NATURALIZING QUARRY SITES IN SOUTHERN ONTARIO

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ABSTRACT

Two approaches to renaturalizing quarry sites located in southern Ontario are discussed. The first approach, which was applied at the Walker Brothers quarry in Thorold, involves the use of nursery stock planted in cells. As the planting mature, they should begin to spread and intergrade with each other to form a dynamic, diverse and self-sustaining vegetation community. The second approach, which was applied at the Dufferin Aggregates Milton quarry, involves the use of forest soil as the source of vegetation stock. The soil, which was stripped as part of the on-going extraction operation, provides a large quantity of seeds, rhizomes and stolons. These native species should be sufficient to provide a dynamic, evolving plant community. Both of these sites will be monitored over the long term to determine changes in the vegetation community composition, influence on colonizing plant species and use by wildlife. The first year's results of the monitoring program are discussed.

Introduction

Quarry rehabilitation invariably involves the establishment of vegetation regardless of the planned afteruse. Rehabilitation specifically for wildlife habitat entails the establishment of a vegetation community that is diverse, composed mainly of species native to the area, self-sustaining both in the short and long term and that will progress towards a climax community which is familiar to the area. Several techniques exist for the establishment of such a vegetation community, each with their own merits and disadvantages (Table 1).

Table 1.
Vegetation Establishment Techniques and their Relative Merits and Disadvantages

	Planting of Nursery Stock	Soil Seed Bank	Transplantation of Existing Plants	Direct Seeding of Native Woody and Herbaceous Plants	Natural Colonization with no Intervention	Notes
1. Level of control over species established	medium to high	low	medium to high	high	low	natural succession always has final word as to species
2. Relative cost	high	low	medium to high	medium	low	
3. Level of expertise required	medium	medium	high to medium	high	low	
4. Time of establishment of target community	medium to fast	medium	medium	medium	slow	

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Vegetation Establishment Techniques and their Relative Merits and Disadvantages

	Planting of Nursery Stock	Soil Seed Bank	Transplantation of Existing Plants	Direct Seeding of Native Woody and Herbaceous Plants	Natural Colonization with no Intervention	Notes
5. Species availability problems	yes	no	yes	yes	no	
6. Level of maintenance required	high	low	high	medium	low	

This paper examines the preliminary results of the use of soil seed banks and the planting of nursery stock as vegetation establishment techniques at two sites: the Milton Quarry (Dufferin Aggregates) and the Thorold Quarry (Walker Brothers Quarries Limited). The results are preliminary since they represent the first set of data collected for what is to be a long-term (several years) monitoring program of vegetation establishment and succession.

Milton Quarry (Dufferin Aggregates)

Milton Quarry is established on the Niagara Escarpment. Prior to the quarry the site was forested with the dominant species being sugar maple (*Acer saccharum*), white ash (*Fraxinus americana*), and red oak (*Quercus rubra*).

Slopes along the western edge of the quarry were created in 1991 using a topsoil and subsoil mixture at 3:1 to 2:1 slopes. Topsoil is native to the quarry site and has been applied directly following stripping. Soil originates from a variety of forest types including cedar lowland. Seedlings of staghorn sumac, autumn olive (*Eleagnus commutata*) and white spruce (*Picea glauca*) were planted on these slopes following soil application.

Observation of the slope in the summer of 1992 revealed that a diverse vegetation community comprised of various exotic and native forbs, grasses, sedges and volunteer staghorn sumac had developed amongst the planted seedlings. Other slopes that had been created using pond fines with no application of topsoil were virtually bare after several years except for the occasional coltsfoot (*Tussilago farfara*). Also, slopes that had not received an application of topsoil exhibited signs of significant erosion whereas the slope that had been created from the topsoil/subsoil mixture, had no observable erosion. Dufferin Aggregates' Property and Resource Manager and staff from Ecological Services for Planning Ltd. (ESP) agreed that there would be some value in studying the dynamics of the vegetation on the slopes over the long term to determine if simply spreading forest topsoil would be a sufficient effort to initiate the development of a diverse and productive native plant community. The aim of the study is to examine the succession of the vegetation community over the long term using annual measurements of percent cover by species.

Methods

To measure the percent cover of the various species along the slope, ESP established four randomly placed quadrats, each measuring 30m in length. The ends of the transects were marked with wooden stakes which are to remain in place permanently. A point quadrat frame was used to record vegetation cover at one metre intervals along each transect. The frame was placed perpendicular to the transect line and a plumb bob was dropped at six points along

the frame, each 20 cm apart. The species of the first plant touched by the plumb bob was recorded for a total of 720 records along the four transects. Percent cover for each species represents the total number of times that the plumb bob touched a given species over the total number of plumb bob drops (i.e. 720). All records were taken on July 18, 1993 and will be recorded in subsequent years at approximately this date.

Results and Discussions

Coltsfoot (*Tussilago farfara*) has by far the highest percent cover (68.1%) followed by bare ground (8.9%), alfalfa (*Medicago sativa* (4.7%), staghorn sumac (*Rhus typhina*) (4.0%), red raspberry (*Rubus idaeus*) (2.4%), and boneset (*Eupatorium perfoliatum*) (2.2%) (Table 2). Other species indicated on Table 2 have a very low percent cover. Of the 27 species recorded, approximately 22% are exotic whereas 78% are native. Few woody species were recorded and it was not possible to differentiate between those staghorn sumacs that had been planted from those that had arisen from rhizomes or seeds present in the seed bank. It is known, however, that not all of the sumacs present on the slope were planted. Other species present on the slope but not recorded include swamp milkweed (*Asclepias incarnata*), choke cherry (*Prunus virginiana*), columbine (*Aquilegia canadensis*), black-eyed susan (*Rudbeckia hirta*) and oxeye daisy (*Chrysanthemum leucanthemum*). American hazel (*Corylus americana*) and poplar (*Populus* sp.) seedlings were also present but only on the quarry floor adjacent to the base of the slope.

Table 2.
Percent Cover of Species Recorded on Slope at Milton Quarry

Scientific Name	Common Name	Percent Cover	Status
Tussilago farfara	Coltsfoot	68.1	E
Bare Ground	Bare Ground	8.9	
Medicago sativa	Alfalfa	4.7	E
Rhus typhina	Staghorn Sumac	4.0	N
Rubus idaeus	Red Raspberry	2.4	N
Eupatorium perfoliatum	Boneset	2.2	N
Glyceria striata	Fowl Manna Grass	1.3	N
Solidago canadensis	Canada Goldenrod	1.0	N
Rubus occidentalis	Black Raspberry	0.9	N
Carex stipata	Sedge	0.7	N
Equisetum arvense	Field Horsetail	0.5	N
Rubus odoratus	Flowering Raspberry	0.5	N
Aster puniceus	Purple-stemmed Aster	0.4	N
Clematis virginiana	Virgin's - bower	0.4	N
Eupatorium maculatum	Spotted Joe-pye Weed	0.4	N

Table 2.

Percent Cover of Species Recorded on Slope at Milton Quarry

Scientific Name	Common Name	Percent Cover	Status
Carex retrorsa	Sedge	0.3	N
Cornus sericea	Red-osier Dogwood	0.3	N
Euthamia graminifolia	Grass-leaved Goldenrod	0.3	N
Muhlenbergia sp.	Muhly Grass	0.3	N
Poa palustris	Fowl Manna Grass	0.3	N
Potentilla norvegica	Strawberry weed	0.3	E
Bromus inermis	Smooth Brome	0.1	E
Daucus carota	Wild Carrot	0.1	E
Lycopus uniflorus	Northern Water-horehound	0.1	N
Picea glauca	White Spruce	0.1	N
Ribes americanum	Wild Black Currant	0.1	N
Solanum dulcamara	Bittersweet Nightshade	0.1	E
Vitis riparia	Riverbank Grape	0.1	N

E - exotic
N - native

The relative absence of woody species was unanticipated. Other studies have shown early colonization by native woody and herbaceous species from the seed bank for forest topsoil used in site reclamation (Farmer *et al.*, 1982; Johnson and West, 1989; and Wade, 1989). The soil seed bank is at least partly responsible for succession in old fields (Egler, 1954), and it is important in recovery of forest stands after disturbance through supplying species that are important in the early stages of secondary succession (Livingston and Allessio, 1968). The relative absence of woody plants in this study may be due to competition by the herbaceous vegetation. American hazel and poplar seedlings were found growing at the bottom of the slope in the absence of herbaceous species.

Since the soil was used immediately after stripping, soil storage time should not have contributed to the low numbers of woody plants. Results from other studies have shown an exponential decrease in seed numbers in soil following a disturbance (Roberts and Dankins, 1967; Roberts and Feast, 1973; Hargis and Redente, 1984). Other studies have shown the opposite; the number of viable seeds in samples from a one-year-old to two-year-old topsoil stockpiles exceeded the number in samples from freshly stockpiled topsoil (Iverson and Wali, 1982 and Johnson and West, 1989). The latter two studies were only conducted using topsoil stockpiles of a maximum of two years old and it is unknown what the viability of seeds is in soils stored for longer periods.

Data collected from future years will help to elucidate the vegetation dynamics on the slope. Further studies which ESP hopes to conduct at the Milton Quarry would investigate such factors as:

- soil storage time;
- soil provenance;
- supplemental fertilization; and
- supplemental seeding with native seeds.

Thorold Quarry (Walker Brother Quarries Limited)

In early 1993, Walker Brothers Quarries Limited was granted a licence to expand their current quarry operations. Conditions of the licence, as expressed in the site plan, included the planting of numerous areas prior to site operation in order to provide screening and/or wildlife habitat. ESP was retained to develop the landscape design and planting plan and to provide supervision during the landscaping work to ensure that the plans were followed as intended. Although these plantings are not established as part of the quarry rehabilitation work *per se*, their design and intended purpose are analogous to that of rehabilitation plantings. A series of plantings were also established along a section of the existing quarry to increase biotic diversity.

Methods

Site lines from adjacent roads and residences were determined using a topographical plan and field verification. Plantings were then designed that would provide adequate screening at the required time and that would also have other attributes such as wildlife habitat and native vegetation community development. Plantings were designed in cells measuring approximately 10m x 10m, 10m x 50m and 20m x 50m. Trees and larger stock were planted in the centre of the cell and shrubs on the outer edges to simulate the natural appearance of small forested pockets. Table 3 shows the species that were used in the cells. It is hypothesized that the cells would spread in time and join together to form larger forested bands. Conifers within the cells were laid out in such a way as to provide year round screening as well as wildlife cover. Prior to planting, the cells were mulched with wood chips to a depth of 10 cm. The mulch was added to reduce weed growth, maintain soil moisture and reduce the incidence of rodent damage. Spot herbicide application was done in the first year after planting in those cells that showed a relatively high level of weed infestation.

Table 3.
Species Planted at the Thorold Quarry (Walker Brothers Quarries Limited)

Scientific Names	Common Names	Notes
Shrubs		
Aronia arbutifolia	Red Chokeberry	Although an exotic to the area, it was used due to its salt tolerance
Clethra alnifolia	Sweet Pepperbush	" "
Cornus racemosa	Grey Dogwood	
Cornus sericea	Red-osier Dogwood	
Rhus typhina	Staghorn Sumac	

Table 3.
Species Planted at the Thorold Quarry (Walker Brothers Quarries Limited)

Scientific Names	Common Names	Notes
Salix discolor	Pussy Willow	
Sambucus canadensis	Elderberry	
Viburnum dentatum	Arrow-wood Viburnum	
Viburnum lentago	Nannyberry	
Viburnum trilobum	Cranberrybush Viburnum	
Trees		
Acer rubrum	Red Maple	
Acer saccharum	Sugar Maple	
Acer saccharinum	Silver Maple	
Amelanchier canadensis	Serviceberry	
Betula papyrifera	White Birch	
Celtis occidentalis	Hackberry	
Fraxinus americana	White Ash	
Gleditsia triacanthos	Honeylocust	
Larix laricina	Tamarack	
Picea glauca	White Spruce	
Pinus strobus	White Pine	> 50% mortality of seedlings; planted late
Populus tremuloides	Trembling Aspen	20% mortality; perhaps due to herbicide drift
Prunus virginiana	Choke Cherry	
Robinia pseudoacacia	Black Locust	Although an exotic, it was used due to its salt tolerance
Quercus rubra	Red Oak	
Thuja occidentalis	Eastern White Cedar	
Tsuga canadensis	Eastern Hemlock	

To date, cells that have been established include those along a portion of the edge of the existing quarry (1992), those along a major screening berm (1993), and those at the intersection of two main roads (1993). Additional cells will be added over the next year to complete the pre-operational landscaping requirements.

Results and Discussion

Mortality of the planted stock was inspected during the months following planting and was found to be higher for some species than others. Aspen, eastern white cedar, and white pine (seedlings) had mortality levels of approximately 20% to 50% while that for other species was lower. Mortality may have been due to poor stock that could not cope with the relatively harsh conditions of the site. Although the site was prepared by plowing and harrowing, large clumps of the clay soils were still evident after planting. Even with occasional watering and initial fertilization, the conditions for plant growth are still less than favourable due to the difficulty in providing good soil tilth and due to plant desiccation on the wind-exposed sites. Survival rates of most of the plants, however, are considered adequate.

Monitoring over the next years will reveal which species survive best and exhibit the fastest growth and which species begin to colonize the cells through wind-dispersed and bird-dispersed seeds. Robinson *et al.* (1992) found that after 14 years only half of the original 190 plants planted as part of a landfill reclamation effort had survived. An additional 752 trees and shrubs had colonized the plantation and its perimeter, as well as 2955 stems of vines. However, over 95% of woody plants that had colonized were not progeny of the plant cohort, but instead belonged to 18 invading species, mostly native, bird-dispersed, and associated with intermediate stages of secondary plant succession. Based on their findings, Robinson *et al.* (1992) suggest that plants used in rehabilitation work be selected not only in terms of their survival and growth but also based on the following criteria:

- high and quickly realized reproduction capacity;
- attractiveness to seed dispersers; and
- relatively rapid turnover to permit continued successional sequence.

Plantings at the Thorold Quarry will also be assessed on the basis of the above criteria.

Results from Robinson *et al.* (1992) appear to suggest that the initial plantings do not so much provide the biological source for colonization and vegetation spread but rather provide physical and biological attributes by which natural plant dispersal, colonization and succession can take place. Plantings at the Thorold Quarry differ from those in the Robinson *et al.* (1992) study in that planting cells were used at the Thorold Quarry whereas individual trees and shrubs were planted in the other. It was noticed that one year after planting, some of the staghorn sumacs were spreading vegetatively. Time will reveal whether planting cells, by simulating some of the characteristics of natural vegetation groupings, can also provide the source by which the plantings spread and develop into diverse, self-sustaining ecosystems.

Conclusion

First-year results of two long-term vegetation establishment projects indicate that while providing a highly diverse flora, use of the soil seed bank at Milton Quarry has failed to provide adequate amounts of woody species. These woody species are required if the vegetation community is to develop into an early successional, mid-successional and finally a climax forest community. Further monitoring results will reveal the dynamics of this community and may lead to insight into the importance of soil seed bank versus colonization from wind and animal-dispersed seeds as the factor determining species composition.

Initial results of vegetation establishment at the Thorold Quarry using planted nursery stock indicate good survival rate of the plants. Future monitoring results will show whether the plantings are responsible for any spread in woody vegetation or whether other sources such as wind and animal dispersion are responsible.

REFERENCES

Egler, F.E. 1984.
Vegetation science concepts. I. Initial floristic composition, a factor in old field development. Vegetatio. 4:412-417.

Farmer, R.E. Jr., M. Cunningham and M.A. Barnhill. 1982.
First-year development of plant communities originating from forest topsoils placed on southern Appalachian minesoils. J. Appl. Ecol. 19:283-294.

Hargis, N.E. and E.F. Redente. 1984.
Soil handling for surface mine reclamation. J. Soil Water Conserv. 39:300-305.

Iverson, L.R. and M.K. Wali. 1982.
Buried, viable seeds and their relation to revegetation after surface mining. J. Range Manage. 35:648-652.

Johnson, C.K. and N.E. West. 1989.
Seed reserves in stockpiled topsoil on a coal stripmine near Kemmerer, Wyoming. Landscape and Urban Planning. 17:169-173.

Livingston, R.B. and M.L. Allessio. 1968.
Buried viable seed in successional field and forest stands. Harvest Forest, Massachusetts. Bull. Torrey Bot. Club. 95:58-69.

Roberts, H.A. and P.A. Dawkins. 1967.
Effects of cultivation on the number of viable weed seeds in soil. Weed Res. 7:290-301.

Roberts, H.A. and P.M. Feast. 1973.
Changes in the number of viable weed seeds in soil under different regimes. Weed Res. 13:298-303.

Robinson, G.R., S.N. Handel and V.R. Schmalhofer. 1992.
Survival, reproduction and recruitment of woody plants after 14 years on a reforested landfill. Environmental Management. 16:265-271.

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