

LICHEN DIVERSITY IN THE RECLAIMED AREAS OF SUDBURY, ONTARIO*

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Abstract

The Sudbury Land Reclamation Program has been operating since 1978 and has treated about 25% of the heavily stressed land near the base mining and smelting complexes. In the subsequent years following reclamation over 20 species of lichen have invaded the ground in the developing open woodland ecosystem. The most numerous lichens are members of the *Cladonia* ('Pixie cup') group but Reindeer lichens (*Cladina* spp) also occur. The pattern of invasion has similarities to that observed in other disturbed ecosystems (cutting or burning in forests, or abandoned farmland).

Introduction

The Region of Sudbury's Land Reclamation Program commenced in 1978 and has continued until the present time. Approximately 3500 hectares of acid metal-contaminated land have been treated, mostly with an application of dolomitic limestone, fertilizer and a grass-legume mixture (Lautenbach *et al.*, (1995)). Subsequently 2.75 million trees, using 17 species, have been planted with pines being widely used.

Since the late 60's there has been considerable improvement in air quality. Industrial sulphur dioxide emissions have been reduced by 90% and quantities of metal particulate emissions have also decreased. There has been some natural recovery (*ie* without remedial assistance) of ecosystems in the Sudbury area (Gunn *et al.*, (1995)).

Lichens are good indicators of ecosystem health and in particular respond to air contaminants such as sulphur dioxide. With the change in sulphur dioxide concentrations there has been a response by lichens in areas not subject to land reclamation. Surveys (from 1968) of epiphytic lichens growing on Balsam Poplar

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(*Populus balsamifera*) demonstrate a reinvasion of the lichen desert once present around the smelters and the existence of pollution sensitive species (Leblanc *et al.* (1972); Beckett (1995); Gunn *et al.* (1995)). Field observations since 1978 have shown that following reclamation treatment there appeared to be a slow invasion of terricolous lichens into microsites created by the changes in vascular plant composition and cover. However, no systematic or detailed investigation had been made until the commencement of this study in 1995.

Sites and Methods

A series of sites on reclaimed land in the Coniston-Wahnapiatae area, 10 km east of Sudbury, were chosen since there were several years of reclamation activity in a small geographical region. The sites span the years of operation of the land reclamation program and were picked to have similar landscape characteristics of gentle slopes above valley floors and stony substrates. Recently reclaimed sites, 1993, 1994, 1995, were dominated by grasses and legumes with few shrubs or trees except for small planted conifers. 1988, 1983, and 1979 sites have been invaded by a number of herbaceous vascular plants, poplar, birch and willow and have the appearance of an open woodland. Substrates were acid with a pH range from 4.5 - 5.5. For comparative purposes two sites in a logged pine forest (1978) and a burnt forest (1973) were investigated.

At each site three or four transects up to 5 m in length were marked. Along each transect a series of contiguous 20 cm by 24 cm quadrats were placed and percent cover of each lichen species measured. General vegetation characteristics and pH were determined.

Results.

The number of lichen species found ranges from 0 in 1995, 1994, 1993 to 17-21 at sites reclaimed in 1988 and earlier. Similar number of species were observed in the burnt and logged sites. There was no gradual increase in number of species over time. Likewise the overall coverage of lichens along the transects at the 1988 and earlier sites was around 40%. The burnt site showed a higher coverage of lichens (approximately 70%) and the logged site was similar to the reclaimed site.

Lichens observed belonged mainly to the *Cladonia* ('Pixie cup' group) with 19 species. There were no consistent patterns in cover but *Cladonia botrytes*, *C. cornuta*, *C. cristatella*, *C. gracilis* and *C. pleurota* were the most abundant on reclaimed sites. *C. cristatella* and *C. gracilis* were also abundant in the forest sites. The Reindeer lichens (*Cladonia mitis* and *C. rangiferina*) were present at all sites at and before 1988. *Peltigera canina* and *Stereocaulon* sp (both nitrogen fixers) were present in small amounts.

Discussion

Reclaimed sites contain a higher number of species than nearby barren or open birch woodlands where cover of *Cladonia. rei* > *C. cristatella* > *C. pleurota* > *C. botrytes*. *Stereocaulon* sp. is more abundant in untreated areas than on reclaimed land and may make a significant contribution to the nitrogen budget. No Reindeer lichens are found within 20 km of Sudbury (Beckett (1995)).

Intermittent field observations over a number of years suggested that the number of lichen species had increased with time. However in this investigation this observation was not supported since there were approximately the same number of lichens at each reclaimed site after several years. The sites were in the same geographical area and maybe once a lichen species had reached reclaimed land from outside the Sudbury area it quickly spread into all available microsites independent of time of reclamation. In abandoned fields it takes about 3 years for the first lichens to appear. Many species of *Cladonia* are abundant for the next 70 years and then start to disappear as the forest canopy closes (Hale (1983)). On reclaimed land there were no lichens for the first three years following reclamation (1995-1993 sites). However at a 1992 location (not reported here) lichens were present and can be found at all sites back to 1979 (18 years after reclamation). Further observations are needed to see if lichens remain abundant or species composition changes as the trees begin to shade the soil.

The pattern of establishment is similar to that observed in other major disturbances in NE Ontario (fire and logging) and suggests that the detoxifying effect of limestone is beneficial to lichen establishment and successional changes. Since lichens are excellent accumulators of metals it is not surprising that elevated copper and nickel amounts (> 100 µg/g) are found in lichen communities in the Sudbury area (Cox (1993)). Whether amounts are less in lichens on reclaimed sites has yet to be determined.

Conclusion.

The effect of liming and grassing has provided suitable microsites for the invasion of lichens not otherwise present in the Sudbury area. The number of lichen species found approaches the number of vascular species found and if one were to include the bryophytes may exceed the number of vascular species. The policy of aiming for an open grass sward allowing for subsequent colonization has been successful in that plant biodiversity is large. It will be interesting to follow further lichen changes over time, especially in reclaimed area where the tree canopy is closing. Many of the observed species are characteristic of open or semi-open areas and may be replaced as the Sudbury reclaimed ecosystems continue to develop.

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TABLE OF CONTENTS

LIST OF SPONSORS	vi
INDUSTRIAL FACILITIES	
Industrial Site Decommissioning in Alberta	1
Walter J. Ceroici	
Changing Knowledge Needs for Wellsite Reclamation	3
Jim Smith	
The Orphan Facilities and Pipeline Program: An Industry/Government Responsibility	7
David Lloyd and David Sandmeyer	
In-Situ Amelioration of Sodic Mine Spoil Using Sulfur, Gypsum and Crop Management ...	11
Jeff J. Sansom, M. Anne Naeth, and David S. Chanasyk	
Bioremediation of Contaminated Sites	13
Christopher Schneider	
Contaminant Metal Concentration in Alberta Soils Under Different Land Uses	17
Gerry Lutwick, Gordon D. Dinwoodie, David Gower and G. E. Nason	
Waste Disposal Guidelines from a Testing Lab's Perspective	19
John Ashworth	
Reclamation of a Former Heavy Oil Plant in Northeastern Alberta	23
Tim R. Bossenberry, J. Jeffrey Wilson, David Evans, Darrell Chollak and George Walker	
Nutrient and Metal Levels and Dynamics on a 30-year Revegetated Copper-Nickel Tailings Site at Copper Cliff, Ontario	27
Jeremy Niemi, John Giffen and Keith Winterhalder	
FORESTS	
Land Application of BCTMP Mill Waste Research in Alberta	31
Terry M. Macyk	
Reclamation to Native Forest Ecosystems in the Oil Sand Region	33
Steve Tuttle	
Land Capability Classification for Forest Ecosystems	37
Leonard A. Leskiw, Steve Tuttle and Earle Anderson	
Forest Land Restoration on Vancouver Island	39
David Polster	

Lichen Diversity in the Reclaimed Areas of Sudbury, Ontario	43
S. Wainio and Peter Beckett	

MOUNTAINS

Application of Population Biology, Conservation Biology and Succession Theory to the Reclamation of a High Elevation Coal Mine	47
Clint R. Smyth	

Plant Community Changes in Response to Anchor Chaining and Seeding on Pinyon/Juniper Sites in Central Utah	51
J. Gregory Sutor	

Tailings Disposal and Reclamation at the Coal Valley Mine	53
Dane McCoy	

In-Pit Disposal Program for Acid Generating Waste Rock	57
Jamie Quesnel and S. W. Stogran	

Reclamation, Trans Canada Highway Twinning, Banff National Park	63
Otto Hammer	

GENERAL ISSUES

Railway Reclamation: Issues and Opportunities	67
Chris B. Powter and David A. Lloyd	

Experiences in Reclaiming Railways Under Alberta's new Reclamation Guidelines	71
Mark Polet	

Pipeline Abandonment: A Discussion Paper	73
Karen Etherington	

Legal Perspectives on Land Reclamation	75
Gilbert Van Nes	

Liability for Reclamation: Enforcement at Common Law	77
Adrian Currie	

WATER AND WETLANDS

Coursier Reservoir: The Planning and Costs Associated with the Reconstruction and Revegetation of a Subalpine Lake	81
J. Leah Jackson	

Spray Lakes Reclamation Project	85
Margwyn R. Zaccaruk	

The Pine Coulee Project: Linking Reclamation Planning to Impact Assessment	89
Ron Middleton	

Design and Construction Management Aspects of Constructed Wetlands	93
Bernard Amell and Kim Eastlick	

Natural Revegetation of an Alberta Peatland after Horticultural Peat Extraction	97
Wayne S. Tedder and Larry W. Turchenek	

RUNOFF/EROSION

Computer Modelling of Soil Erosion from Reclaimed Land	101
Les Sawatsky, Wes Dick and Senarath Ekanayake	

Runoff and Sediment Yield under Grazing in Foothills Fescue Grassland of Alberta	103
M. Anne Naeth and David S. Chanasyk	

Runoff Curve Numbers for Two Reclaimed Watersheds in Central Alberta	107
Ted E. Harms and David S. Chanasyk	

Vegetation Characteristics, Grazing Disturbance and Soil Erosion	111
Suzanne I. Gill, M. Anne Naeth, David S. Chanasyk and V. S. Baron	

PRAIRIE

Renewing the Ecological Integrity of Disturbed Native Prairie	113
Heather S. Gerling	

Mixed Grass Prairie habitat Restoration Project: Landscape Restoration in the Moist Mixed Grass Prairie	117
Dean Nerberg	

Native Prairie Regeneration After Pipeline Construction: A Comparison Between Topsoil Stripping versus No Topsoil Stripping During Construction	119
Gordon Dunn and Gina Fryer	

Restoration of Native Sandhills Vegetation after Pipeline Construction in the Great Sand Hills Region of Saskatchewan	123
David G. Walker, Laurier Kremer and Wayne Marshall	

The Effects of Grazing, Mowing, Glyphosate and Burning on Smooth Brome in Fescue Grassland	125
D. J. Brown and M. Anne Naeth	

VEGETATION

Avoiding Downy Brome When Buying Seed	127
Kerby Lowen and Sarah Foster-Stubbs	

Biodiversity and Reclamation: How Many Species do we Need in a Seed Mix?	131
Dana Bush and M. Anne Naeth	
Germination and Survivability of Selected Native and Introduced Grasses and Legumes	133
William E. Pelech and M. Anne Naeth	
Road Maps for Repairing Ecological Damage	135
Andy Hammermeister	
Ecovar Developments in Western Canada	137
Les Wetter and Brent Wark	
Plant Growth on Aggregated Oil Sands Processing Wastes	139
Xiaomei Li, Jim Storey, Paul Y. P. Yeung and Martin Y. P. Fung	
The Clover Bar Landfill: A State of the Art Landfill Reclamation Process	141
Ann Smreciu, Nolan Turner and Don Barron	
BULK DENSITY	
A Method of Characterizing the Bulk Density of Compressible Particulate Material	145
D. Guenther, Stacy Schaub and J. Leonard	
Near-Surface Compaction Under Grazing of Annual and Perennial Forages	149
Dennis Twerdoff, David S. Chanasyk, M. Anne Naeth and V. S. Baron	
Grazing Impacts on Bulk Density and Soil Strength in the Foothills Fescue Grasslands of Alberta, Canada	151
David S. Chanasyk and M. Anne Naeth	
Computer Modelling of Soil Erosion from Reclaimed Land	155
Les Sawatsky, Wes Dick and Senarath Ekanayake	

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