RESEARCH ARTICLE

# Controlling Speckled Alder (*Alnus incana* ssp. *rugosa*) Invasion in a Wetland Reserve of Southern Québec

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**ABSTRACT**: Managing invasive species in natural areas of high ecological value generally involves the selection of an appropriate control method that is cost effective while minimizing the secondary impacts of the control operation on the ecosystem. During the last decades, speckled alder (*Alnus incana* ssp. *rugosa*) has been invading wet sedge meadows of the Lac Saint-François National Wildlife Area (NWA), Québec, Canada. This invasion threatens the habitat of several bird and plant species considered rare at the national and provincial levels. We evaluated effectiveness and impacts of four methods for controlling alder invasion in the wetland. As a short-term control method, controlled fire appears to be ineffective in the context of the Lac Saint-François NWA, as suggested by the high survival of alders in a zone previously burnt on our study site. Double-cut of the shoots aims at killing the shrubs by depleting nutrient reserves in the roots using two successive cuts during the same growing season. This method was also shown to be ineffective: more than 80% of the treated alders resprouted vigorously the following year. Foliar application of herbicide with a rope-wick applicator to control smaller shrubs did kill all treated individuals. However, this method showed high risks of herbicide dripping and should be used with care. The most promising control method was the herbicide treatment of cut stumps. This method was efficient and cheap. It was also efficient at the end of winter, when the ground of the wetland was still frozen, which facilitated accessibility and limited damages to non-target species caused by trampling or herbicide dripping.

*Index terms: Alnus incana* spp. *rugosa*, controlled fire, herbicide, sedge meadows, speckled alder, wetland management

## INTRODUCTION

Native plant species may occasionally show invasive behavior in neighboring natural ecosystems, especially those affected by human activities. For example, speckled alder (*Alnus incana* (L.) Moench ssp. *rugosa* (Du Roi) Clausen; syn. *Alnus rugosa* (Du Roi) Spreng.) has invaded the wet sedge meadows of Lac Saint-François National Wildlife Area (NWA), a 1347 ha reserve that has been established to protect various types of wetland ecosystems. Using aerial photographs to assess changes in wetland composition, Jean and Bouchard (1991) and Gratton (1996) showed that up to 10% of the surface area of open wetlands in the NWA had been lost to shrubs – mostly or entirely speckled alder – during the last decades. The change revealed by these small scale photographs underestimates the invasion magnitude because it only detects increases in large shrub thickets at the edge of the wetland, missing the numerous smaller shrub islands that establish directly in the herbaceous part of the sedge meadow (Gratton 1996). While a significant decrease in fire frequency is the most likely cause for this invasion (Jean and Bouchard 1991), the damming and control of the Lac Saint-François water level may have also played a role.

Speckled alder is a clumping shrub that shows strong vegetative reproduction, primarily through sprouting but also through layering, suckers, and underground stems. It naturally forms dense and impenetrable thickets along creeks, rivers, and lakeshores, often accompanied by red-osier dogwood (*Cornus stolonifera* Michx.) and various willow species (*Salix* spp). While speckled alder prefers wet sites, including those that are permanently or temporarily flooded, it also tolerates more mesic conditions. It may invade recently logged sites where it inhibits tree regeneration. It is then very hard to control, notably because of its strong resprouting capacity (Jobidon 1995, Richardson 1979).

Located on the south shore of the St. Lawrence River, in southern Québec, the Lac Saint-François National Wildlife Area (45° 01'N, 74°32'W) has been acknowledged since 1987 as being of international importance under the Ramsar Convention (Ramsar site no 361). It includes a rare herbaceous fen ecosystem dominated by sedges and other wetland species such as *Carex aquatilis* L., *Carex lacustris* L., *Carex lanuginosa* Michx., *Calamagrostis canadensis* L., and *Typha angustifolia* L. (Auclair et al. 1973). In this fen, the well-decomposed organic material averages 1.5 m thick (max. 4 m) and rests on top of a clay deposit inherited from the last postglacial era (Melançon and Lethiecq 1981). The water table ranges between a few centimeters below up to 25 cm above the soil surface (Auclair et al. 1973). The fen provides breeding habitat to two bird species at risk: the yellow rail (*Coturnicops noveboracensis*), listed as "of special concern" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2004), and the Sedge Wren (*Cistothorus platensis*), likely to be designated "threatened" or "vulnerable" in Québec (Gazette officielle du Québec 2003). It also shelters four plant species likely to be designated "threatened" or "vulnerable" in Québec: *Bidens discoideus, Carex sartwellii, Carex trichocarpa* and *Zizania aquatica* var. *aquatica* (Labrecque and Lavoie 2002, Gazette officielle du Québec 2003).

The invasion of alder in the fen of Lac Saint-François NWA, if let unimpeded, could irremediably affect ecosystem processes and biodiversity. Alder colonies are often so dense that they may exclude most other plant species (Jobidon 1995). Moreover, nitrogen-fixing bacteria colonize alder's root nodules that, over a period of time, may irremediably alter soil conditions by increasing nitrogen content. In the short term, the reduction in surface area of sedge meadows may represent a loss of potential breeding habitat for the yellow rail, which is found in fens dominated by *Carex lacustris, Calamagrostis canadensis*, and *Carex aquatilis* in the Lac Saint-François NWA (Robert et al. 2000, Robert and Laporte 1996). Given these threats, the Canadian Wildlife Service of Environment Canada, who manages the Lac Saint-François NWA, is considering controlling alder expansion in the fens of the NWA, but the best control method remains to be determined. Beside its natural resistance and resprouting ability, controlling speckled alder in the Lac Saint-François NWA represents a particular challenge for additional reasons. The vegetation and peat soil are highly sensitive to trampling, and traveling on foot across the fen is hazardous and slow due to the presence of hummocks, standing water, and floating mats (Auclair et al. 1973, Robert and Laporte 1996). Nevertheless, in order to be consistent with the conservation mission of the NWA, broadcast treatment, like herbicide spraying from a helicopter, cannot be considered. The control method used, while being efficient, should therefore be highly selective with minimal impact on non-target species.

Starting in 1996, we evaluated in situ four methods for controlling alder while limiting the impact of the control operation on the fragile fen environment. The methods consisted of: (1) double-cut of the stem, (2) foliar herbicide application with a wick-applicator, and (3) herbicide application of cut stumps. Moreover, we estimated the efficiency of controlled fire by evaluating the impact on alder survival of a surface fire that burned a small area of the fen one year prior to the study.

## CONTROLLED FIRES

Controlled fires are frequently used in vegetation management to favor herbaceous vegetation at the expanse of woody species (Dickmann and Rollinger 1998, Wright and Bailey 1982), notably in sedge meadows and fens (Middleton 2002, Kost and DeSteven 2000). The fact that a decrease in fire frequency has been identified as a probable cause of alder invasion in Lac Saint-François NWA naturally leads to prescribed burning as the most obvious method of control. In early spring, the surface of the fen is covered with highly flammable mulch. A surface fire burns rapidly, presumably killing aboveground portions of the shrubs.

We took advantage of a surface fire of unknown origin that burned approximately 1 ha of the wetland to assess its effect on speckled alder mortality. We positioned four 12.5 $m^2$ quadrats in a section of the wet sedge meadow that was highly invaded by small to medium-size individual alder shrubs. We then measured survival by noting the presence of resprouting at the base of all burned shrubs. We easily found, in the quadrats, all the individuals that burned the year before, 40 in total, from the presence of their dead but usually still-standing charred multiple stems.

All the 40 individuals survived the fire and resprouted vigorously from the root crown. Less formal examination of the rest of the burned area confirms our result as we could not find a single burned shrub that did not survive the fire. Aksamit and Scott (1984) and Burgason (1976) also noted the high resprouting ability of alder in response to prescribed fires for silvicultural purposes. Survival may depend on fire intensity or timing, but it is unlikely that any single fire would provoke a high mortality rate, considering that the belowground portion, most of which is located at or below the water table, is well protected from fire. Buckman (1965) claims that repeated fires during a relatively short period of time may eventually eliminate alder. Heidorn (1991) came to a similar conclusion for controlling another invasive shrub, common buckthorn (*Rhamnus cathartica*), showing that it takes one or two fires annually during five consecutive years to be effective. Such a program to control alder in NWR of Lac Saint-François would obviously carry high operation costs. In addition, its efficiency and the possible detrimental effects of repeated fires on other aspects of the ecosystem would need to be assessed before it is implemented.

While the use of fire to eliminate alder may not seem promising, it may, at least briefly, delay or slow down further progress of alder by rejuvenating the shrubs (Bergason 1976). Other studies showed small or temporary reductions in the dominance of shrubs in wetland after controlled fires (Bowles et al. 1996, Pendergrass et al. 1998). The appropriate fire frequency to efficiently control alder in the case of the Lac Saint-François NWA would need to be evaluated. Also, prescribed burning carries inherent risks and usually high labor costs. Moreover, in the case of the Lac Saint-François NWA, the difficult terrain could hinder a rapid intervention, if one was required. Finally, the burned area might not be used as a breeding habitat for yellow rail the year of the fire, since this bird species hides its nest in the dry litter from the previous year's growth (Robert and Laporte 1999, Robert et al. 2000). While we find it premature to recommend prescribed fires, we think this approach should not be discarded as a long-term management tool for maintaining open conditions in sedge meadows of Lac Saint-François NWA. In fact, many management agencies use prescribed fire as a cost-effective, efficient, and safe control measure (Wright and Bailey 1982). In addition to shrub control, fires may have other beneficial consequences on the ecosystem such as the removal of non-decomposed litter, increase in nutrient availability, and increase in species richness (Middleton 2002, Clark and Wilson 2001).

## DOUBLE-CUT OF THE SHOOTS

Double-cut of the shoots aims at killing the shrubs by depleting nutrient reserves in the roots using two successive cuts during the same growing season (Favreau et al.1995, Seiger and Merchant 1997). While mechanical cutting is not without environmental costs (pollution, energy costs, oil leakage, etc.), double-cut of the shoots appeared to represent the most promising method of control not requiring the use of herbicide. Timing of the operation, however, is crucial and must be based on the seasonal change in nutrient reserve (Kays and Canham 1991). A first cut must be done in early summer, just after leaf formation, when root reserves are at the lowest. After the cut, the plant must then spend more of its root reserve to produce new branches and leaves. A second cut is done just when a new crown is completed but before the translocation period. The shrub may then produce new foliage, but late in the season, and these new leaves, if ever completed, would have no time to replenish the – hopefully – depleted root reserve. This method has the inconvenience of requiring two operations in the same season, resulting in higher operation costs, risks, and damages caused by trampling.

We experimentally tested the efficiency of double-cut on 184 individuals of various sizes (ranging from 50 to 180 cm) in a highly invaded part of the fen. Location, height, and number of stems per individual were recorded. The first cut was done at 20 to 30 cm high in mid-June, leaving a short stump with no leaves that would facilitate the relocation of the shrubs for the second cut, later in the season. The second cut was done at the base of the shrub, in early August. Both cuts were manually done with a hand-cutter. Survival was evaluated the following year.

The operation proved to be ineffective: more than 80% of the treated alders resprouted vigorously the following year (Table 1). There was no difference in pre-cut mean stem size and shrub height between dead and surviving shrubs (*t*-test, p = 0.81 and p = 0.20 respectively).

Alder appears to be surprisingly resistant to even two – presumably well timed – cuts. Maybe another cutting schedule would have resulted in a greater mortality. Yet, with the available evidence, we feel that 20% mortality is not enough to justify the costs and risks of a double-cut operation. Repeating the operation a second year would likely increase mortality, but it would also probably raise the costs to an unacceptable level.

## HERBICIDE FOLIAGE APPLICATION

In the central part of the wetland, the shrubs are scattered and isolated. Yet, these patches form new foci of invasion that represent a priority in alder control. In general, these isolated shrubs are small and consist of a large number of stems, making impractical certain types of control methods, such as herbicide treatment of cut stumps. Spraying herbicide on foliage should be effective, but is not desirable because of the unavoidable drift on the surrounding vegetation. We tested a selective foliar application of a glyphosate herbicide by contact with a rope-wick applicator. The handle of the rope-wick applicator is a 1-m long tube filled with herbicide, at the end of which is a cotton wick that becomes moistened with the herbicide. The wick is brushed on the foliage. This method is easy to apply on small shrub and reduces the risk of herbicide loss (Heidorn 1991).

We tested the rope-wick applicator method on 15 small isolated shrubs (height 75 to 120 cm) located in the sedge meadow. Herbicide mix was 33% Roundup® (13.6% active ingredient glyphosate). This test was less to evaluate effectiveness – which we had little doubt would be high – than to evaluate ease of application and secondary effects. We used a relatively high herbicide concentration for the foliar application in order to compensate for the reduction of foliar area reached by the rope-wick in comparison with spraying. The herbicide level used also maximizes detection of possible effects on the surrounding vegetation, if any. We assumed that if no effects were visible with this high concentration, then a much lower (but still effective) concentration would be safe. The operation was carried out in July, and survival was evaluated the following year.

The operation by itself was easy to execute, although walking in the wetland was often difficult, as would be the case for any control method done in summer. The risk of falling while carrying the herbicide was high, and tripping affected the vegetation and wetland soil. As we expected, none of the treated shrub survived the treatment. However, despite our carefulness, there was some dead herbaceous vegetation immediately under the shrub, probably due to root herbicide exudation, washed out herbicide from the leaves by ulterior dew, or from dead leaves after falling. While foliage treatment with a rope-wick applicator is efficient, inexpensive, and well adapted to smaller and low-density shrubs, it may not be without secondary damaging effects on

**Table 1. Survival and mortality of speckled alder after a double-cut treatment, in a wet sedge meadow of Lac Saint-François National Wildlife Area.**

| Number of shrubs | Percentage of mortality | Pre-cut mean height (cm) | Pre-cut mean number of stems per individuals |
|---|---|---|---|
| 184 | 17.90% | Killed shrubs | Killed shrubs |
| | | 133 ± 34 s.e. | 2.6 ± 2.5 s.e. |
| | | Surviving shrubs | Surviving shrubs |
| | | 134 ± 29 s.e. | 3.2 ± 2.2 s.e. |

the wetland, and therefore must be carried out with caution.

## HERBICIDE TREATMENT OF CUT STUMP

In this treatment, the stem is cut and an herbicide solution is immediately applied on the top of the stump (Heidorn 1991). Generally, the herbicide is sprayed on the stump, and, inevitably, a proportion of the herbicide is lost on the surrounding vegetation, especially if the stump has a small diameter. Alternatively, the herbicide can be applied on the stump by contact, with a brush or a wick, thus minimizing the risks of herbicide drifting on the surrounding vegetation. This method can be applied on a wide range of shrub sizes and densities, but it is impractical on the smallest individuals or those that are composed of a very large number of small stems. When applied during the growing season, herbicide treatment of the cut stump is known to be very effective in controlling a large variety of woody plants. However, Reinhartz (1997) reported that the method was surprisingly efficient when applied in winter on *Rhamnus frangula* in a Wisconsin wetland. The benefit of a winter treatment, if proven effective on alder, would be significant in the case of the Lac Saint-François NWA: walking in the wetland when the ground is solidly frozen is much easier, and there is basically no risk of damage to non-target species caused by trampling or herbicide dripping on non-dormant tissue.

For the summer treatment, 145 individuals were measured (height and number of stems), then cut with pruning shears, and an herbicide solution (96 % Roundup® and 4 % coloring, corresponding to 39% active ingredient glyphosate) was immediately applied with a brush on the cut stump. For the winter treatment, a first test was done on 59 individuals at the end of winter, in early March, when the wetland ground was still frozen, and compared with 47 controls (cut but no herbicide). Because the operator had to wear winter gloves, the herbicide was applied on the stump with a plastic wash bottle. This, without requiring more solution, was more convenient and faster than using a brush. Since this test proved to be effective (see below), we did a second test on 31 individuals for comparison the following winter – this time in the heart of the season (January 21$^{st}$) – with two concentrations (96 % and 50 % Roundup®, corresponding to 39% and 19.5 % active ingredient glyphosate). For both winter treatments, the average snow cover at the base of the shrubs varied from 10 to 30 cm.

In all cases, treatment efficiency was evaluated at the end of the following growth season. Surviving individuals were easy to locate because of the highly visible resprouts. However, even if their exact location was noted at the time of treatment, dead individuals, represented as very short stumps at ground level with no foliage, were often hard to relocate in the high herbaceous vegetation. For this reason, the few individuals that could not be found after careful search were presumed dead.

The summer treatment was relatively efficient but not as effective as anticipated, with less than 80% mortality (Table 2). There was no difference in pre-cut mean height between killed and surviving shrubs ($t$-test, $p < 0.26$), but pre-cut mean number of stems was significantly greater in surviving shrubs ($t$-test, $p < 0.005$), suggesting that a shrub with a large number of stems may have a better chance to survive the treatment operation.

The fact that more than 20 % of the shrubs survived the summer control treatment made us rather pessimistic regarding the possible effectiveness of a winter treatment.

**Table 2. Mortality of speckled alder after a herbicide application on cut stump, in summer (July), late winter (March), and mid-winter (January), in a wet sedge meadow of Lac Saint-François National Wildlife Area.**

| | Number of shrubs | Percentage of mortality | Pre-cut mean height (cm) | Pre-cut mean number of stems per individuals |
|---|---|---|---|---|
| Summer treatment | 145 | 78.6% | Killed shrubs 126 ± 29 s.e. | Killed shrubs 3.5 ± 2.7 s.e. |
| | | | Surviving shrubs 133 ± 23 s.e. | Surviving shrubs 6.1 ± 4.7 s.e. |
| Late winter treatment | 59 | 98.3% | na | na |
| Late winter control (cut but no herbicide) | 47 | 0.0% | na | na |
| Mid-winter treatment 39.0 % glyphosate | 16 | 81.2% | na | na |
| Mid-winter treatment 19.5 % glyphosate | 15 | 73.3% | na | na |

Therefore, we were surprised to discover that 58 of the 59 treated plants did not survive the late winter treatment (all of the control plants survived and resprouted vigorously). To work that effectively, we hypothesize that the herbicide must have to enter the stem and stay confined in the wood structure and protected from decomposing bacteria until spring when the plant becomes active. The mid-winter treatment was less effective but still caused mortality in 73 % to 81% of the shrubs depending on herbicide concentration (the difference being not significant ($\chi^2$, $p = 0.60$)). As for the rather disappointing result for summer treatment, the push of the sap may have forced the herbicide out of the stump, allowing more plants to survive.

Regardless of treatment effectiveness, the advantages of a winter treatment for a large-scale operation are substantial. Not only is it easier to travel on foot, even with a certain snow cover, but also the operators may use a land vehicle (snowmobile, all-terrains vehicle), which can carry equipment or reach more distant parts of the wetland while limiting damages to the wetland soil and vegetation. In addition, the absence of foliage on cut stems greatly facilitates the operation. The low herbicide concentration used in our experimental tests (19.5% active ingredient glyphosate) is proposed and could be eventually compared to lower dosages.

## CONCLUSION

Managing invasive species in natural areas often involve selecting an appropriate control method. Efficiency of a certain method may depend on the species to be treated and the conditions of application. Beside efficiency, costs and applicability of the control method also need to be considered. Finally, the secondary impact of the control operation on the environment must be minimized. This is especially the case for sensitive ecosystems or protected natural areas of high ecological value. For controlling speckled alder in the sedge meadows of Lac Saint-François NWA, non-herbicide methods such as double-cut of the stems and controlled fires proved to be ineffective and are thus not recommended. Foliage treatment by contact with a rope-wick applicator was very efficient and inexpensive but presents some risks of herbicide loss on the non-target vegetation. This method could be best applied at the invasion front, where the alders are rather scattered and small. In the case of high density of mature shrubs, the most promising method for alder control remains cutting followed by an herbicide treatment of the cut stump in winter, when the wetland ground is frozen and risks of damages on wetland soil and vegetation are minimal. In the short-term, prescribed fires appear to be ineffective in controlling speckled alder. However, following a more intensive control method to reduce advanced shrub encroachment, occasional controlled fires could be used as a long-term management tool for maintaining open conditions in the wet sedge meadows in the Lac Saint-François NWA.

Even the best planned control operation carries some risk of bringing unintentional secondary effects on the ecosystem it is trying to restore. The ultimate decision to carry out a control operation on an invasive species should thus be carefully weighted against the risks of letting the invasion proceed unchecked.

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