
Critical Steps Towards an Integrated Vegetation Management Strategy for the Control of Purple Loosestrife in Manitoba, Canada

C. J. LINDGREN¹, T. S. GABOR², HENRY R. MURKIN², and DON HENNE³

¹ Manitoba Purple Loosestrife Project,
Box 1160 Stonewall, Manitoba R0C 2Z0, Canada

² Institute for Wetlands and Waterfowl Research,
Box 1160 Stonewall, Manitoba R0C 2Z0, Canada

³ Department of Entomology, University of Manitoba,
Winnipeg, Manitoba R3T 2N2

Introduction

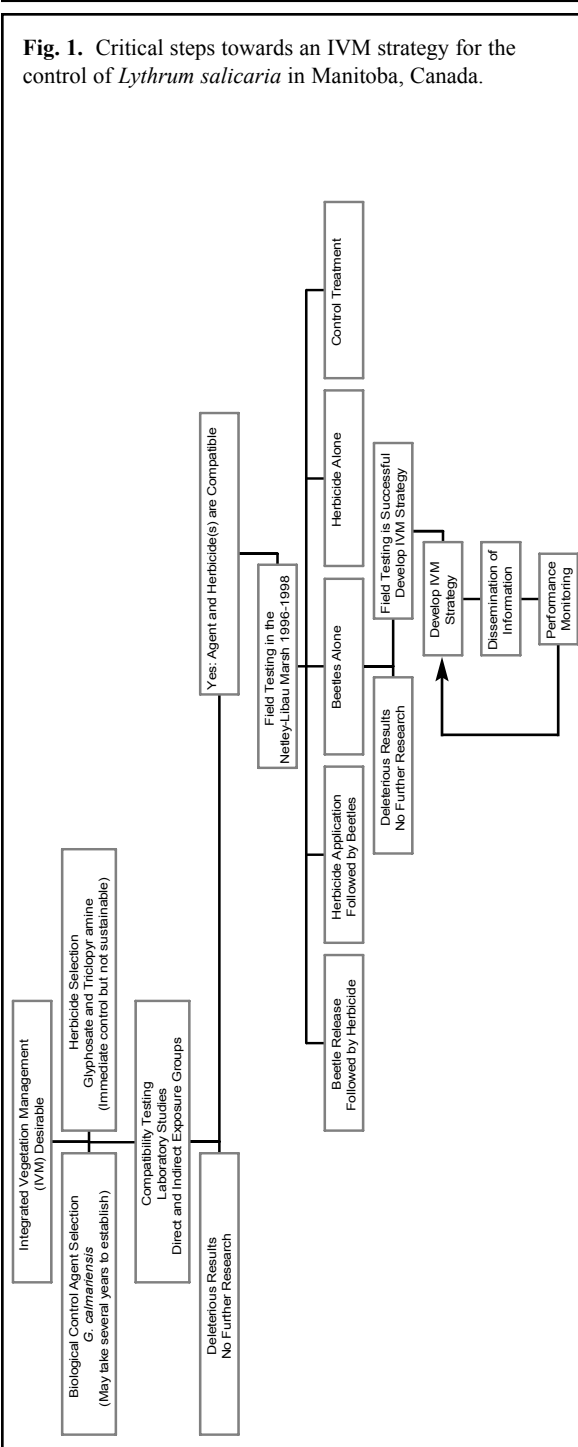
Purple loosestrife (*Lythrum salicaria*) is an aquatic nuisance species that was accidentally introduced into North America in the early 1800's (Thompson *et al.* 1987). Purple loosestrife forms monodominant stands (Mal *et al.* 1992) replacing the native flora required by our wildlife for food, cover, and breeding areas. Associated with the loss of native flora communities is the overall loss of biological diversity essential to maintaining healthy sustaining ecosystems. In many habitats, threatened or endangered species are significantly impacted through the introduction of non-native species such as purple loosestrife. Wilcove *et al.* (1996) reported that exotic species are causes of endangerment for 46% of threatened and endangered species.

Various control strategies have been implemented against purple loosestrife without long-term sustained control. Herbicidal control studies (McKeon 1959; Smith 1964; Rawinski 1982; Balogh 1986; Reinartz *et al.* 1986; Gabor *et al.* 1995, 1996; Skinner and Hollenhorst 1989) generally concluded that short-term control of purple loosestrife can be achieved, however, purple loosestrife quickly re-establishes through the seed bank and often at densities higher than pre-treatment.

Recent purple loosestrife control strategies have been focused on the release of classical biological control agents (Malecki *et al.* 1993, Blossey *et al.* 1994a, 1994b). Four European agents have been approved for release in North America, the leaf-eating beetles *Galerucella californiensis* L. and *G. pusilla* Duftschmidt, a root-mining weevil *Hylobius transversovittatus* Goeze, and a seed-eating weevil *Nanophyes marmoratus* Goeze. Approval for agent introductions into the United States and Canada was received in 1992 (Malecki *et al.* 1993). Classical biological weed control programs may take several years prior to producing any measurable levels of weed control, if they are successful at all. Wetland and natural area managers may not be in a position to wait extended periods of time for control to take effect under classical biological weed control programs.

There is a need to investigate the potential integration of classical biological weed control strategies (long-term) with herbicidal weed control strategies (immediate, short-term) for the management of purple loosestrife. Classical biological control and herbicides represent the most promising management techniques currently available for the control of purple loosestrife (*Lythrum salicaria* L.) in North America. Integrating biolog-

Fig. 1. Critical steps towards an IVM strategy for the control of *Lythrum salicaria* in Manitoba, Canada.



ical weed control with a herbicide weed control strategy may not only provide effective weed management but accelerate management results. A secondary advantage of an integrated strategy would be an overall reduction in herbicide use in sensitive habitats such as wetlands. Using herbicides alone may require several applications over a number of years to provide limited control. Herbicidal control is normally avoided where biological control agents have been released, it is thought that the herbicide will impact deleteriously upon the biological control agent. However, studies that have examined the compatibility of biocontrol agents with herbicides report that herbicides either do not impact agent survival, reduce agent survival, or that proper timing of herbicide application is critical to ensure agent survival (Lindgren et al. 1998).

Our objective was to investigate the potential of an integrated vegetation management (IVM) strategy for the control of purple loosestrife. We employed a decision-based algorithm, similar to that presented by Trumble and Kok (1982) (Figure 1).

Biological Control Agent Selection. We choose to examine the compatibility of *G. calmariensis* with two herbicides since this beetle has been most widely released across North America, it has

established and over-wintered successfully in Manitoba, is easily mass reared, and has high reproductive potential. The remaining biological control agents would not be suitable because the herbicide would destroy mature adult purple loosestrife plants required to sustain them.

Herbicide Selection. Our first step was to investigate the compatibility of the herbicides glyphosate (formulated as Roundup®; [N-(phosphonomethyl) glycine]) and triclopyr amine (formulated as Garlon 3A; the triethylamine salt formulation of triclopyr amine [[3,4,6-trichloro-2-pyridinyl)oxy]acetic acid]) with *Galerucella californiensis* under controlled laboratory conditions. Roundup® is a glyphosate formulation registered for terrestrial plant control and is not registered for direct application to bodies of water due to the ionic surfactant present in the formulation (Balogh 1986). We selected Roundup® as it is registered for the terrestrial control of purple loosestrife in Canada (at a recommended volume application of 2% solution (2.43 L/acre)) and we felt it would be useful management tool in habitats where loosestrife had progressed to a monodominant stand, devoid of any native non-target plant species that would also be harmed. A number of studies have shown that glyphosate is effective for killing adult loosestrife plants (Rawinski 1982, Balogh 1986). In addition, Roundup® is effective at low concentrations, has a fairly short half-life and has low potential for bioaccumulation (Rueppel *et al.* 1977, Thompson *et al.* 1987), which makes it an attractive herbicide for an IVM program. It is of relatively low toxicity to aquatic invertebrates and fish (Folmar *et al.* 1979), birds (Batt *et al.* 1980) and mammals (Monsanto Co. 1973).

We also selected triclopyr amine for compatibility testing for it is a systematic herbicide selective for broad-leaf plants that would be useful in habitats where loosestrife had yet to form a monodominant stand and was mixed with native plant species. It has a number of other characteristics that make it a potential candidate for an IVM program. It is easily absorbed and translocated to the root system (Dow Chemical 1988) and breaks down quickly in soil and water. Research also indicates that triclopyr amine has minimal effects on fish (Mayes *et al.* 1984, Barron *et al.* 1991, Janz *et al.* 1991) and other aquatic organisms (Gersich *et al.* 1984). Triclopyr amine is an auxin-type, systemic broadleaf herbicide that is not currently registered for purple loosestrife control in Canada. When we began our study in 1994, there was considerable industry interest in pursuing a Canadian registration for the aquatic use of triclopyr amine for purple loosestrife control, to date this has not proceeded. The advantage of triclopyr amine over glyphosate is that it will not impact nontarget monocot plants (Katovich *et al.* 1996).

Step 1. Compatibility Testing under Laboratory Conditions

Methods. The main objective of this study was to investigate the compatibility of herbicides glyphosate and triclopyr amine with *G. californiensis* under controlled laboratory conditions. If either herbicide was found to be deleterious to *G. californiensis* our research would have terminated with that particular herbicide. To investigate the effect of each herbicide on adult *G. californiensis* oviposition and adult survival, adults were randomly divided between a direct contact group (adult beetles were sprayed directly with herbicide then placed on host plants), an indirect contact group (host plants with adult beetles were sprayed with herbicide), and a control group (no herbicide application). We further examined the ability of *G. californiensis* third instar larvae to pupate through to teneral adults after being directly sprayed (sprayed-to-wet) with herbicide.

In general, results from these manipulations indicated that the herbicides had no deleterious effects upon *G. californiensis* oviposition or the ability of third instar larvae to pupate through to new generation adults (Lindgren *et al.* 1998; Lindgren *et al.* 1999). The results of the laboratory testing indicated that *G. californiensis* was compatible with both glyphosate and triclopyr amine indicating that further field studies were warranted.

Step 2. Field Testing (Netley-Libau Marsh)

The main objective of the research was to determine if the integration of herbicides and *G. californiensis* would be more effective for controlling purple loosestrife than either control strategy alone. Field experiments were conducted between 1996 and 1998 in the Netley-Libau Marsh to determine the effectiveness of single treatment and combinations of integrated treatments. The Netley-Libau Marsh is an area of 136,000-ha of land and water with 848-km of shoreline located at the southern end of Lake Winnipeg, approximately 65-km north of Winnipeg, Manitoba. Formed through glacial Lake Agassiz, the marsh is a complex of lakes and streams whose water levels are influenced by Lake Winnipeg. Netley-Libau Marsh is recognized as a Manitoba Heritage Marsh and an Important Bird Area (IBA). The marsh is considered an important waterfowl nesting, staging, and molting habitat and has the highest densities of purple loosestrife in Manitoba. Purple loosestrife has been present within the marsh for at least 15 years.

Field trials compared the effectiveness of the following five treatments: (1) herbicides alone, (2) *G. californiensis* alone, (3) herbicide treatments followed by release of *G. californiensis*, and (4) releases of *G. californiensis* followed by herbicide treatments and (5) control or no treatment group. All treatments were conducted in 2 X 2 X 2 meter (wood frame) screened cages.

We envisioned two potential IVM strategies taking into account both the biology and phenology of the biocontrol agent and the recommended herbicide application window.

Our first strategy involved elimination of mature standing purple loosestrife plants with an application of the dicot selective triclopyr amine. Following purple loosestrife removal, *G. californiensis* would be released to control purple loosestrife re-established from the seed bank. Previous field observations suggested that *G. californiensis* prefer the younger purple loosestrife stems over mature senescing plants. The beetles would feed on the seedlings and then enter winter diapause. Beetles would re-emerge in the spring and control emerged host plants.

Our second strategy involved releasing *G. californiensis* onto host plants and allowing them to establish, then following the release with an application of a herbicide. During herbicide application a number of purple loosestrife plants were protected from the herbicide to provide refugia for adult beetles until new seedling emerged from the seed bank.

Next Steps

Field work is complete and data analysis are underway. Initial impressions suggest that the integration of herbicides with beetles resulted in the most effective suppression of purple loosestrife stem densities. In addition, purple loosestrife stem densities in the herbicide alone trials seemed to exceed pretreatment densities by the end of the study. Assuming that combinations of treatments are effective for controlling purple loosestrife, we will suggest an IVM strategy that incorporates both herbicides and the classical biological control agent.

Continuous evaluation and reporting on the effectiveness of an IVM strategy over

broad geographic areas (or ecoregions) will then become critical to the long-term success of an IVM program. Information on site-specific characteristics (i.e. vegetation present, water depth, etc.) will be important when determining the best strategy to be employed in different habitats. Dissemination of IVM program information ensuring that wetland and wildlife managers, naturalists groups, conservation organizations, and municipal/city weed managers faced with purple loosestrife infestations are up to date on management techniques will promote the use of IVM weed programs. Monitoring the performance of the IVM program, perhaps the step most often excluded, will be crucial in providing further program direction for area and site-specific weed control initiatives.

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