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 wooodland 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 pariculate 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-Wahnapitae 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 (*Cladina 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 $\mu g/g$) 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 ecosytems continue to develop.

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