CONTROL OF THE INVASIVE DOG-STRANGLING VINE Cynanchum rossicum

Stephen Smith, Project Manager

Urban Forest Associates

ABSTRACT

Dog-strangling vine *Cynanchum rossicum* is an exotic twinning perennial vine which has recently become invasive in southern Ontario and central New York state. It can be found in abundance within the Toronto area and is spreading quickly along road, hydro, and rail corridors. Although it is an important threat to native vegetation, especially on disturbed sites, no research has been undertaken to determine the plants' phenology or methods to control its spread. In 1996, we undertook field studies to determine the plant's life cycle, reproductive capacity, and methods to control its spread.

This presentation will discuss the results of the study and recommend the most effective control measures.

Introduction

The recent proliferation of dog-strangling vines (*Cynanchum* [=*Vincetoxicum*] *spp.)* is posing a serious threat to southern Ontario's flora. These perennial members of the milkweed family, also known as swallow-worts, can reach a length of 2 metres and produce copious amounts of wind-blown seed. If present in sufficient densities, the plants intertwine and create an impenetrable tangle that shades out other species of open fields and open forests.

To date, there has been very little published information on the ecology of dog-strangling vines in Canada or Europe. Gaining an understanding of the reproductive biology of these plants in southern Ontario is an important first step in the design of effective control programs. For this reason, a phenological study of the most invasive of these species, *C. rossicum*, was undertaken between June and October of 1996, concurrent with the control study.

The control study was undertaken to assess the potential value of mowing, light blockage (involving the use of plastic sheeting to cover plots) and herbicide treatments in reducing the presence of *C. rossicum* in a dense infestation. Specifically, the study was designed to determine the effects of timing and the number of treatments on percent cover of *C. rossicum* one year later.

Methods

Control studies were conducted in Morningside Park, located in the Highland Creek valley in Toronto, Ontario. The park consists of degraded upland forest, conifer plantings, mowed turf and successional fields. A 1200 m^2 area of open field dominated by *C. rossicum* was selected for study. The site is on a south-facing terrace with a 7% slope. Soils are sand loams and loamy sands of variable thickness overlying glacial till. Poor drainage, caused by a compacted Bc layer, is indicated by subsoil mottling.

Other vegetation present on the site included riverbank grape [*Vitis riparia* Michx.], wild red raspberry [*Rubus strigosus* (Michx.], goldenrods (*Solidago spp.*), cow vetch [*Viccia cracca* (L.)], grasses (*Agrostis, Bromus, Phleum spp.*) and other herbaceous species. The study area is bordered by a disturbed forest edge of white spruce [*Picea glauca* (Moench) Voss], Scots pine [*Pinus sylvestris* (L).] and staghorn sumac [*Rhus typhina* (L.)].

A simple block design was used to randomly assign 13 treatments consisting of three replicates each, and one control plot. 4 m^2 plots were marked with wooden stakes in each corner. Treatments (Table 1) consisted of 1) mowing with a rotary mower 5 cm above the ground, 2) covering plots with opaque plastic sheeting and 3) treating plots with a 5% solution of the herbicide glyphosate. All treatments were carried out in 1996.

Mowing treatments included a single mow in mid-June, early August and late August and repeated mows in mid-June, early and late August and in early and late August. Three plots were mowed in mid-June and covered with black plastic sheeting secured by metal pins. The sheeting was intended to suppress growth by blocking light. Herbicide treatments were timed to correspond with mowing treatments, with the exception of the late August application, which was delayed until early September.

Four circular sample plots (1.12 m diameter, 1 m^2 area) were randomly established within each of the 37 square treatment plots. Percent cover of all vegetation in the sample plots was visually estimated on June 18, 1996 to a total of 100%. The average standing height of *C. rossicum* was also recorded in the control and mowed plots. Plots were resampled on June 21, 1997 to determine the effects of different treatments on percent cover of *C. rossicum* the following year. Control is expressed as the percent reduction of cover from initial estimates, and is summarized in table form. Other data and relevant observations are descriptively reported.

Effects of Treatment on Reproduction: Nine root systems were excavated in August, 1997 from plots treated three times with glyphosate. The roots were then potted for observation to determine whether growth could resume following herbicide damage to perennating tissues.

Seed produced in treated plots in 1996 was collected and tested for viability. After three months of dry storage at 4° C, 28 seeds were selected from each treatment and germinated at temperatures averaging 21° C. Seeds were germinated by placing them on top of soil in plastic trays. Viability was tested in the same manner in 1997. In this trial, fifty seeds were selected from each treatment and germinated after one month of dry storage at 21° C.

Table 1. Manual and herbicide treatments applied to *C. rossicum*.

Treatment	Description	Time of Application(s)	Replications
1	Control plot	------	1
2	Mowing (x3)	June, early & late August	3
3	Mowing (x2)	early & late August	3
4	Mowing	June	3
5	Mowing	early August	3
6	Mowing	late August	3
7	Herbicide (x3)	June, ear. Aug.,ear. Sept.	3
8	Herbicide (x2)	June, early August	3
9	Herbicide (x2)	June, early September	3
10	Herbicide	June	3
11	Herbicide	early August	3
12	Herbicide	early September	3
13	Light blockage	June	3

Results

Mowing: As Table 2 shows, mowing did not cause a significant reduction in percent cover of *C. rossicum* the following year. Percent cover varied between 75 and 86% after different mowing treatments, and fell within the range of values for the control plot in 1996 (75%) and 1997 (86%). Reductions of up to 13%, and increases of up to 6% were observed, although there was no consistent pattern of increase or decrease. Mowing had a visible effect on average height, however (with the exception of a single mow in early August). The average height of vines declined by as much as 28 cm (46%) after mowing, although no relationship between height and number of treatments was apparent. Seed set was observed in all mowed plots in 1997, and seed viability was confirmed by subsequent germination studies.

Table 2. Mean percent cover reduction/increase of *C. rossicum* one year after mowing, herbicide and light blockage treatments.

Treatment	**Time of Application**	**Percent cover reduction (↓) or increase (↑)**
Control	------	------
Mowing (x3)	June, early & late August	13% ↓
Mowing (x2)	early & late August	5% ↑
Mowing	June	6% ↑
Mowing	early August	8% ↓
Mowing	late August	10% ↓
Herbicide (x3)	June, early Aug., early Sept.	97% ↓
Herbicide (x2)	June, early August	97% ↓
Herbicide (x2)	June, early September	92% ↓
Herbicide	June	59% ↓
Herbicide	early August	85% ↓
Herbicide	early September	57% ↓
Light blockage	June	------

Light Blockage Treatments: The plastic sheeting was repeatedly torn open by skunks and other animals, allowing cover of *C. rossicum* to return to 85% (compared to 96% in 1996) by June of 1997. While intact and secure, the plastic sheeting suppressed the growth of the plants.

Herbicide Treatment: Prior to treatment, *C. rossicum* comprised 71 to 95% of the total cover in herbicide plots, compared to 75% in the control. All herbicide treatments reduced cover values, regardless of the number of treatments or timing of application (Table 2). Single treatments of glyphosate were less effective than multiple applications. A single treatment in mid-June reduced cover from 75% in 1996 to 31% in 1997 (a reduction of 59%). Cover declined to almost the same extent following treatment in early September, from 72% in 1996 to 31% in 1997 (a reduction of 57%). Treatment in early August resulted in the strongest reductions in *C. rossicum*, from 82% in 1996 to 12% in 1997 (a reduction of 85%).

Multiple treatments in mid-June and early August and in mid-June, early August and early September provided excellent control in 1997 (Table 2). In both cases, cover declined to only two and 3% in 1997, from pre-treatment values of 71% and 93% respectively (reductions of 97% in both cases). An application of glyphosate in mid-June and early September also sharply decreased cover values from 95% in 1996 to 8% in 1997 (a reduction of 92%).

Following single treatments with herbicide in 1996, some stems, although top-killed, remained yellow-green until the end of the summer. The dense, intertangled foliage made treatment of the lower layers of vegetation difficult. Although most growth in 1997 was from seed, a few mature plants managed to regenerate in plots which received one or two applications of glyphosate.

Root excavations revealed that *C. rossicum* may persist below ground without giving any aboveground indications of its survival. Triple applications of glyphosate had a devastating effect on root systems, which had largely disintegrated, leaving a rotted root crown. In spite of extensive damage, several of the root crowns examined had white, living buds which turned green after watering and exposure to light. Of the nine crowns potted in soil, two produced aerial shoots in 1997. After four months these plants were only 2 cm tall, but had roots up to 7 cm in length. A new "crown" had developed, and the older, damaged tissues had completely necrotized.

Plants which regenerated from established root systems were able to produce normal fruit with viable seed in 1997. No seed was produced in plots treated three times, since no aerial shoots were present in 1997, and because seedlings did not mature to the reproductive stage. Seed set was observed in 1996 following single applications of glyphosate in early August and early September. Treatment in early August accelerated the process of seed development, which enabled plants to release seed before succumbing to the herbicide. Treatment in early September also had a catalyzing effect on dispersal, which had begun in the control plot at this time.

Seed obtained from herbicided plots in 1996 appeared small and shriveled when compared to seed from untreated plants. Not surprisingly, germination was 0%, compared to 30% for the control and 40% for plants mowed only in mid-June. Lower germination rates were obtained for the control in 1997 (15%), however, 44% of the seed collected from plots treated with herbicide only in mid-June germinated without stratification.

A dramatic shift in species composition was observed in herbicided plots in 1997. Sweet white clover [*Melilotus alba* (Medikus)] replaced *C. rossicum* as the dominant species in most plots, and became especially abundant after treatment in early August and in mid-June and early September. Total cover of sweet white clover ranged from 22 to 71% between treatments and reached 87% in one plot. The sudden proliferation of this species is of interest since it comprised a very low percentage of total cover where it occurred in 1996. Several other exotic plants including bull thistle [*Cirsium vulgare* (Savi) Ten.], common mullein [*Verbascum thapsus* (L.)], curled dock [*Rumex crispus* (L.)], charlock [*Brassica kaber* (L.)], rough bedstraw [*Galium asprellum* (Michaux)] and St. John's wort [*Hypericum perforatum* (L.)] formed conspicuous patches on bare soil. These species comprised a lower percentage of total cover in 1996 or were not recorded on the study site. Cow vetch, riverbank grape, grasses and goldenrods declined to a small degree in 1997 when compared to 1996 cover values (data not given).

Discussion

Of the methods tested, herbicide treatments provided the most effective control of *C. rossicum* in the short-term. Glyphosate had a dramatic impact when compared to mowing, which had no significant effect on cover. Although mowing diminishes growth, it is unlikely that an additional year of treatment would be sufficient to exhaust stored carbohydrate reserves. The extensive, fibrous root system of this species may enable it to survive several years of top growth removal. Hodgson (1968 - in Evans 1984) found that four years of repeated mowing was necessary to reduce Canada thistle [*Cirsium arvense* (L.) Scop.] another invasive perennial, to 1% of its initial value. Over the longer-term, mowing may have value as an environmentally benign, but labour-intensive form of controlling *C. rossicum*.

Although plastic sheeting was not successfully used to control *C. rossicum* in this study, this method may hold promise. While intact and secure, the plastic sheets effectively suppressed growth, which did not resume until openings in the sheets were created. This observation suggests that if more durable material had been used, and steps taken to more firmly anchor it, the trial may have yielded positive results. In a similar experiment, Ambrose (1996) reported the near complete elimination of *C. rossicum* (aboveground) after covering a plot with plastic sheeting for one year.

The greatest reductions in *C. rossicum* were observed after repeated applications of glyphosate. The results of this study indicate that two or more treatments may be required to achieve a high degree of control within one year. The lack of difference between treatments in June and early August and June, early August and early September suggests that a third treatment in September had no further effect on reducing cover. A third application may be of added benefit, however, since no regrowth of adult plants was observed in plots treated in early September.

Single treatments may have been less effective than repeated treatments for several reasons. As mentioned earlier, the rank, tangled growth of the vines made even application of the herbicide difficult. This factor undoubtedly contributed to higher regrowth in plots treated once (some top-killed stems even produced fruit if flowers were missed on lower cymes). Single treatments may be less injurious to roots, and allow quicker recovery and resumption of growth. The results of the root potting trial suggest that seedlings may have had sufficient time following treatment in mid-June, and possibly early August, to become established and produce perennating parts. Treatments which reduce seedling frequency will also reduce the number of adults the following year.

The invasion of *C. rossicum* seeds from outside of the plots was likely of minor importance as a source of addition to the seedbank. According to Aldrich and Kremer (1997), dispersal falls off rapidly with distance from the source, even in wind-dispersed species. In a study of tansy ragwort [*Senecio jacobea* (L.)], which has comose seed, 60% of all seeds were found at the base of the plant, while only 1.4% were found beyond 4.6 m (Harper 1977 - in Aldrich and Kremer 1997).

Single herbicide treatments were most effective when applied in early August, when fruit maturation was well underway. However, weather, differences in plot coverage and various other factors may have influenced the efficacy of glyphosate at different treatment times. The early September treatment provided a higher degree of control than expected, since plants were largely yellowed by this point. According to Monsanto (1996), glyphosate is most effective when applied to broad-leaved perennials just before the onset of flowering, when carbohydrate reserves are at a minimum. At the time of the mid-June treatments, *C. rossicum* was at the late flower bud stage of development. In a study of herbicide control of common milkweed [*Asclepias syriaca* (L.)] Bhowmik (1982) found that glyphosate applied at 2.2 kg/ha provided 100% control after one year when applied on June 25, compared to 81% control when applied on August 30. However, studies of the effects of glyphosate on various perennial species show that there is no simple relationship between growth stage and glyphosate translocation (Franz et al 1997).

Obviously, further studies will be required to more accurately assess the sensitivity of *C. rossicum* to glyphosate at different phenological stages. This aside, it is recommended that at least one treatment be carried out before fruit maturation begins (early to mid-July in Toronto) to avoid seed set. Following treatment in early August, green fruit continued to ripen at an accelerated rate, enabling seed dispersal to occur. Although seed from these plots did not germinate, viability should not be precluded, as only a small number of seeds were tested.

It is unlikely that one year of repeated glyphosate treatments will be sufficient to control *C. rossicum* over the longer-term. After removal from competition, treated roots were able to produce new stems from living buds. This finding is consistent with other research which shows that weedy perennials can resume growth over an extended time period following glyphosate treatment. Carlson (1988) reported that two consecutive fall applications of glyphosate reduced root density of Canada thistle by 77% one year after the second treatment, but did not eradicate the roots. In another study, strong reductions in common milkweed were observed for two years following single treatments with glyphosate, however, recovery was observed in the third year (Bhowmik 1982).

In the short-term, effective control of this species can be achieved through the reduction of seeds and perennating parts. Control over the longer-term will require the depletion of existing seed banks and the prevention of further seed production. The number of seeds in the soil, their longevity, and the number of seeds returning to the soil determines the future threat of an aggressive species (Franz et al 1997). The viability and extent of *C. rossicum* seed banks have not been studied, however, several years of treatment may be necessary to deplete seed reserves. Complete eradication must be the ultimate goal of management, since the survival of a single plant may in theory be sufficient to cause a reinfestation.

Once the presence of *C. rossicum* has been strongly diminished, another exotic species will likely replace it, unless a desired species is first introduced. In this study, sweet white clover, an alien biennial, quickly invaded herbicided plots to replace *C. rossicum* as the dominant species. Thus, control itself can create another control problem, which should be anticipated in advance of designing a treatment program (although the establishment of species such as sweet white clover may be considered desirable, since nitrogen-fixing legumes are widely used as a successional cover to enhance and protect bare soil). Careful monitoring for new invasions is important, since *C. rossicum* seedlings can persist under the dense shade of other species, making their detection difficult.

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Box 61047, Kensington P.O.
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T2N 4S6

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TABLE OF CONTENTS

An Ecosystem Approach to Management: A Context for Restoration and Reclamation
Gray, P.

Abandoned Pit and Quarry Sites: Living Experiments
Browning, M.

The Revegetation of Drastically Disturbed Lands
Mrena, C.

Caledon Creek and Credit River Subwatersheds – A Case Study
Breton, H.

Community Involvement in Reclamation and Urban Ecology Restoration
Napier, D.

Managing for Natural and Cultural Heritage at Red Cloud Cemetery Prairie
Lamb, L.

The Alex Wilson Community Garden
Johnson, L.

Naturalization of Landscaped Parkland at Ontario Hydro's Nanticoke Generating Station
McKenna, G.

Sensitive Indicators of Urban Stresses in Hardwood Forests along a Toronto-Peterborough Urban-Rural Corridor
Hutchinson, T. and Sager, E.

Penetanguishene Harbour Shore Habitat Restoration & Monitoring
Crispin, S., Dougan, J., Portt ,C., Dimock, C., Sherman,K.

The Influence of Cyanobacterial Amendments on Soil Aggregate Size, Soil Nitrogen Content and Seedling Establishment in a Gravel Pit
Casper, D., Maxwell, C. D., Browning, M.

Historical Land Use Inventories: A Guide to Their Creation
MacRitchie, S. and Block, D.

The Utility of Aggregate Processing Fines in the Rehabilitation of Dolomite Quarries
Fraser, J. and McBride, R. A.

Rapid Ecological Inventories for Ecological Restoration of Industrial Lands
Murphy, S., Michalenko, G., Whitfield, J., Lamb, L., Suffling, R.

Landscape Ecology Approaches to the Sustainable Management of Mineral Aggregate Resources, Oak Ridges Moraine, Ontario, Canada
Fraser, J.

Ecological Restoration of Meadowlily Woods
Kraus, D., Dowsley, B. J., Hilditch, T. W., Knutson, R.

The Rehabilitation of the Glenridge Quarry Landfill Site
Girt, S. L. and Smith, D.G.

Mitigating Impacts of Sewer Construction through Wetland Restoration and Habitat Creation: The Devils Creek Trunk Sewer Project
Fausto, J., Mainguy, S., Pastrik, E., Patel, K., Bandoni, F.

Toward a Predictive Model for Naturalization of Aggregate Pits on the Oak Ridges Moraine
Dance, K. and Browning, M.

Brant Prairie: Union Gas Customer Service Centre, Brantford, Ontario
Hensel, M. and Thompson, J.

Lessons Learned for Ecological Rehabilitation from an Investigation of the Regional Municipality of Waterloo, Ontario
Quon, S.

Reconfiguration of Westside Creek and Marsh, Bowmanville
Taylor, S.

Rehabilitation of Dufferin Aggregates' Milton Quarry
Zimmerman, K., Lowe, S., Carbone, S.

Practical Considerations and Lessons Learned in the Reclamation/Restoration of Habitat as a Component of Site Development
Wynia, M. and Jones, C.

Aggregate Supply Trends and Reclamation Opportunities
Parkin, J.

Control of the Invasive Dog-strangling Vine *Cynanchum rossicum*
Smith, S.

Development of a Native Plant Prescription for Urban Hydro Rights of Way
Suffling, R., Lamb, L., Murphy, S.

A System for Urban Wildlife Habitat Restoration
Buchanan, M.

Long Term Monitoring of a Wetland Ecotone in Southern Ontario; Implications for Environmental Planning
van de Lande ,R. and Eagles, P.

Mount Forest Wetland Sanctuary Project
Smith, D., Bos, A., Hayman, D.

Community Involvement in Reclamation and Urban Ecology Restoration: Over the Fence Project
Porter, J.

Community Involvement in the Restoration of High Park
Harris, C.

Industrial Reclamation: Partnerships Between Industry, Government and Academia - The Role of Graduate Students of Landscape Architecture
Harder, L., Rintoul, F., Hands, D.

Developments Past, Present And Future of Lands Stressed by the Mining Industry
Peters, T. H.

A Test of Plant-Aided Petroleum Hydrocarbon Degradation
Hosler, K., and Drake, E.N.

A Natural Heritage Approach to the Rehabilitation of Southern Ontario's Limestone Quarries
Ursic, K., Ursic, M., Dougan, J.

Management of Abandoned Aggregate Properties Program
McGuckin, C.

An Innovative Approach to Waste Site Management, Treatment and Rehabilitation
Madison, M., Lanier, A., Shrive, C.

Pipeline Reclamation Criteria Development in Alberta
Fedkenheuer , A. and Burke, J.

The Don Valley Brickworks: Transformation to a City of Toronto Park
Bosco, T.