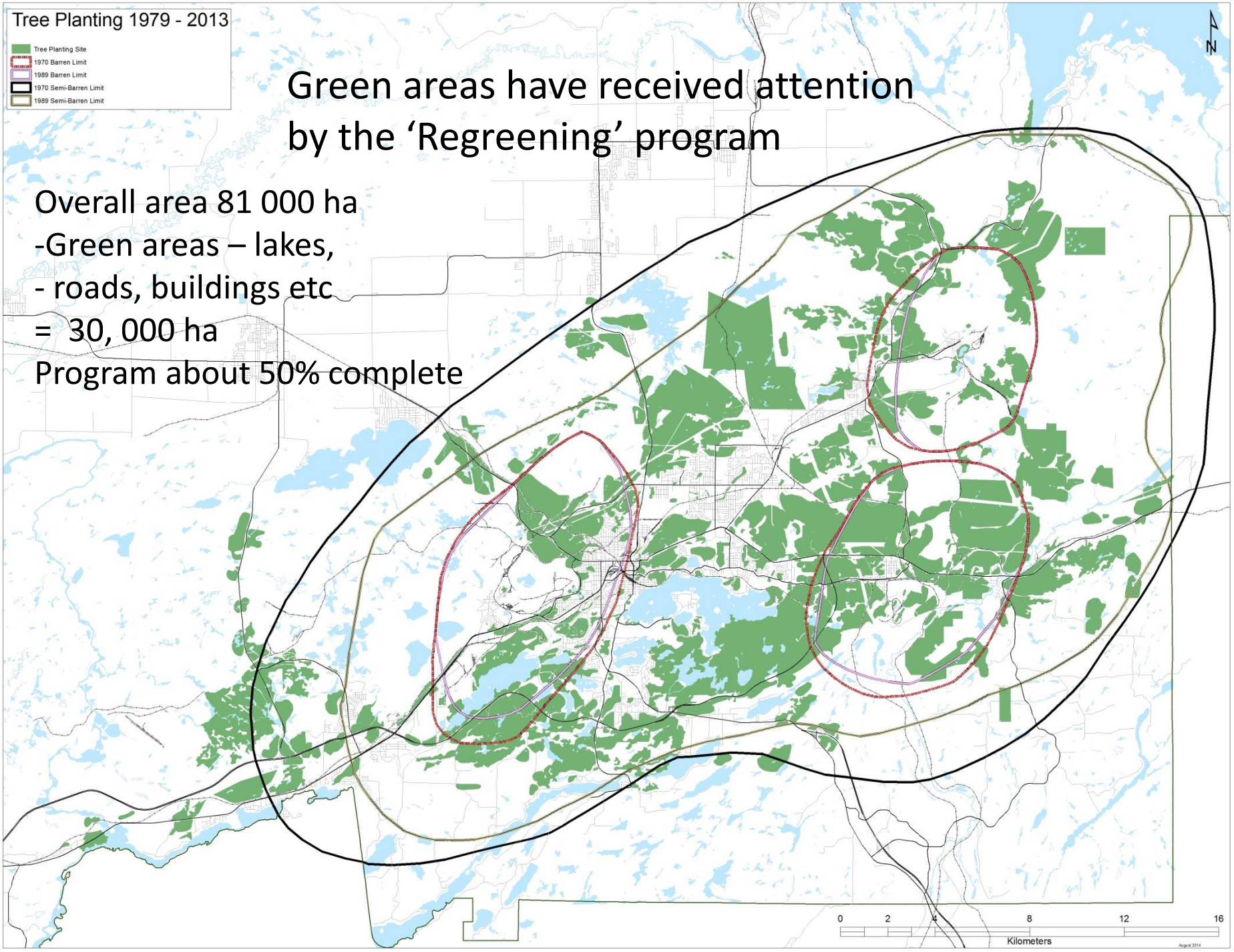


Others Include: balsam fir 0.2%, tamarack 1.3%, Norway spruce 0.2%, larch 0.2%, hemlock 0.1%, and Austrian pine <0.0%.

Percent Deciduous Species Planted 1979 to 2017 – 472, 680



Others Include: Russian olive 1.1%, bur oak 0.8%, ironwood 0.3%, American beech 0.1%, bitternut hickory 0.1%, white oak 0.1% and basswood 0.1%.



Green areas have received attention by the 'Regreening' program

Overall area 81 000 ha

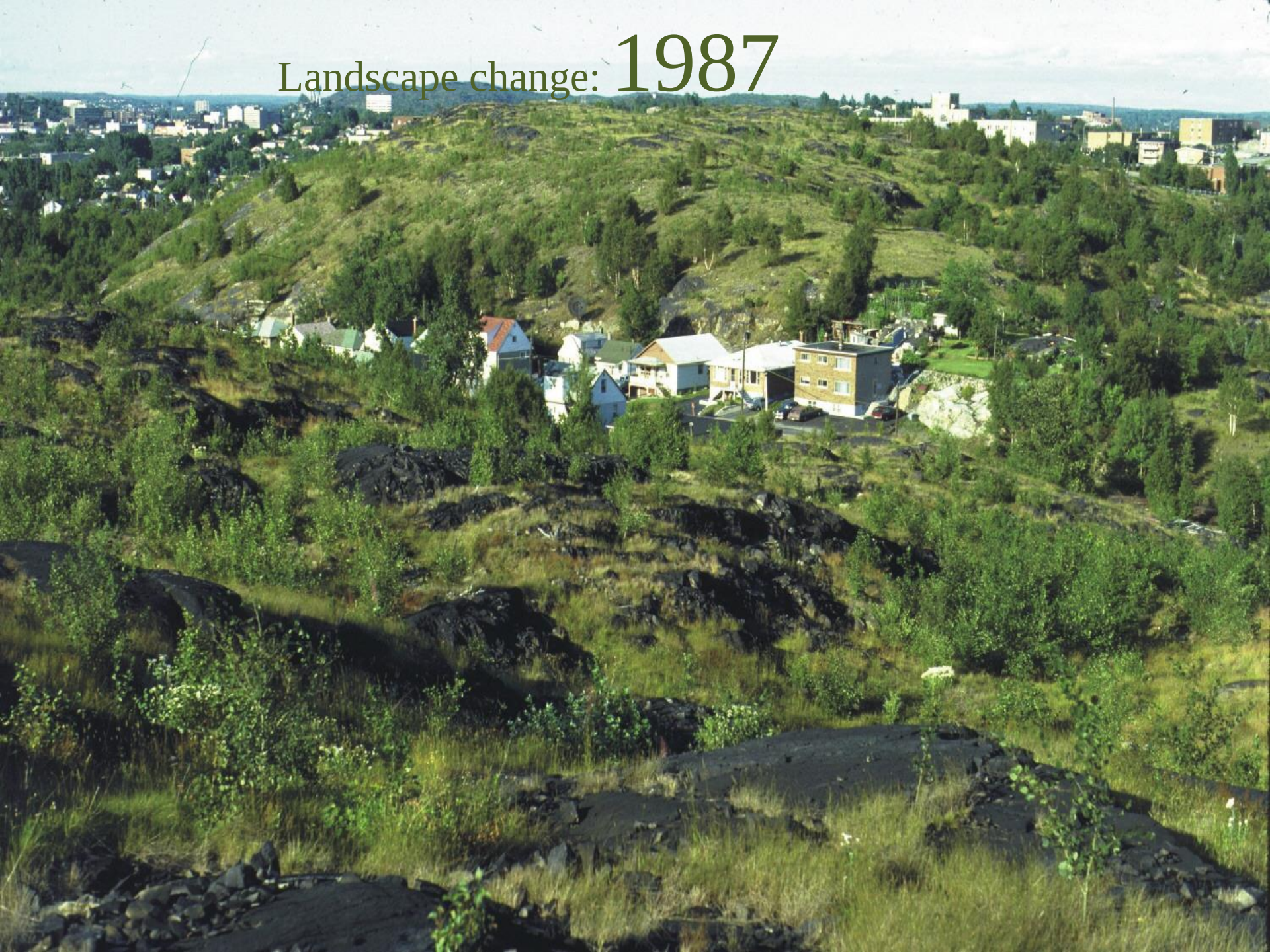
-Green areas – lakes,

- roads, buildings etc

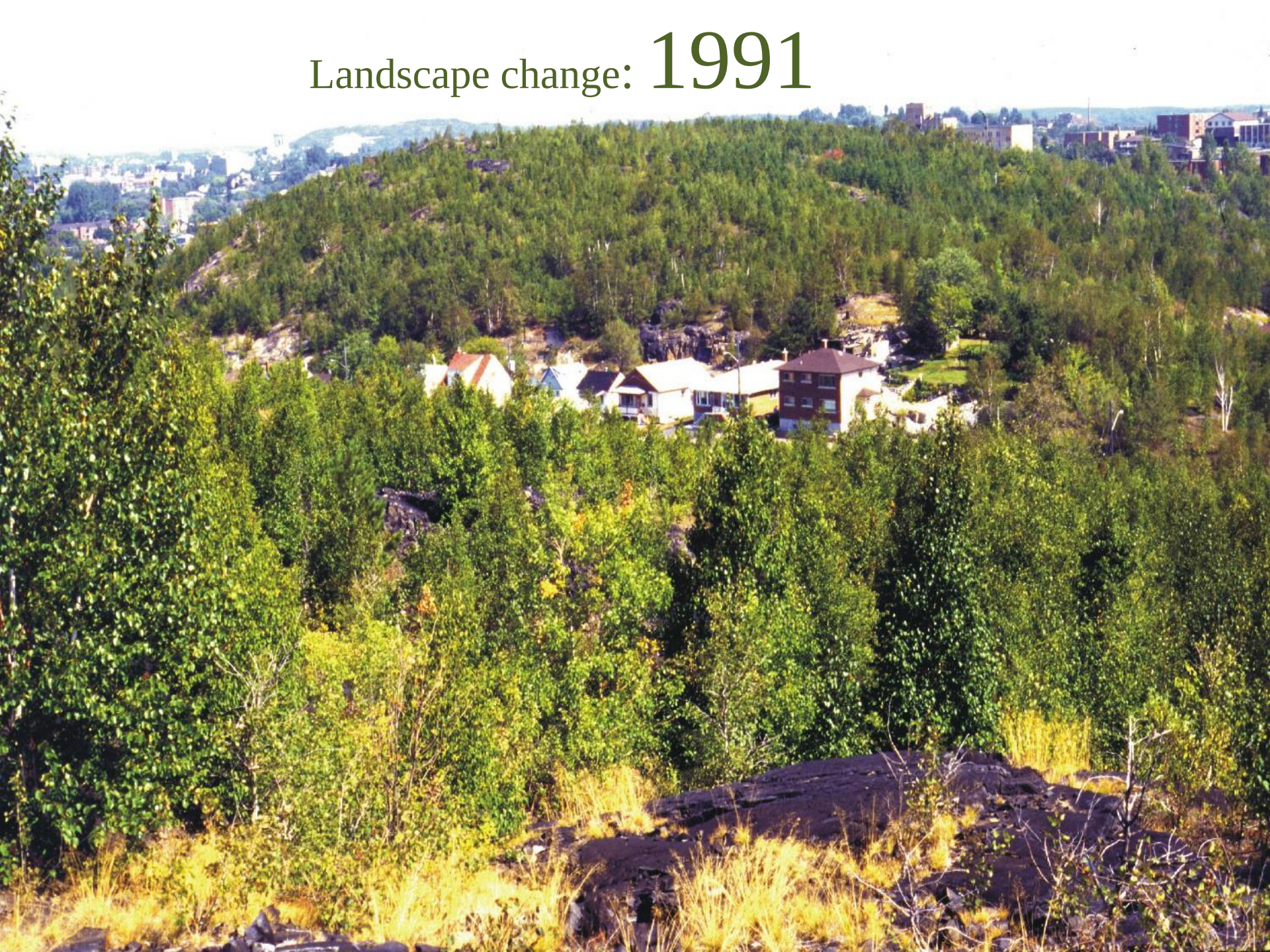
= 30, 000 ha

Program about 50% complete

Landscape change: 1981


Landscape change: 1987

Landscape change: 1991



- Landscape change: 1994

Landscape change: 2004

Landscape change: 2011

- Landscape change: 2018

Healing

Barren

1 year post liming, grassing

Addition of
Trees and shrubs

25 year

8 year post treatment

Reference site outside

Sudbury

Lichens from Reclaimed Land

Cladonia – 5 species in picture

20+ species on reclaimed areas

Mosses

Polytrichium

Pleurozium schreberi

Pohlia nutans

25 years →

Open sites → Forest mosses

Ecosystem Components Return

Number of Species

- Vascular Plant Species >250
-
- Mosses (woodland) *ca* 20
- Lichens >50
- Mammals 16
- Birds 80

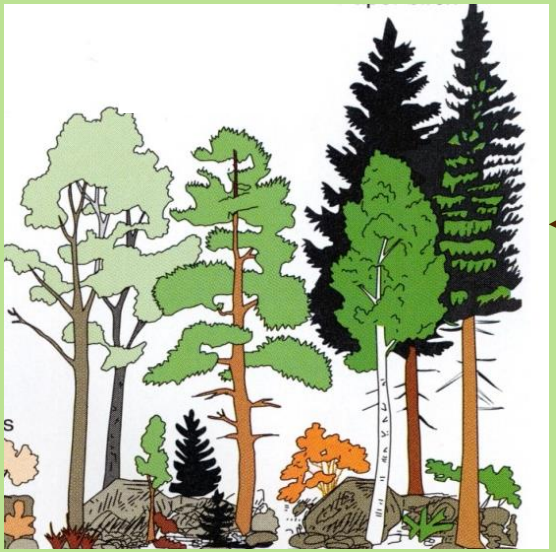
Soil pH – target	*>5.0*
young sites (<5 y)	5.4 – 6.3
middle (10-15 y)	5.2 – 5.8
old (>20 y)	5.0 – 5.8

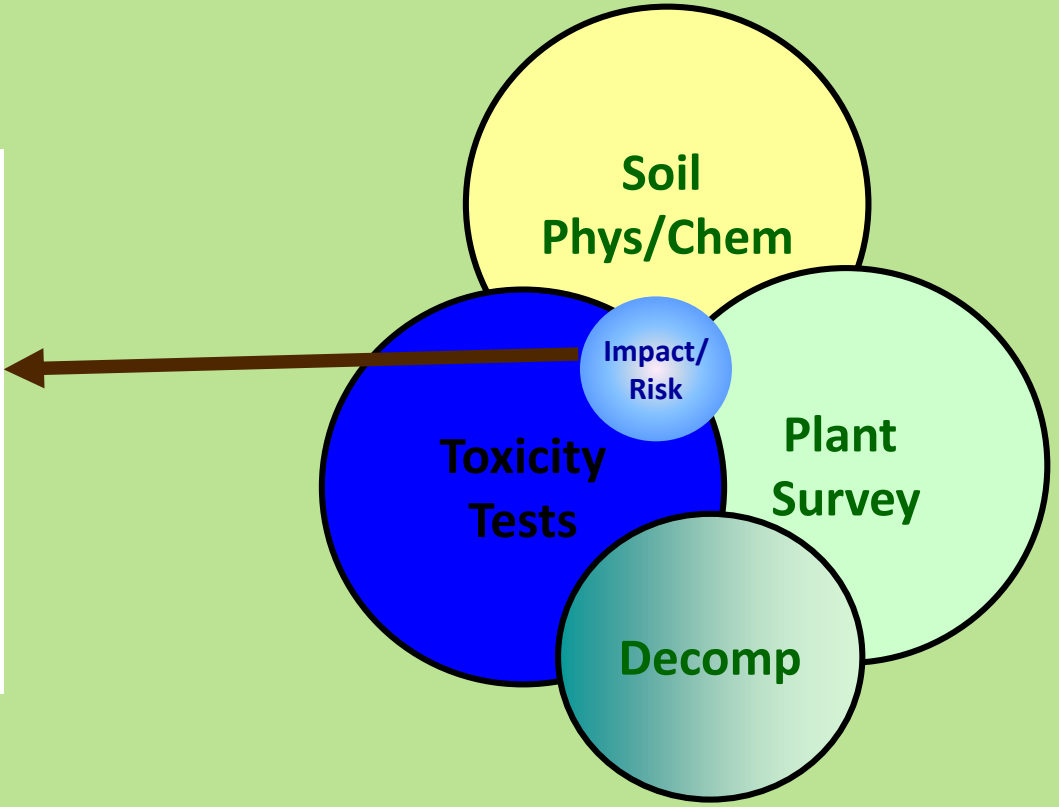
No significant increase of
Cu, Ni, Cd, Co, As, Pb in plants

Coniston

27 years

Ecological Risk Assessment 2001-2007





Conclusion:

Despite over 30 years of regreening and natural ecological recovery following large reductions in ambient sulphur dioxide levels:

Terrestrial plants continue to be impacted by metals in the soil.

Terrestrial plants are also impacted by other factors such as soil erosion, low nutrient levels, lack of soil organic matter, and/or low pH which contribute to inhibit recovery.

Land Reclamation Program Deficiency

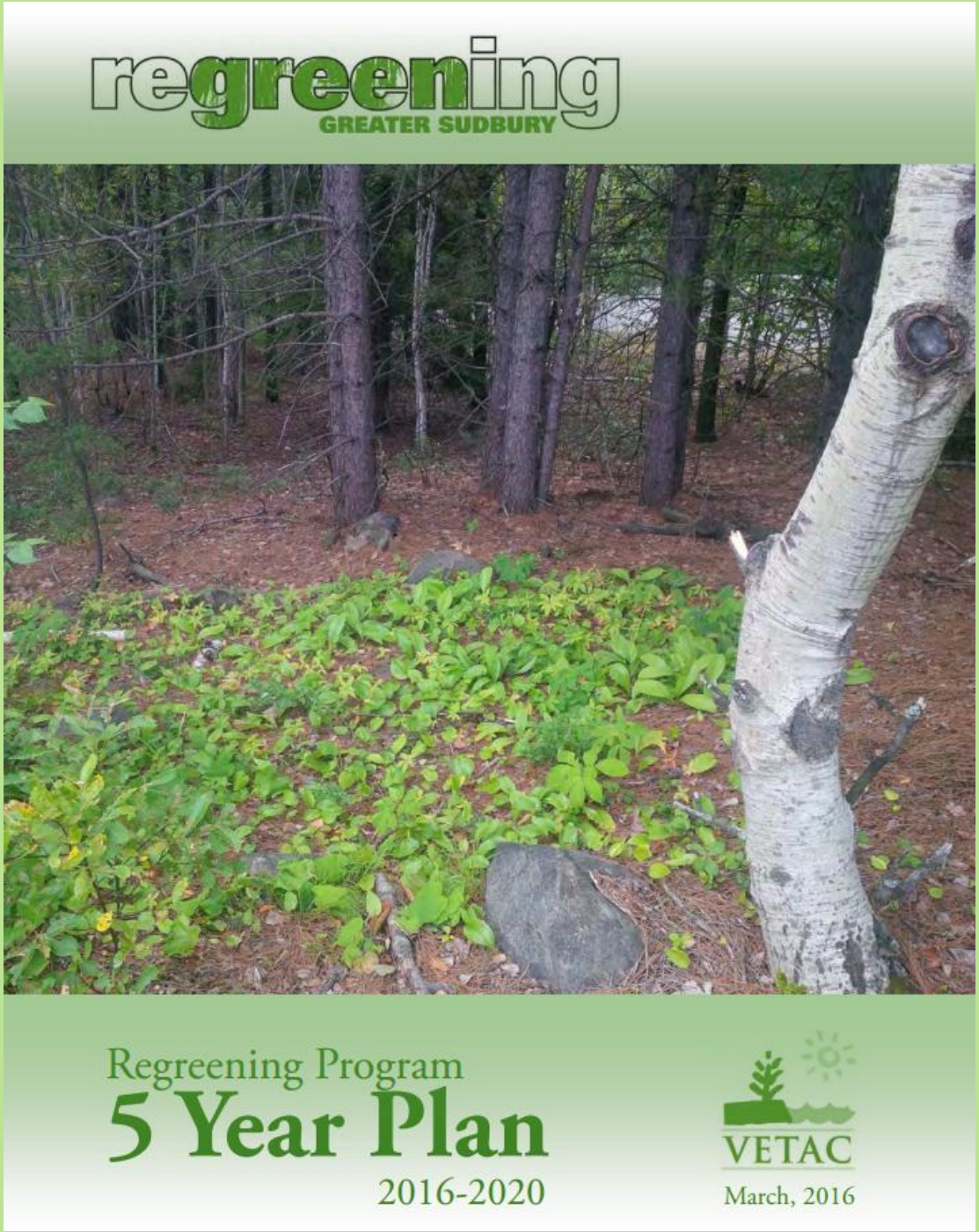
25-30 years on – structure of woodland
Composition – non-native grasses, non-woodland herbs dominate

Woodland – understory herb and shrub species missing

Living Landscape

A Biodiversity Action Plan for Greater Sudbury

December 23, 2009



View on
City of Greater Sudbury
Website

Sudbury Treatments since 2010: Aiming for Biodiversity ‘New’ Sudbury Recipe

- Crushed limestone (dolomitic) – 10 t/ha
- Fertilizer (6-20-20) - 200 or 400 kg/ha
- Initial seed mixture (mostly native grasses)
- Over 65 native tree and shrub species used:
  (for habitat, structure, food and general diversity)
- Forest Floor mat and other transplants

Different Grass Mixture

- Variations of
- 40% Fall Rye (*Secale cereal) as nurse crop*
- 20% Canada Wildrye (*Elymus canadensis)*
- 10% Slender Wheatgrass (*Elymus trachycaulus)*
- 20% little bluestem (*Schizachyrium scoparium)*
- 10% Alsike Clover (*Trifolium hybridum)*

- *Note other local native grasses not generally commerially available*

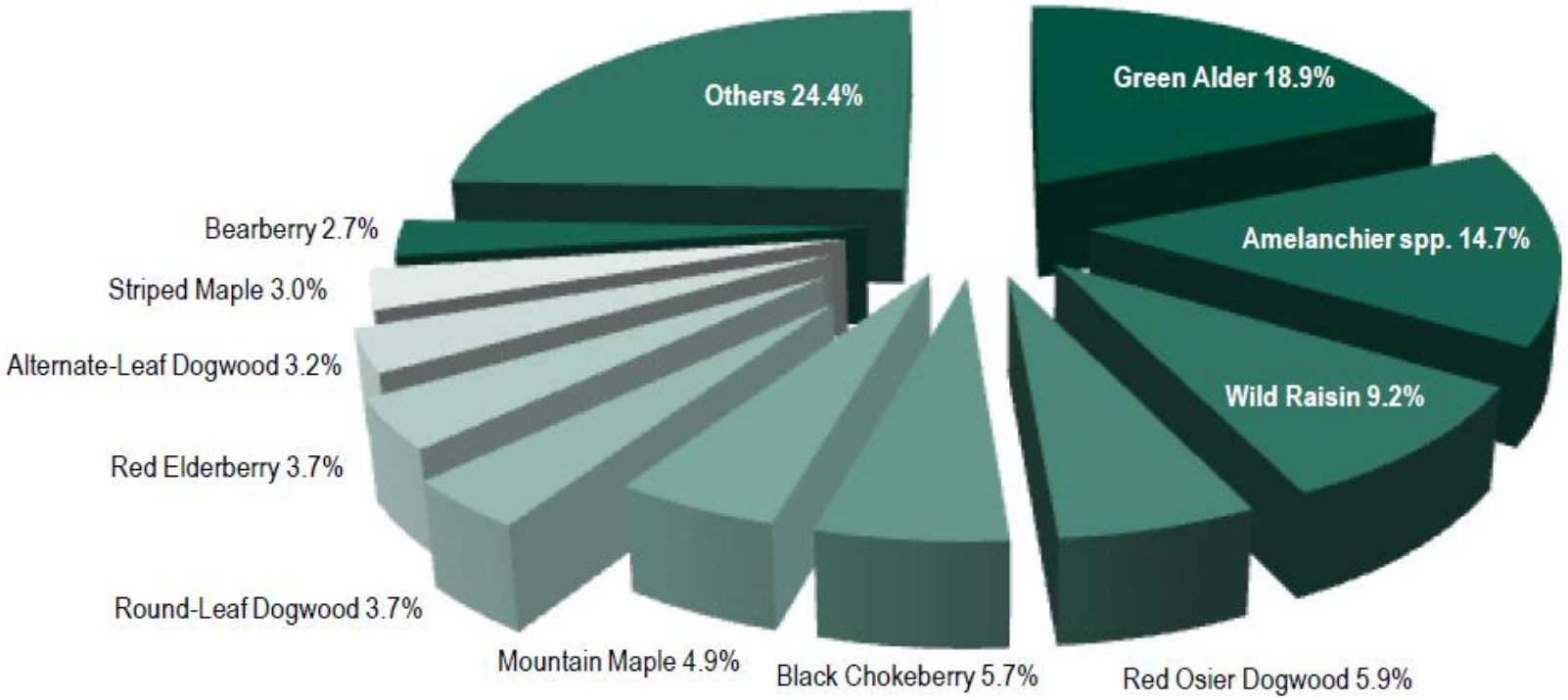
Poverty Oat
Grass

Seed Collection

Trees & Shrubs
> 65 species used
Along with seed collection

Species	Unclean Seed Weight (in grams)
Green Alder	5000
Red Elderberry	4860
Black Chokeberry	4383
Round Leaved Dogwood	1434
Alternate Leaved Dogwood	1300
Mountain-holly	1042
Smooth Wild Rose	994
Highbush Cranberry	591
Yellow Birch	200
Virginia virgin's bower	53

Shrubs and Understory Trees Planted 1979 to 2017 – 360,539



Others include: common elderberry 2.4%, staghorn sumac 2.3%, caragana/Siberian pea shrub 2.1%, mountain-holly 2.0%, bushhoneysuckle 1.7%, winterberry holly 1.4%, smooth wild rose 1.2%, American mountain-ash 1.2%, hardhack 1.2%, highbush cranberry 1.0%, swamp rose 1.0%, common juniper 0.9%, showy mountain-ash 0.5%, buffalo berry 0.5%, white meadowsweet 0.5%, mugho pine 0.5%, nannyberry 0.4%, ninebark 0.4%, prickly wild rose 0.4%, choke cherry 0.3%, snowberry 0.3%, broad-leaved meadowsweet 0.2%, hobblebush 0.2%, buttonbush 0.2%, pin cherry 0.2%, Canada yew 0.2%, black chokeberry 'Viking' 0.2%, wild currant 0.2%, flowering raspberry 0.1%, sweet gale 0.1%, wintergreen <0.1%, red chokeberry <0.0%, American hazel <0.0%,
sandcherry <0.0%, and Canada plum <0.0%.

Understorey Diversity Introduction

Transplants

Approximately 40 different species re-introduced.

- Most common included:
- balsam fir (*Abies balsamea*),
- bluebead lily (*Clintonia borealis*)
- starflower (*Trientalis borealis*),
- bunchberry (*Cornus canadensis*)
- goldthread (*Coptis trifolia*)
- twinflower (*Linnaea borealis)*

Some are migrating from the original plots

Exposed Mats

Barren exposed rocky habitats are abundant in Sudbury

Mount Ramsey

Alice Lake

Lichen ‘seeding’ and transplant

VETAC

Large linden tree planted behind the stone amphitheatre at Sudbury Secondary School.

UGLIEST SCHOOLYARD CONTEST

2018 14th annual

43 schoolyards regreened

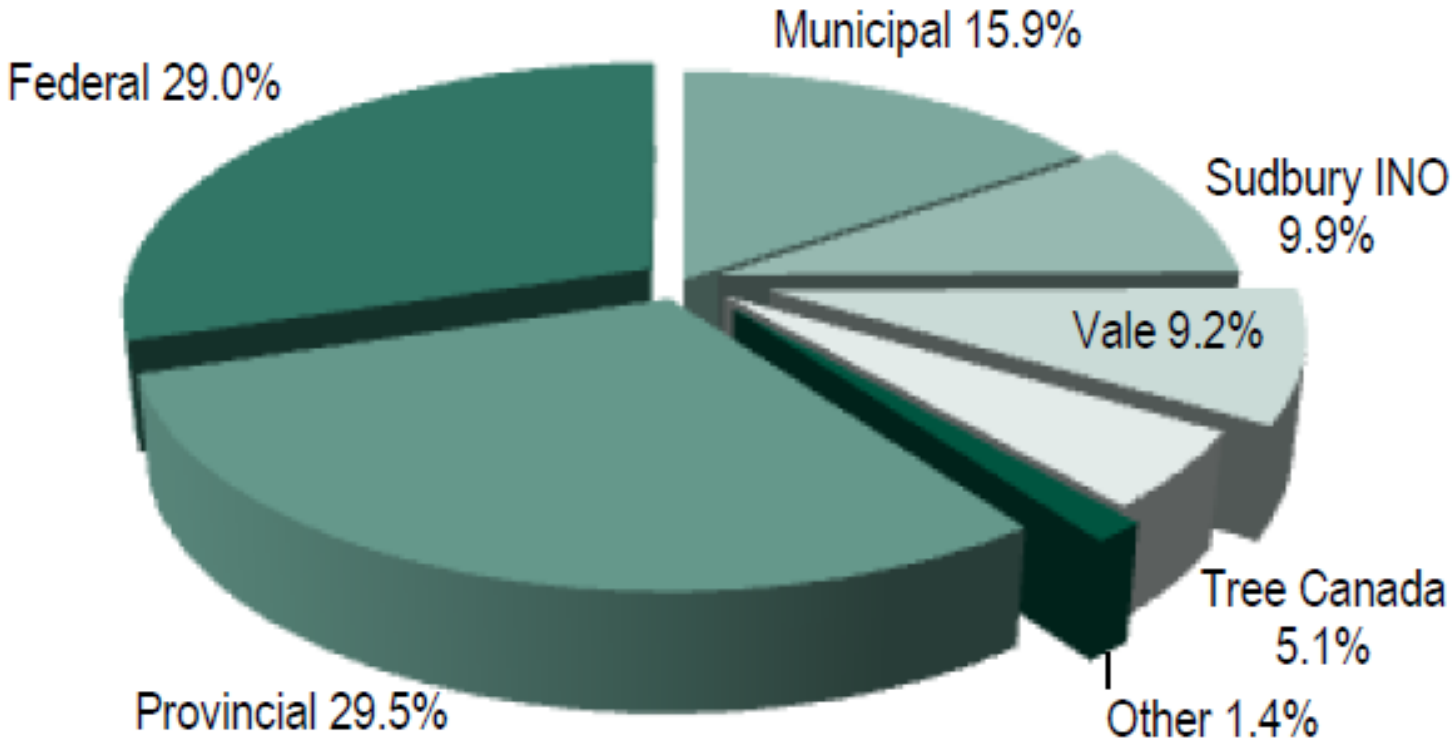
+2 in 2018

- Tree Seedlings Planted
  9,723,172
- Shrub/Understory Tree Seedlings 360,539
- Area Limed 3,471 ha
- Area Fertilized 3,246 ha
- Area Seeded 3,173 ha
- Forest Floor Transplants 1.83 ha

- Program Cost
  $31,837,747
- Temporary Employment Opportunities 4,746
- Awards – 14
- Number of Schoolyards Regreened 43
- Volunteer Tree Planters 11,662
- Trees Planted by Volunteers 375,046
- Trees for Residential
- Plantings 429,023

Regreening Components 1978 – 2017 40 years

Total costs 1978 – 2017 $31,837,747



2017 Partners

Regreening Program

Greater Sudbury
VALE
SUDBURY INTEGRATED NICKEL OPERATIONS A GLENCORE COMPANY
KGHM
TreeCanada
COLLÈGE BORÉAL éducation · innovation · recherche
ONTARIO PARKS
earthdancers
Laurentian University Université Laurentienne
Conservation Sudbury

Ugliest Schoolyard Contest

Corporate Sponsor:

SUDBURY INTEGRATED NICKEL OPERATIONS A GLENCORE COMPANY

Azilda Greenhouses

Brown's Concrete Products Ltd.

Canadian Tire on Regent Street

Futurescape Landscaping

Greater Sudbury Regreening Program

Jetty's Landscaping Supplies

King Fabricating

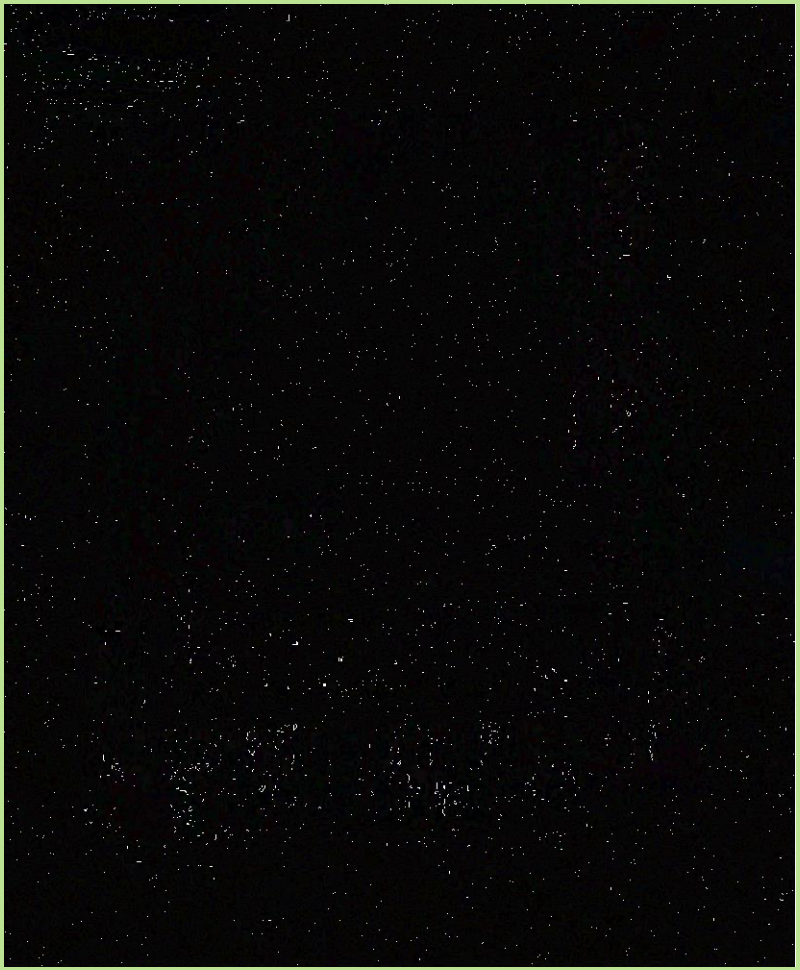
Southview Greenhouse Growers

Sudbury Horticultural Society

Sudbury Master Gardeners

Vale

Milestone Celebrations - célébrations



Trees planted: >8 million

Greater Grand Sudbury

Jane Goodall Self-Guided Reclamation Trail

30 Jane Goodall Reclamation Trail

1.0 km | Easy | Natural

Location: Corner of Hwy. 17 East and MR 90 (Garson-Coniston Rd.) Free parking at the Welcome Centre. Trail Head: Welcome Centre.
GPS: 17 T 512180 5149079 Bus Route: 103

This trail, named in honour of the internationally renowned scientist and environmentalist, Jane Goodall, is located at the Coniston Welcome Centre. As you walk along this 1 km trail, you will encounter projects dating from 1979 which were initiated to heal the landscape. In 1978, this site was totally bare of vegetation. Logging, followed by the smelting of nickel/copper ore, which produced noxious emissions of sulphur dioxide, depleted the vegetation and allowed soil erosion to occur. Through the efforts of the Sudbury Land Reclamation Program, this site has been transformed into a startlingly beautiful trail. A guided walk brochure can be found at: www.rainbowroutes.com

Lookout 1

Lookout 2

EXIT POINT

Gazebo

ACCE POIN

Info

Coniston

C.N.R.

Highway 17 East

Regreening/Biodiversity posters
Rock Barrens: Lakes & Streams: Forests: Wetlands

Education

http://www.greatersudbury.ca/living/environmental-initiatives/biodiversity/habitats/

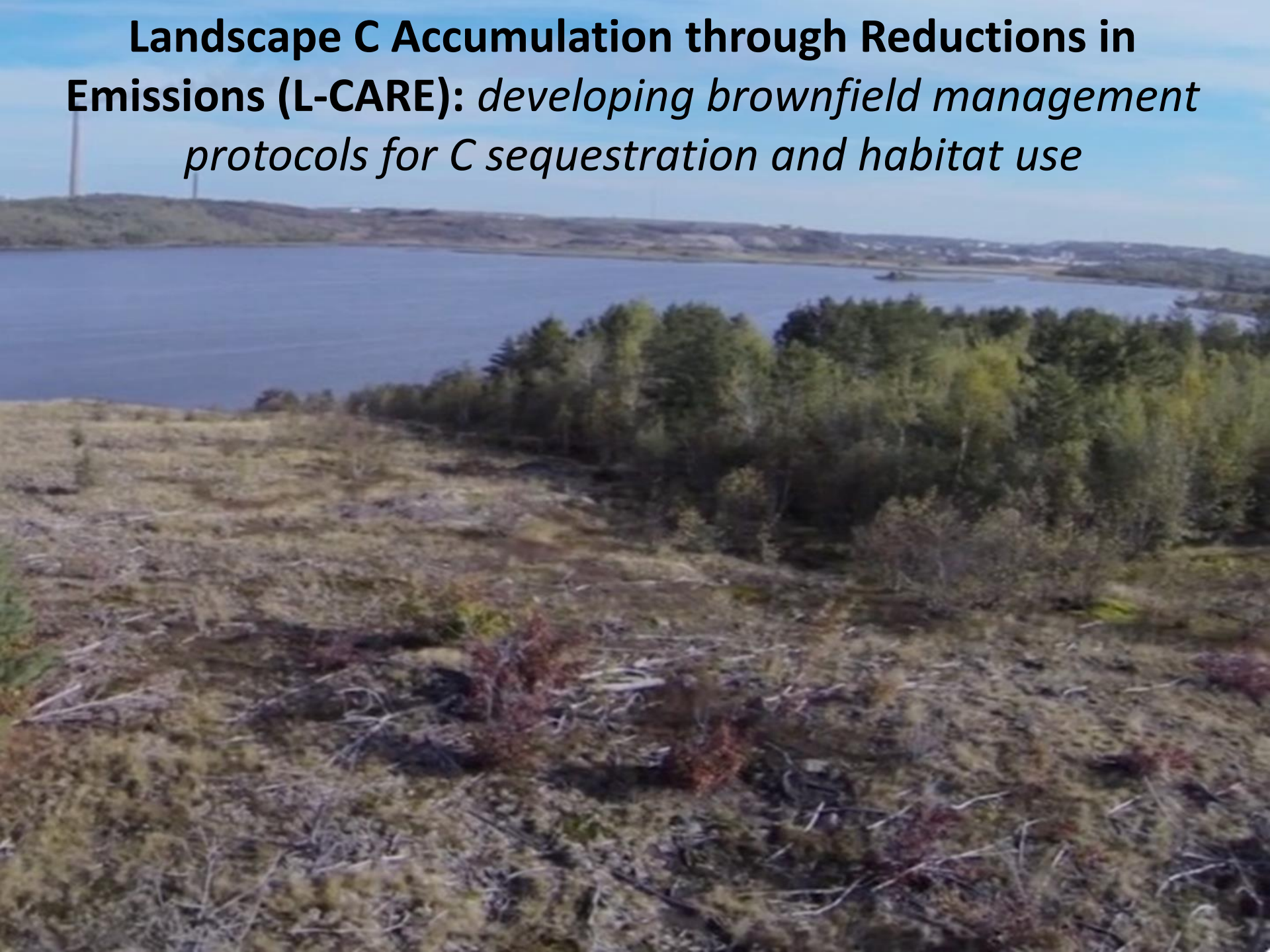
Completion Criteria

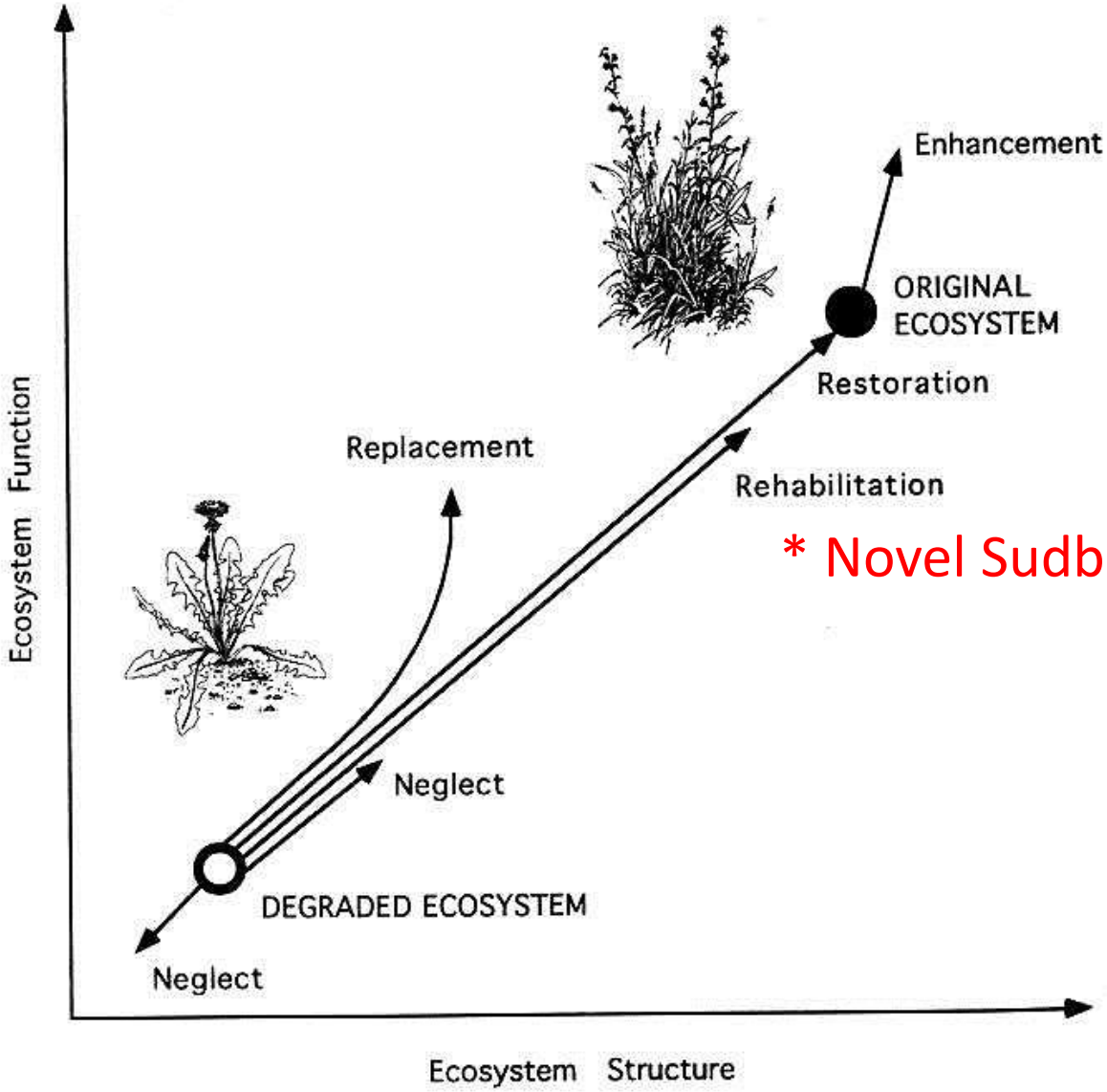
- These criteria will assist VETAC in gauging when sufficient regreening activities have been undertaken in a particular area.
- 4 components: Site characteristics & soil;
  Ecosystem structure,

  Ecosystem function,

  Social aspects.
- Trial assessments have suggested sites 30+ years old maybe 70-80% complete

Landscape C Accumulation through Reductions in Emissions (L-CARE): *developing brownfield management protocols for C sequestration and habitat use*





* Novel Sudbury

Figure 11.13. A conceptual representation of ecosystem degradation, restoration, and related processes. See the text for an explanation; for each line on this graph there is an italicized term in the text. (Redrawn by permission from Bradshaw 1984.)

Key To Sudbury Restoration Success

Dedicated volunteers

(There are many youth scattered on the hillside.)

- Industry co-operation
- Municipal leadership
- Academic guidance
- Lack of finger-pointing
- Early visibility of success
- VETAC is an action - based semi-independent group
- Citizen involvement
- Program refinement

QUESTIONS?
Thanks- Merci beaucoup
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40 YEARS
GREEN

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