Garlic Mustard (*Alliaria petiolata*) Management Plan
for
Village of Grand Pré and Surrounding Area
Nova Scotia, Canada

Prepared by

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http://www.gov.ns.ca/tran/enviroservices/Mustard/Garlic%20Mustard%20Management%20Plan.pdf

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Some of the text in this plan is based on a paper prepared for the Transportation Association of Canada (TAC) by Pett et al. (2008; available on-line at the NSTIR website: http://www.gov.ns.ca/tran/enviroservices/Mustard/TAC_2008%20Garlic%20Mustard%20paper.pdf).

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Executive Summary

Garlic mustard (*Alliaria petiolata*) is a shade-tolerant, invasive alien, biennial plant from Europe. In 2002, a roadside population of garlic mustard was reported in the community of Grand Pré, Nova Scotia, the only known occurrence of this plant in the province. The population has subsequently spread along roadsides, infested the Grand Pré National Historic Site, crossed a major watershed divide and formed a colony in Hantsport, approximately 10km east of the original infestation. Garlic mustard becomes established in disturbed areas, such as ditches, and spreads into undisturbed areas, including closed-canopy forests.

In the summer of 2007, Clean Annapolis River Project (CARP) organized a meeting of managers from key government agencies to initiate discussion about management of this isolated population. Given the limited size of the infestation, and based on professional experience and scientific research, numerous experts felt that immediate action to eradicate the existing garlic mustard population would be the best course of action. As a result of that meeting, Parks Canada and the Nova Scotia Department of Transportation and Infrastructure Renewal (NSTIR) both expressed a keen interest in working towards the long-term management of this species.

This document is the management plan that was developed jointly by Parks Canada, NSTIR, and CARP. The long-term management goals identified for garlic mustard are:

- Prevent further spread and new introductions of garlic mustard in NS.
- Conduct a case study of best management practices (BMP) applied to managing roadside populations of garlic mustard in NS.
- Increase public awareness of invasive alien species.
- Engage other agencies in the management of garlic mustard in NS, and solicit additional project support.
- Establish a management committee to oversee the management plan implementation and annual revisions.

The Year 1 (2008 – 2009) management objectives were:

- Accurately inventory/map all known populations of garlic mustard in NS.
- Prevent seed production in all known outlier/satellite populations of garlic mustard in NS.
- Implement BMP along roadsides in the Grand Pré area.
- Increase public awareness about garlic mustard, and invasive alien plants in general.
- Engage the communities of Grand Pré and surrounding areas in taking an active role in the management of garlic mustard.

The Year 2 (2009-2010) management objectives were:

- Accurately inventory/map all known populations of garlic mustard in NS.
- Remove all adult plants in outlying populations in order to prevent seed production
- Implement BMP along roadsides in Grand Pré area
- Increase public awareness about garlic mustard and invasive plants in general though posters, an information session and personal communications.

- Engage the communities of Grand Pré and surrounding areas in taking an active role in the management of garlic mustard

Management plans from Year 1 were implemented in the summer of 2009 and whenever possible, notes and recommendations for improvements and/or changes to the plan have been included by section based on the results of work done in 2008 and our experiences in the summer of 2009. In addition, further management considerations are detailed for 6 topics as summarized below.

Lead Agency – In 2009, Dr. Bob Pett, NSTIR Environmental Services, took the initiative to hire students through the NS Youth Conservation Corps (NSYCC) to further this project. A multi-year commitment from one or more provincial government departments will still be necessary in order to reassess the feasibility of carrying-out long-term management actions to control this infestation of garlic mustard.

Plant Biology – It is recommended that a number of permanent sample plots be established in the Grand Pré area to make local observations about the biological traits of garlic mustard.

Community Engagement – As a means of engaging the local community in Grand Pré and area, it is recommended that an annual community "workday" be planned to coincide with Environment Week, the first week of June. Community engagement activities must be a top priority again in Year 3 (2010).

New Occurrences – It is recommended that project partners contact the E.C. Smith Herbarium at Acadia University to see if any new reports of garlic mustard have been received. In addition, it is recommended that partners follow-up on the possible report of garlic mustard in Halifax, and determine its extent.

BMP – The roadside BMP drafted for NSTIR (Godwin and Stewart 2007), and described in Pett et al. (2008) should be revised based on the outcomes of Year 1 (2008) and Year 2 (2009) actions. Any changes to the BMP must be made in consultation with NSTIR Operations and Environmental Services staff.

Project Support – It is recommended that partners remain involved in the Invasive Species Alliance of *Nova Scotia*, and the *Invasive Alien Species Atlantic Network*. Membership in these groups will enable partners to stay connected with other groups involved in invasive plant management, and may result in access to other funding or project support

NOTE: This document is loosely formatted after The Nature Conservancy's (TNC) "Site Weed Management Plan" template (Tu and Meyers-Rice 2001). Though the template is designed for use in protected areas, its format can be applied to any management area.

Introduction

Grand Pré is a rural community of fewer than 1,000 inhabitants in Kings County, western Nova Scotia (Figure 1). The populations of garlic mustard (*Alliaria petiolata*) in Grand Pré, and surrounding area, are the only documented populations in the province of Nova Scotia. The populations are located on federal, provincial, and private lands. Federal property belongs to the Grand Pré National Historic Site of Canada. Provincial property is comprised of road right-of-ways (ROW) belonging to the Nova Scotia Department of Transportation and Infrastructure Renewal (NSTIR). Private lands include residential and agricultural properties in the community of Grand Pré, and surrounding area. All area types are "disturbed", and include ditches, pathways, lawns, gardens, etc. As such, there are no conservation targets or goals for these locations. Plants have not been reported in any areas of high natural value, but are present in hedgerows, wooded areas on residential properties, and along streambanks. The management concern is that this plant becomes established in disturbed areas, such as ditches, and subsequently spreads into undisturbed areas (e.g., Kaufman and Kaufman 2007).

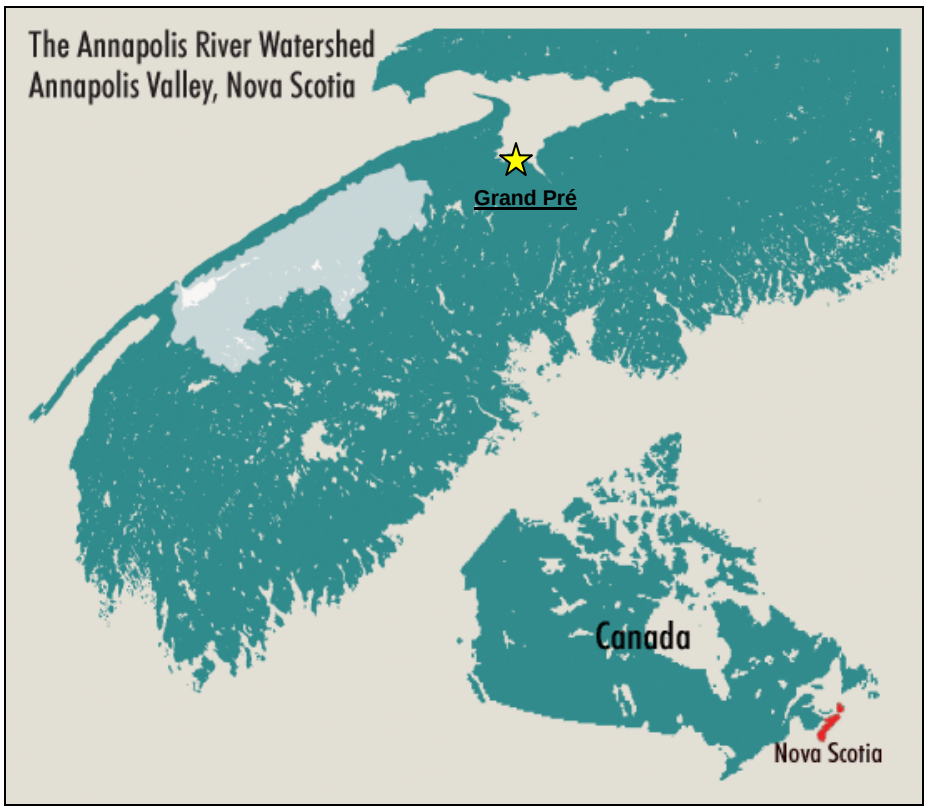

Figure 1. Map of Nova Scotia, depicting the village of Grand Pré, Nova Scotia. The light blue area on the map represents the Annapolis River Watershed, within the Annapolis Valley. This is the geographic area in which the Clean Annapolis River Project (CARP) typically conducts its project work.

Given that there are no conservation goals for these sites due to lack of high-value natural areas, and mixed land ownership, garlic mustard is not interfering with any specific targets. Currently, there is no way of knowing the extent to which forests in Nova Scotia might be affected by this plant. Threats posed to natural areas by garlic mustard are documented in the "Garlic Mustard"

section of this document, under the heading “Damage & Threats.” Due to its documented ability to invade and impact undisturbed closed-canopy forested systems (e.g., Stinson et al. 2006, Meekins and McCarthy 2001, Munger 2001, Nuzzo 2000), project partners and supporters feel that developing a management plan would be a proactive measure. Though one management goal cannot be specified for the entire infested area, all project partners have the collective goal of preventing further spread and/or new introductions of garlic mustard in Nova Scotia. After the initial management year (2008), partners have chosen to pursue management actions again in 2009 and will need to decide whether to continue this action in 2010 based on the results of the two previous years.

Background information on how this management initiative came to be is detailed in Appendix A.

Garlic Mustard

Note: Unless otherwise cited, information on plant biology, life history, threats, and distribution, is drawn from Nuzzo (2000), which is an “Element Stewardship Abstract” (ESA) prepared for The Nature Conservancy (TNC). ESAs are summaries of available information on invasive species, compiled from literature, researchers, and managers. Similar information is also widely available in less detail on numerous invasive species factsheets.

Description

Native to Europe, garlic mustard is a biennial herb reproducing solely by seed. The first-year plants are basal rosettes with kidney-shaped leaves with scalloped edges (Figure 2a). In early spring of the second year, the plant produces a single or few-branched 1m tall (approx) flowering stalk (in NS, June 2008, flowering stalks ranged from 8cm to almost 2m tall). Alternate leaves on the flowering stem are triangular in shape, and sharply toothed (Figure 2b). Garlic mustard, as the name implies, has a strong garlic odor in spring and fall, which differentiates it from all similar native species. Interestingly, some people who have a garlic-rich diet have difficulty recognizing the garlic mustard odour (Bob Pett, Jocelyne Marchand, personal communication 2008). Small flowers have four white petals arranged in a cross shape. First flowers were noted in NS on 10 May 2008 and 18 April 2009 (Sam Vander Kloet, personal communication 2008, 2009). Seeds are borne in linear siliquae, and a single plant can disperse up to 8,000 seeds before dying in mid-late summer. The seeds are spread primarily by anthropogenic disturbance. Garlic mustard seed can remain viable in the soil for up to five years, and some sources claim up to seven years (Johnson 2001).

Figure 2a. Handful of first-year garlic mustard (*Alliaria petiolata*) plants. These rosettes are quite large, but size is highly variable.

Figure 2b. Top of a second-year garlic mustard (*Allaria petiolata*) plant, displaying small white cross-shaped flowers, and triangular toothed leaves.

Current Distribution

Within Canada, garlic mustard occurs in British Columbia, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island. In the United States, the plant is most common in the Northeast and Midwest, but also occurs as far west as Oregon and Washington, and as far south as Georgia. A distribution map for the species in North America can be seen on the United States Department of Agriculture (USDA) Plants Database website, http://plants.usda.gov/java/profile?symbol=ALPE4.

The USDA site does not list PEI as having any occurrences, but garlic mustard has been present in Prince Edward Island National Park for several years (Kirby Tulk, Jackie Waddell, personal communication 2007). Nuzzo (1992, 1993, cited in Nuzzo 2000) noted that garlic mustard has demonstrated exponential spread since its introduction.

The current known distribution for garlic mustard in Nova Scotia is described in the "Inventory" section of this document, and is illustrated in Appendix B. The E.C. Smith Herbarium at Acadia University is soliciting additional reports of this species through the distribution of notices and flyers (Appendix C and D). Yearly spread of garlic mustard along roadsides, from the point of origin in Grand Pré, has been observed by Dr. Sam Vander Kloet (personal communication 2008), and others.

Damage & Threats

Many invasive plants remain weeds of disturbed landscapes, and do not pose a real threat to native ecosystems. Garlic mustard is one of the few species that has the ability to invade and dominate closed-canopy forest understories. The Canadian Council of Forest Ministers (2006) describes garlic mustard as "highly invasive" in reference to Canadian forests. This may be of particular concern in Atlantic Canada, where the remaining Acadian Forest is considered an endangered ecosystem type (Ricketts et al. 1999). Recent research has indicated that garlic mustard invasion in forest understories may suppress the regeneration of native tree seedlings, including sugar maple (*Acer saccharum*), red maple (*Acer rubrum*), and white ash (*Fraxinus americana*), and in turn alter the overall community composition (Stinson et al.2006).

Havinga et al. (2000) list garlic mustard as a Category 1 invasive plant in southern Ontario, defined as "Species that exclude all other species and dominate sites indefinitely." They note that garlic mustard "dominates forest herb layer". Blaney (2001) and Blaney and Hill (2006) identified garlic mustard as one of the most important invasive alien plants in the Maritimes, and noted that it may have the potential to impact native species. More recently, Blaney, a botanist with the Atlantic Canada Conservation Data Centre (ACCDC), stated that "…there is high potential for local impacts that would be significant to biodiversity conservation", in reference to garlic mustard in NS (personal communication 2007).

In addition, garlic mustard may impact diversity and cover of native plant species, threaten several species of butterfly, and render habitat less suitable for native animals. There are conflicting observations on the use of garlic mustard as food by white-tailed deer (Cavers et al., 1979, cited in Nuzzo 2000).

Inventory

Note: An accurate inventory of garlic mustard in Nova Scotia was one of the management objectives identified in for Year 1 (2008 – 2009). Methods for describing density are derived from Atkinson (2008) and the Aldo Leopold Foundation (2007).

The only known population of garlic mustard in Nova Scotia was discovered in 2002 along a roadside adjacent to private property in the village of Grand Pré (Ruth Newell, Jim Wolford, personal communication 2007). Since its establishment, botanists at Acadia University and local community members have been recording the spread of this population along roadside ditches west to Lower Wolfville, and east to Hantsport. Figure 3 illustrates the spread of garlic mustard in the Grand Pré area between 2005 and 2007.

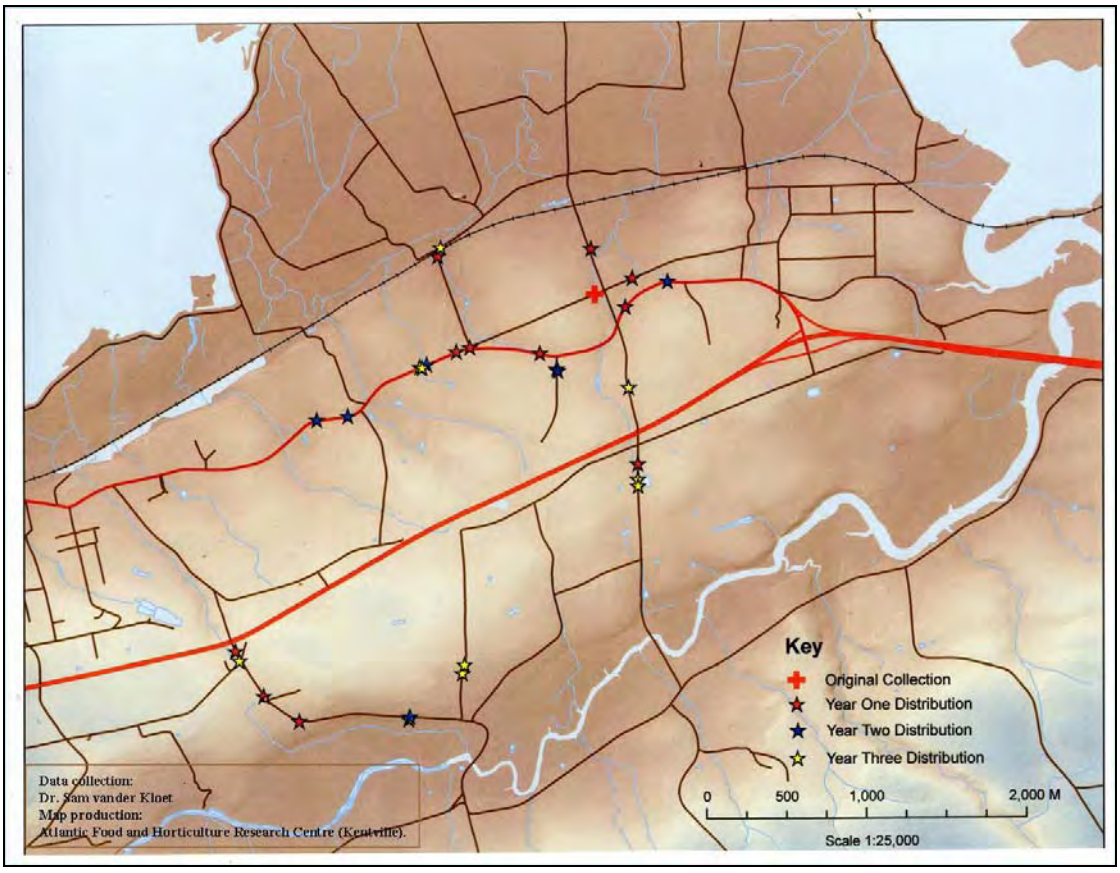

Figure 3. Spread of garlic mustard (*Alliaria petiolata*) from the point of original collection in Grand Pré, NS. Year one was 2005, year two was 2006, and year three was 2007. Data collected by Dr. Sam Vander Kloet, and map produced by the Atlantic Food and Horticulture Research Centre.

In May of 2009, the extent of garlic mustard in NS was re-mapped by NSTIR-NSYCC staff. Known populations form the previous year were revisited and examined. Several new populations were also discovered in Kentville and Canning. Some of these were reported by residents while others were spotted by NSTIR-NSYCC staff during monitoring operations. The current known extent of garlic mustard in Nova Scotia is described in Table 1 and illustrated in Appendices B and E.

Table 1. Description of garlic mustard populations in the Grand Pre area of Nova Scotia. These are the only confirmed occurrences in the province. All populations not called “Core1”, “Core 2” or “Core 3” are outlier/ satellite populations.

Name	**Area (ha)**	**Length (km)**	**Density**
Core 1	57.49	-	Isolated (20%) with dense patches (80%)
Core1 Roads	-	4.2	Isolated (20%) with dense patches (80%)
Core 2	1.12	-	Scattered (60%)
Core 3			Dense (80%)
Lower Wolfville	-	-	Small Patch
Melanson Road			
A	-	-	Scattered Patches
B	-	-	-
C	-	-	-
D	-	-	-
E	-	-	-
F	-	-	-
Melanson Road Creek	-	-	-
Martin Cross Road	-	-	-
Grand Pre Road	-	-	-
A	-	-	Small Patch
B	-	-	Larger Patch
Hantsport	-	-	Scattered (60%)
Dyke Road	-	-	One plant
Miner lane-Dykes	-	-	Patchy (20%)
Greenwhich	-	-	Dense Patch (80%)
Kentville	-	-	

It is possible that garlic mustard is present in other areas of Nova Scotia but that occurrences have not been reported or recorded. The E.C. Smith Herbarium at Acadia University is indirectly continuing inventory activities by soliciting additional reports through the distribution of notices (Appendix C). Dr. Bob Pett of NSTIR is currently investigating a reported sighting or garlic mustard at a residence in Halifax.

Management Plans

Goals

At a March 2008 planning meeting, project partners (NSTIR, Parks Canada, and CARP) identified the following long-term goals for the management of garlic mustard in NS (as per meeting minutes 19 March 2008): eradicate all known garlic mustard populations in NS; prevent further spread and new introductions of garlic mustard in NS; conduct a case study of best management practices (BMP) applied to managing roadside populations of garlic mustard in NS; and increase public awareness of invasive alien species.

When mapping the known garlic mustard populations in May and June 2008, it was discovered that the extent of the infestation was much larger than originally thought, making the goal of eradication an unlikely prospect. As such, long-term management goals were revised as follows (as per meeting minutes 27 August 2008):

- Prevent further spread and new introductions of garlic mustard in NS.
- Conduct a case study of BMP applied to managing roadside populations of garlic mustard in NS.
- Increase public awareness of invasive alien species.
- Engage other agencies in the management of garlic mustard in NS, and solicit additional project support.
- Establish a management committee to oversee the management plan implementation and annual revisions.

It is recommended that these long-term goals be revisited on an annual basis by the management committee to determine whether or not they are still realistic. Reevaluation of goals must consider the following factors: distribution and extent of the species (garlic mustard), resources of the management committee or project partners, community involvement, and monitoring and evaluation of previous management efforts.

Objectives

Year 1 (2008-2009) and Year 2 (2009-2010) management objectives for garlic mustard were identified as follows:

- Accurately inventory/map all known populations of garlic mustard in NS.
- Prevent seed production in all known outlier/satellite populations of garlic mustard in NS.
- Implement BMP along roadsides in the Grand Pré area.
- Increase public awareness about garlic mustard, and invasive alien plants in general.
- Engage the communities of Grand Pré and surrounding areas in taking an active role in the management of garlic mustard.

Each objective is briefly summarized below.

<u>Inventory/Map</u>
See the “Inventory” section for a description of the known extent of garlic mustard in Nova Scotia. A map is provided in Appendix B. Updated maps for 2009 surveys are provided in Appendix E.

Prevent Seed Production in Outlier Populations

All adult (second-year) garlic mustard plants in outlier populations were hand-pulled, as described in the "Management" section of this document, under the heading "Materials & Methods".

Implement Roadside BMPs

BMPs for working in ditches containing garlic mustard were researched, written, and forwarded to NSTIR for their consideration (Godwin and Stewart 2007). After circulating the BMP document to their Operations staff, the Environmental Services Section of NSTIR committed to implementing the recommendations in 2008 and 2009. Control and prevention of further spread of this invasive plant relies on the following practices: (1) proper identification of garlic mustard plants in all life history stages (*i.e*., training), (2) mechanical removal of the plants during the flowering stage and prior to seed production (*i.e.*, timing mowing for control), (3) proper disposal of cut plant material to reduce the risk of spread, (4) quality control surveys to inspect cut areas and the entire infested area for missed or late-blooming plants, (5) cleaning of equipment before it leaves the affected area, and (6) long-term commitment by NSTIR, Parks Canada, and the local community to implement the BMPs until the seedbank is depleted. The BMPs are described in greater detail in Pett et al. (2008).

Increase Public Awareness

In 2008, CARP organized and led a community information session for the residents of Grand Pré and surrounding area, held on 14 August 2007. The goals were to increase public awareness about garlic mustard, and engage community members to take action. A good turnout of 20 local residents and ensuing lively discussion were encouraging. A second community information session 27 March 2008 was attended by only 8 people. It was later discovered that another community meeting was scheduled for the same date. In March and April 2008, CARP delivered presentations about garlic mustard to 10 Women's Institutes of Nova Scotia (WINS) groups (more than 60 people), including as an invited guest at the Eastern Kings District WINS annual meeting. Eastern Kings is the geographic area in which garlic mustard is known to occur, and therefore comprises an important audience. On 19 May 2008, CARP was invited by the Grand Pré Community Association to set up a display at the Horton Community Hall Plant Sale, an annual fundraiser in support of the hall. Garlic mustard identification, impacts, and management were discussed with approximately 30 local residents. In early June 2008, CARP staff conducted door-to-door community outreach in Grand Pré and surrounding area. A flyer with information about garlic mustard (Appendix D) was delivered to 119 households. Staff also collected contact information for residents that they spoke with, and documented their willingness to participate in future community management initiatives. A spreadsheet of this contact information is archived at CARP. In addition, CARP contacted David Morse (MLA, Kings South, and Minister, NS Natural Resources), Mark Parent (MLA, Kings North, and Minister, NS Environment), Fred Whalen (Warden, Municipality of the County of Kings), and John Fuller (Councillor, Municipality of Kings) in an effort to solicit municipal support for the project. Though we were commended for our efforts, there was no offer of support, and no political presence at any public garlic mustard event.

In 2009, an information session was held for the community of Grand Pré on June 4th, 2009 at the Grand Pré National Historic Site. This presentation had very low attendance. However, it was noted by the two NSYCC students that most of the community was already very informed about

and interested in the Garlic Mustard problem. They noticed that, while working in the field, residents that passed-by would comment on the work being done and were already aware of the issue. Residents were also very receptive to any new information on the project and any ideas regarding how they could get rid of garlic mustard on their own properties. This is evidence that the community involvement campaign of 2008 was very successful.

Engage Communities

Project partners discussed volunteer training, and community work days or pulling events, but none were coordinated for 2008 or 2009. Due to the unknown timeline for control (unsure of peak flowering time, disposal methods, etc.), it was decided that planning and implementing a successful community event in the first and second management year was not feasible. Despite numerous requests for leadership from within the Grand Pré community, no volunteers came forward in 2007, 2008 or 2009. However, during the implementation of control efforts, numerous local residents came and talked with CARP and NSTIR staff about garlic mustard, and several people arranged for NSTIR staff to collect garbage bags of pulled plant material from their properties. Parks Canada and the E.C. Smith Herbarium at Acadia University received more than 10 phone calls after CARP's public outreach campaign (Wayne Kelley, Ruth Newell, personal communication 2008), demonstrating public interest in the issue. One possible explanation for the lack of leadership at the community level may be that Grand Pré has submitted a bid to the United Nations Educational, Scientific and Cultural Organization (UNESCO) for consideration as a "World Heritage Site". The bid is a very involved process, and numerous residents were previously committed to this effort (see www.nominationgrandpre.ca).

Year 3 (2010-2011) management objectives for garlic mustard were identified as follows:

- Accurately inventory/map all known populations of garlic mustard in NS.
  TARGET IMPACT: No undocumented/unknown occurrences of garlic mustard.

- Prevent seed production in all known outlier/satellite populations of garlic mustard in NS.
  TARGET IMPACT: No increase in overall area infested with garlic mustard. No increase in number outlier/satellite garlic mustard populations.

- Implement BMPs along roadsides in the Grand Pré area.
  TARGET IMPACT: Develop partnership BMP model for application to other roadside invasive plant populations and/or other areas of NS.

- Increase public awareness about garlic mustard, and invasive alien plants in general.
  TARGET IMPACT: Increase capacity for early detection and rapid response for new invasive plant occurrences.

- Engage the communities of Grand Pré and surrounding areas in taking an active role in the management of garlic mustard.
  TARGET IMPACT: Increase in number of committed community volunteers.

Materials & Methods

Note: Unless otherwise cited, information on management options are drawn from Nuzzo (2000).

Control techniques for garlic mustard are well documented by Nuzzo (2000). Given that garlic mustard reproduces solely by seed, the key to control and eventual eradication is reducing or eliminating seed production. Control methods for garlic mustard include burning, herbicide, cutting, pulling, and mowing. While no control method has proven to be 100% effective, cutting plants at ground level during peak flowering has resulted in 99% mortality. Mowing may have a similar impact, but the use of mowing equipment presents additional risks for soil disturbance, damage to native vegetation, and further spread of seed. Plants cut, pulled or mowed prior to full flowering may have enough resources to send up additional stems and hence a second mowing may be required together with comprehensive quality assurance surveys. Depending upon the type of mower used, the flowers on cut flowering stems may also have sufficient resources to sustain seed production (Solis 1998, cited in Nuzzo 2000; pulled flowering plants were still able to produce seed when laid in piles on the ground). It is unknown whether this latter risk could be minimized by the use of a "Brush-Hog" mower that effectively mulches the plants and may eliminate the need to collect and dispose of cut materials. Upon assessing available options and resources for control, project partners decided to implement a combination of mowing, cutting, and pulling in 2008 and 2009.

As stated, when conducting inventory and mapping activities it was discovered that the extent of the infestation was beyond the scope of the project's management resources. It was decided that efforts would be concentrated on controlling satellite (outlier) populations, and reducing the risk of spread along major transportation corridors within the original population, named Core 1 (see Appendix B for map of core and outlier populations). Satellite populations were assigned names based on their geographic locations, as follows:

- Lower Wolfville
- Melanson Road (A, B, C, D, E, F)
- Martin Cross Road *
- Melanson Road Creek **
- Grand Pré Road (A, B)
- Hantsport (Ben Jackson Road)
- Dyke Road
- Greenwhich
- Kentville
- Woodland Trails

*Sam Vander Kloet (personal communication 2008) noticed an "explosion" in the number of plants in this population from the previous year. When implementing control measures on this outlier, a large population was discovered on the adjacent property. Note: Unless otherwise cited, information on management options are drawn from Nuzzo (2000).

** When implementing control measures, another satellite population was discovered in the riparian area along a creek at the intersection of Melanson Road and Martin Cross Road. The

unnamed creek was surveyed downstream to where it flows out into the Gaspereau River, and the population was named Melanson Road Creek.

Materials Required

The following materials are required for mechanical control of garlic mustard:

- Gloves
- Closed-toe footwear
- Health and safety equipment (appropriate first aid kit, water, sunscreen, insect repellent)
- Black garbage bags (regular and 3mm contractor grade)
- Camera
- GPS unit
- Datasheets
- Clipboards
- Pencils
- Flagging tape
- Gas-powered trimmer (whipper-snipper) - OPTIONAL

Methods for Outlier/Satellite Populations

Outlier populations were treated by staff and volunteers. At all 10 outlier populations, identified above, all second-year (flowering) plants were counted, hand-pulled, and bagged. Teams of two people recorded the following information at each outlier site: date, name(s), start time, site name, GPS coordinates, location description (with sketch), number of plants pulled, number of garbage bags, end time, total time, and comments/observations. Upon completion of treatment, garbage bags were double-bagged in 3mm contractor grade black plastic bags, and placed on the roadside for same-day collection by NSTIR trucks.

Methods for Roadsides in Core 1 Population

Roadsides in the Core 1 population were treated by operations staff. The project leader provided "in the field" training to NSTIR employees. This included site visits to ditches infested with garlic mustard, instruction in first and second-year plant identification, demonstration of hand-pulling and plant bagging procedures, as well as delineation of areas to be treated (maps provided). All roadside (ditch) populations within Core 1 were hand-pulled and bagged. No data sheets were completed by NSTIR staff, but they kept the project leader informed of areas treated. The number of plants pulled was not recorded in the Core 1 population, as tallying pulled plants significantly increases treatment time (Brendan MacNeill, personal communication 2008). Again, upon completion of treatment, garbage bags were double-bagged in 3mm contractor grade black plastic bags, and placed on the roadside for same-day collection by NSTIR trucks.

Methods for Parks Canada Properties

All second-year (flowering) plants on the small federal property (Grand Pré National Historic Site) were hand-pulled and bagged by Parks Canada staff throughout the growing season.

Outcomes for Year 1: Over a 2 week period between June 9 and June 20, 2008, NSTIR, CARP staff, and community volunteers hand-pulled 106 extra large garbage bags full of garlic mustard plants from the core infestation area and six outlier populations. Parks Canada staff pulled three garbage bags full of garlic mustard plants from their properties. For several reasons, no mowing

was conducted in the Grand Pré area specifically for the purpose of garlic mustard control. The primary factor in this decision was that no pressure washing equipment was available for on-site cleaning of the mower, which, if not cleaned, would pose a risk for dispersal. The second factor was that most of the garlic mustard plants are located beyond the reach of the mower blade (i.e., upper side of ditches, and low lying areas). Other roadside vegetation, particularly grasses, was very tall at the proposed mowing time, and would have constituted the bulk of cut plant material that then would have had to be collected and bagged.

Outcomes for Year 2: Over a four week period between May 19 to June 12, 2009, NSTIR staff and some community volunteers hand-pulled 36 extra large garbage bags full of garlic mustard plants from core infestation areas and 10 outlier populations. Parks Canada staff also pulled several garbage bags full of garlic mustard plants from their property. Planned changes for Year 2 proposed that NSTIR would either mow or whipper-snip some of the garlic mustard populations prior to peak flowering in order to minimize the risk of seed dispersal. This was not implemented due to time restrictions as well an unanticipated early flowering of the garlic mustard (April 18, 2009 whereas in the previous year the first flower was noted on May 10, 2008). Another reason mowing was not used was the necessary cleaning of the machines required to reduce the spread and the danger of using heavy machinery in ditches. It was also planned to engage Grand Pré community members in a "community work day" during Environment Week (the first week of June). This objective was also not achieved due to time constraints associated with the late (mid-May) start of picking.

Planned changes for Year 3: In 2010, NSTIR will reexamine the possible use of mowing and/or whipper-snipping as an alternate form of control on seed dispersal. Also, monitoring efforts for identifying early blooming plants should take place in April, with control efforts starting as soon as possible in May. A strong effort should be made to plan a "community work day" during Environment week in June.

Schedule

It was anticipated that peak flowering would occur around mid-June (Kirby Tulk, personal communication 2008), and control activities for Year 1 were planned to start on 09 June 2008, and continue until the project objectives were met. Based the outcomes of the first (trial) year, and considering plant biology, project resources, community involvement, and annual objectives, partners should strive to establish a management schedule for 2009 and beyond. Approximate dates include the following:

- April-May – conduct monitoring surveys to assess effectiveness of previous control efforts and search for new occurrences;
- May – engage "Invasive Plants Team" (NSYCC and NSTIR staff) and make plans for community/volunteer training and management activities;
- Early June – implement volunteer training and management activities;
- Early June – implement all project management activities (Note: this is dependent on the type of actions planned for the next control year);
- Late June – Quality Assessment/Quality Control (QA/QC) surveys;
- July, August, September – monitoring activities;
- September and beyond – evaluate and revise management plan.

In order to maximize use of resources, mechanical control of garlic mustard plants should be conducted at peak flowering (Nuzzo 2000). The logic behind this is that by waiting until peak flowering (full bloom and/or siliques developing), the plants will have used up too many resources producing flowers to send up a second flowering stalk in the event that the entire root system is not pulled. In other words, you get the most "bang for your buck" for control. Unfortunately, because cut/pulled flowering plants may still produce viable seed, plants must be collected for disposal, as opposed to left on site to decompose.

Disposal

Because pulled and cut material can still generate viable seed (Solis 1998, cited in Nuzzo 2000), harvested plant material must be collected for proper disposal. Composting is generally not recommended for highly invasive plants as it typically requires off-site transport and there are no guarantees that the process is hot enough and lengthy enough to kill all seed (e.g., Ward 2003). Based on literature review, and expert recommendations (e.g., Heather Stewart, Julia Reekie, Kirby Tulk, personal communication 2007), the ideal disposal method for cut or pulled flowering garlic mustard, and other invasive plants, is on-site incineration. Unfortunately, a portable incinerator was not available during 2008, and purchasing one was not an option.

A viable alternative to incineration is the "cooking" of plant material in black plastic, followed by disposal in a landfill (Adirondack Park Agency 2006, and Diane LaRue, personal communication 2007). Sealing harvested plant material in thick black plastic (3mm thickness minimum) and leaving it in the sun to liquefy is an effective method that eliminates the risk of seed dispersal (Adirondack Park Agency 2006). Though very rapid decomposition has been recorded using clear bags (Kirby Tulk, personal communication 2008), literature suggests leaving black bags in the sun for a minimum of three weeks to allow plant material to decompose (Hamilton County Soil and Water Conservation District, date unknown).

Outcomes for Year 1: This year, all cut/pulled plant material was double bagged in black plastic (regular garbage bag first, then 3mm contractor-quality bags). Each large 3mm bag holds two to three smaller bags, depending on how full they are. At the end of each day, NSTIR Operations staff collected the bags and transported them to the NSTIR base in New Minas, NS, approximately 12 km away from the infestation. This included a number of bags that were placed roadside by private landowners who had pulled plants on their own properties. Bags were laid out (not piled) on gravel, in a slight depression to prevent movement, and left to decompose. Six marked bags of the 106 large bags are checked weekly to assess the state of decomposition. The following information was recorded on a datasheet: bag number, colour of plants, state of decomposition, odour, and presence of mould. At the time of printing of the 2008 programme, project partners were looking at a variety of options for disposal of the decomposed plant material. The province of Nova Scotia does not permit landfilling of organic material, and as described above, composting is generally not recommended for invasive plant material. In the Spring of 2009, bags were transported to the incineration facility at the Nova Scotia Agriculture College in Truro, and burned.

Outcomes for Year 2: Similar to Year 1, all cut/pulled plant material was double bagged in black plastic contractor-quality bags. The bags were collected and stored near a core area. Bags placed roadside by community members were also picked up and placed with the NSTIR

collection. The bags were laid out on gravel roadside, which prevented movement, and left to decompose. Bags will be incinerated at the Nova Scotia Agriculture College in Spring 2010.

Planned changes for Year 3: It is recommended that NSTIR continue to remove garlic mustard plants from outlier and core areas and continue double bagging the plants. Bags from community members in the Grand Pré area should be collected from roadsides on days specified for garlic mustard removal. Plant material should be transported to the NSTIR base for temporary storage and ultimately to NSAC-Truro for incineration.

Evaluation

Two types of monitoring are required for this program. The first is to determine that short-term objectives are being met, and that the process is being carried out correctly and at the right time. The second is to determine that over the long-term, the management program is effective for the ultimate goal of prevention of further spread and new introductions. The short-term monitoring is a quality assessment/quality control (QA/QC) mechanism to determine if the management actions are being applied at the correct time, and if they are effective. This will include monitoring for presence/absence of new or remnant flowers and seed material after the management actions have been implemented.

Long-term monitoring is required to determine the success of the management program. This management effectiveness monitoring is required for assessment of overall success balanced with costs. To adequately carry out this type of monitoring, population density or biomass needs to be measured at the outset, and annually at the same time of year to determine if the plant density/biomass is actually decreasing. Recommendations by Nuzzo (2000) are to monitor annually for presence/absence, frequency, cover, density, and seed production using a meter square (m^2) plot.

Outcomes for Year 1: While mapping garlic mustard plants using GPS, the team discovered that the area of infestation was much larger than originally known. Given the resources allocated to the project for 2008, it was determined that control efforts would be focused on isolated, outlier populations. Six populations (the only known outliers in 2008) were mapped and targeted for control. All adult garlic mustard plants were counted and hand-pulled from every site. These sites will be the focus of short-term and long-term monitoring efforts. Immediately following treatment, all sites were surveyed for missed plants, as part of the QA/QC plan. In the short term, July – September 2008, all outlier sites were to be surveyed once a month for new plants or new shoots coming off plants that were broken (as opposed to completely pulled) during the control effort. All outlier sites were surveyed in mid-late August, and no adult plants were found at any site. Some sites had been mowed through NSTIR's right-of-way maintenance practices.

Outcomes for Year 2: Outlier sites were surveyed in May to observe the changes in the density of plants and roadsides were surveyed for new populations as per the planned changes for Year 2. Roadside surveys were done on foot and by car with numerous locations found by Sam Vander Kloet. The Team discovered four new outlier populations that greatly expanded the total area of infestation, from Kentville to Hantsport and the Gaspereau River to Canning (efforts were again focused on isolated outlier populations for control). This large increase in area could be a result of

further spread by garlic mustard but is more likely due to previous education, better identification by local community members, and disposal of "contaminated" soil (the Greenwich site is situated at a waste disposal site). All flowering garlic mustard plants were pulled by hand in the 10 outlier sites. Following treatment, sites were surveyed throughout the summer for any reoccurring flowering plants. In a large patch of garlic mustard found on Miner Lane in Grand Pré, a few large plants were also tagged. This was done in order to monitor the growth in following years and to see if the plant came back the following year.

Planned changes for Year 3: For the long term, outlier sites will be surveyed at the same time (April/May) every year for changes in the density of plants. Surveying of roadsides will take place yearly for new populations. For efficiency, roadside surveys must be done on foot or by bicycle as small plants are easily missed when traveling by car. Sam Vander Kloet has noted that small populations can appear and disappear from one year to the next, and these changes in frequency and cover should be noted. Some permanent $1m^2$ plots should be established in the core population to monitor biological traits. This would best be done on property of private ownership, with landowner permission. The tagged plants should be examined and their status recorded to better understand the life cycle of the garlic mustard.

Resource Requirements

Prior to the initiation of control activities, NSTIR did not specify how many resources would be allocated to the garlic mustard project. One crew of two men worked for a total of 7 days (4 days for one, 3 days for the other) at a rate of $127/day = $889. The use of the NSTIR half-ton truck is valued at $136/day for 4 days = $544. In reality, the cost for the truck would be slightly more, as it came to the control sites every treatment day to collect bags for disposal. The total known costs incurred by NSTIR are $1,671. Costs do not take into account the project planning time for NSTIR Environmental Services staff, NSTIR Operations Supervisors time, use of the NSTIR base for temporary storage, or costs to dispose of the 100+ bags of plant material.

The costs for CARP's involvement in the planning, outreach, control, and monitoring portions of the project were relatively high, attributed mostly to travel expenses. Staff wages spent on outreach and control activities were $4,095, travel costs were in excess of $1,500, and approximately $200 was spent on field supplies, for a total cost of $5,795. This does not take into account supervisor's time, prior research on garlic mustard control, or time spent preparing this management plan.

Parks Canada had their summer staff spend approximately three hours hand pulling plants on Parks property. No estimates of costs incurred by Parks Canada (including planning and hosting of meetings and public outreach events) was available at the time of report writing.

PEI National Park gives the following resource estimates for garlic mustard monitoring and control (Atkinson 2008): two technicians for one week for field work (monitoring and control) at a rate of $158/technician/day = $1,580; and, one person for three days for data entry and report preparation at a rate of $158/day = $475. The total annual Park budget for garlic mustard control on 2.7ha is $2,055. No costs are cited for equipment, transportation, or disposal, though they would not be expected to be significant given the Park's ownership of vehicles and equipment.

It is important to note that hand pulling garlic mustard plants is not difficult. The number of plants that can be pulled by one person in a given amount of time varies widely depending on the site, soil type and moisture, competing vegetation, and size of the plants. CARP counted all of the plants at each outlier site, so that long-term monitoring would indicate changes in abundance over time. While it is possible to determine a rate using this data, it is not felt that it would be relevant. Counting plants as they are being pulled significantly impacts the amount of time it takes to pull them (Brendan MacNeill, personal communication 2008). When not counting, it is possible to pull garlic mustard plants in big handfuls, as opposed to one at a time.

Outcomes for Year 1: No resource planning was conducted prior to implementing management actions in 2008. There are several reasons for this: no existing management plan or template to use as a reference, unknown density and distribution of garlic mustard plants, multiple project partners, little knowledge of time required to implement desired management actions, and lack of resource planning meetings. We therefore view 2008 as a trial year.

Outcomes for Year 2: NSTIR created a partnership with the NS Youth Conservation Corps (NSYCC) and Clean Nova Scotia to help alleviate some of the cost and resource availability associated with use of NSTIR District Operations staff. NSYCC summer students were hired from the Grand Pré area and were required to have their own transportation (local mileage was covered by NSTIR).

Planned changes for Year 3: A continued partnership between NSTIR and NSYCC is recommended for 2010, along with hiring of local students. The summer students should be encouraged to organize a “community work day” and work towards transferring this responsibility to an committed community member. A large group of volunteers could potentially have a significant impact on garlic mustard populations, in addition to making access to private property less difficult. NSTIR will continue to examine the option of mowing/cutting prior to flowering, provided the cut material does not contribute to the seedbank (some test-plots should be developed to re-examine this possibility). At some point in the future, NSTIR and its partners will have to determine if they should continue to spend public dollars (and community efforts) to continue the control program. Decisions will be based on success of the control efforts (trends in plant abundance and distribution) and government funding priorities, and perhaps public will and/or government regulations.

Further Recommendations

It is recommended that the following items be considered by project partners in Year 3 (2010-2011).

1 – Lead Agency

Given the scope of the garlic mustard infestation in Grand Pré, the potential impact of the further spread of garlic mustard into undisturbed forests of Nova Scotia, and the limited resources of the not-for-profit community, there is a need for one or more government departments to take the initiative with this management plan. It is recognized that the successful, long-term implementation of the management plan will require the collaboration of multiple levels of government, the not-for-

profit sector, universities and community members. One year of management actions is unlikely to have any significant impact on garlic mustard populations (Jim Rockwood, Jeremy Lundholm, Kirby Tulk, personal communication 2008). Without the contribution of other groups, it is recommended that project partners assess the feasibility of carrying-out long-term management actions.

2 – Plant Biology

Literature states that adult garlic mustard plants can be variable in size, ranging from short, single-stemmed plants, to tall multi-stemmed plants (e.g. Nuzzo 2000). It was observed in June and July 2008 that some plants are especially vigorous, having upwards of 15 stems on a single plant. In addition, these large plants had substantially larger tap roots than their smaller companions (hence the possibility of more than two-year old plants). It is recommended that some permanent sample plots be established to observe biological traits of garlic mustard. It is likely that this will be possible to do in partnership with a private landowner (Lawrence Sangster, personal communication 2008).

3 – Community Engagement

Though numerous landowners expressed interest in garlic mustard management, and volunteered their personal contact information, no clear community leaders were identified. It is imperative that the community be engaged in the project, and participate in the planning process. It is therefore recommended that a community "work day" be planned to coincide with Environment Week, and that community engagement activities be a top priority again in Year 3.

4 – New Reports

Given that it's possible that there are undocumented occurrences of garlic mustard in Nova Scotia, it is important to continue to increase awareness, and solicit and document new reports. If garlic mustard is more widespread than originally thought, control and/or eradication of the Grand Pré population may not be realistic. If garlic mustard is widespread in Nova Scotia, management goals will also likely change from those currently established. It is recommended that partners maintain contact with the E.C. Smith Herbarium at Acadia University to learn of any new reports of garlic mustard occurrence. In addition, it is recommended that partners follow-up on the possible report of garlic mustard in Halifax, and determine its extent.

5 – BMPs

The roadside BMPs drafted for NSTIR (Godwin and Stewart 2007), and described in Pett et. al (2008) should be revised based on the outcomes of Year 2 actions. It is recommended that any changes to the BMPs be made in consultation with NSTIR Operations and Environmental Services staff.

6 – Project Support

Project partners should continue to pursue additional support for management of the only known occurrences of garlic mustard in Nova Scotia. It is recommended that partners remain involved in the *Invasive Species Alliance of Nova Scotia (ISANS)*, and the *Invasive Alien Species Atlantic Network*. Membership in these groups will enable partners to stay connected with other groups involved in invasive plant management, and may result in access to funding or other project support opportunities.

NOTE: All GPS data and raw data collected in 2008 and 2009, spreadsheets generated with this data, datasheets, community contact information, and all notes associated with this project are located at the CARP offices in Annapolis Royal or NSTIR offices (Dr. Bob Pett). All inquiries about the data or this management plan should be directed to Dr. Bob Pett at the NSTIR head office in Halifax (1672 Granville Street, PO Box 186, B3J 2N2; Tel: 902-424-4082; pettrj@gov.ns.ca).

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Appendix A – Background Information on Initiating Management of Garlic Mustard in Nova Scotia and Management Plan Development

Responsibility for invasive plants, at present, does not fall under any Nova Scotia provincial government agency (with the exception of noxious weeds, Nova Scotia Department of Agriculture). As such, no geographically relevant template for management of invasive plants is readily available for reference.

In an effort to initiate some discussion about the management of this isolated population of garlic mustard, CARP organized a meeting of managers from key government agencies. Based on professional experience and scientific research, numerous experts feel that immediate eradication of the existing garlic mustard population would be the best course of action (e.g., Heather Stewart, Sean Blaney, personal communication 2007). The meeting was held in the multi-purpose room at the Grand Pré National Historic Site, Grand Pré, NS. Attendees at the 23 July 2007 meeting included representatives from Parks Canada, NSTIR, the NS Department of Natural Resources, Wildlife and Forestry Divisions (NSDNR), the Acadia University E.C. Smith Herbarium, a volunteer with the Nova Scotia Nature Trust (NSNT) experienced in the control of invasive plants, and a Research Scientist/Botanist with the Applied Geomatics Research Group (AGRG), Nova Scotia Community College. Several others, including the NS provincial Weed Inspector (Department of Agriculture) were also invited, but unable to attend. The objectives of this meeting were as follows:

- Raise awareness about garlic mustard.
- Identify partners who will collaborate to create and implement a management plan for garlic mustard.
- Develop components of a management strategy to deal with current outbreak of garlic mustard in Grand Pré, NS, and beyond.
- Establish a timeline for management.
- Identify management milestones (within accepted timeline).

Unfortunately, no agency was able to take leadership on this initiative, but Parks Canada (Grand Pré National Historic Site) and NSTIR both expressed a keen interest in working towards the long-term management of this species. It was decided that further public outreach and spatial data collection should be the next steps taken towards management of the garlic mustard population (as per meeting minutes 31 July 2007). NSTIR requested that some better management practices (BMPs) for working in garlic mustard infested ditches be developed for operational consideration.

Parks Canada Agency is developing an ecological integrity (EI) program for all national parks (Atkinson 2008). At this time, it does not appear as though the EI program will apply to Historic Sites (Wayne Kelley, personal communication 2008). However, in practicing due diligence, the Grand Pré National Historic Site will conduct monitoring and management activities for garlic mustard.

NSTIR has an important role in preventing further spread of this plant by adjusting ROW maintenance practices in areas infested with garlic mustard. In addition, the Transportation Association of Canada (TAC) included a session on the “management of the spread of invasive

plants" at their 2008 annual conference. The session received entries from 4 provinces (Bob Pett, personal communication 2008), including Nova Scotia's garlic mustard submission, highlighting the role of provincial transportation agencies in the management of invasive plants. NSTIR describes the goals of their Integrated Roadside Vegetation Management (IRVM) program as follows: erosion control, slope stability, clear sight lines, drainage of roadways, biofiltration of roadway pollutants, promotion of species diversity, habitat creation, and control of undesirable vegetation, which includes noxious weeds, sweet clover, and trees and large shrubs (LaRue 2004, and Bob Pett, personal communication 2008). The author of the NSTIR Roadside Vegetation Field Manual is a vegetation consultant who feels that the agency has a key role in dealing with the problems associated with invasive alien plants (Diane LaRue, personal communication 2007).

CARP has been involved in numerous local, regional, national, and international initiatives to support community environmental management. Though the community of Grand Pré is located outside of the Annapolis River watershed, CARP became involved in the initial 2007 efforts to solicit support for management of this isolated population of garlic mustard. Given their extensive experience with public outreach, and their more recent experience with invasive terrestrial plants, garlic mustard management seemed a natural extension of the work CARP was doing. In addition, CARP feels that public education is an important means of preventing future introductions, and receiving early reports of detection of new invasive alien species (IAS).

Because no locally relevant management plan for invasive alien plants exists, the components of the garlic mustard management plan were derived from The Nature Conservancy's (TNC) *Site Weed Management Template* (Tu and Meyers-Rice 2001).

It is widely accepted that an adaptive management approach (AMA) is the only way to effectively mitigate the impacts of invasive alien species (Smith 2008). AMA has been used for garlic mustard control in Ontario (Silvia Strobl, personal communication 2007), and Prince Edward Island (Kirby Tulk, personal communication 2007). The concept of AMA is especially important in this case, given that this will be the first time a management plan has been implemented for garlic mustard in Nova Scotia. The U.S. Nature Conservancy (TNC) has modified the original concept of adaptive management to apply to invasive species (Smith 2008). AMA begins with establishing goals for the site. After goal-setting, management follows a cyclical pattern of steps, as follows: (1) establish targets and goals, (2) identify and prioritize species that threaten targets and goals, (3) assess control techniques, (4) develop and implement management plan, (5) monitor and assess impact of management actions, and (6) review and modify plan. At the end of each cycle (one management year), goals are modified to reflect outcomes of management actions. Though the TNC AMA template is designed to apply to geographic areas with conservation targets (e.g., parks, preserves), its basic components are applicable to any location, provided there are management goals.

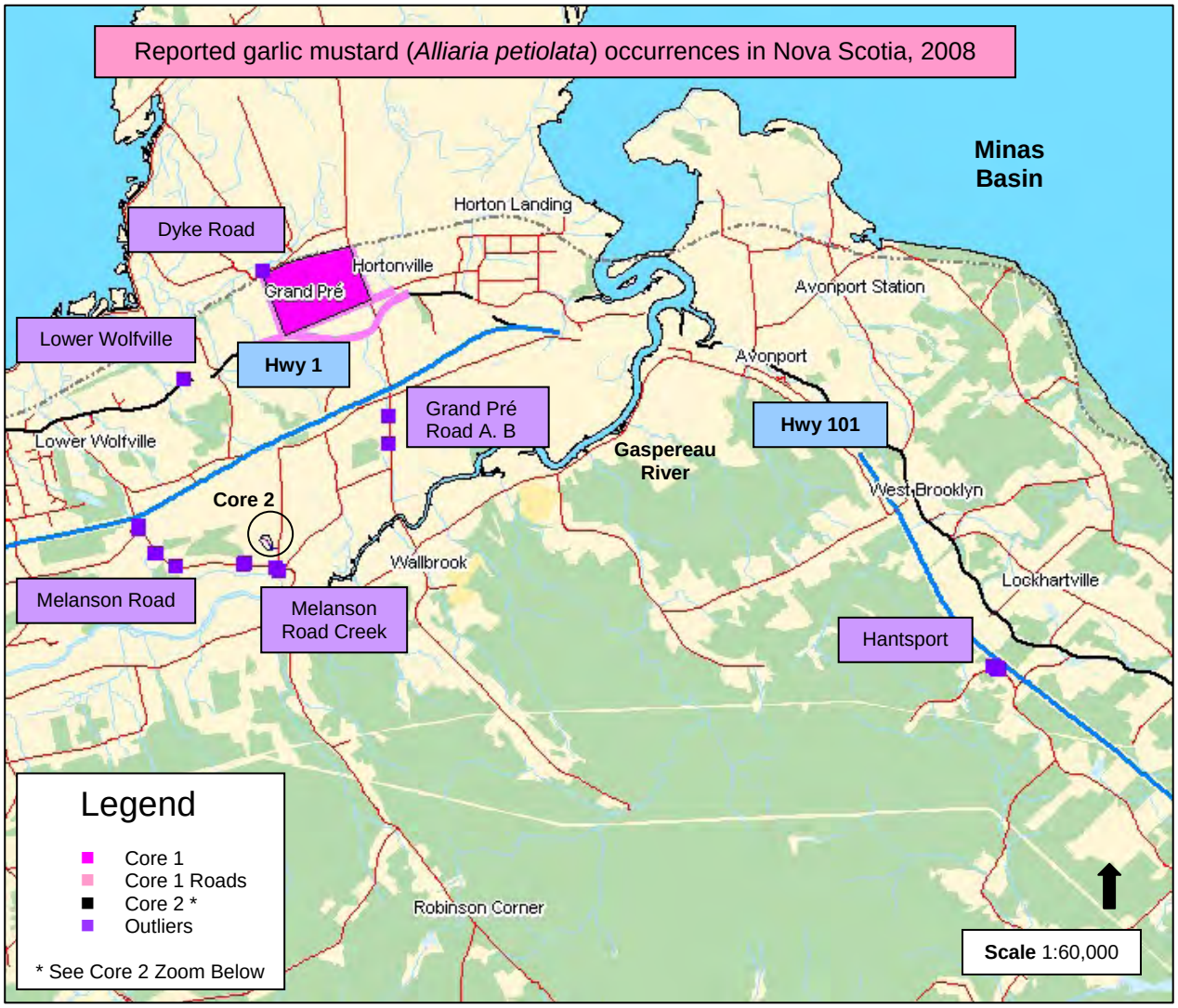
When dealing with numerous species on one site, management priorities must be determined based on priority. This "Priority Setting" section of the plan is used to rank invasive species using four categories: (1) current extent of the species, (2) current and potential impacts of the species, (3) value of habitats/areas infested or potentially infested, and (4) difficulty of control. Based on the ranking, management priorities are established. TNC emphasizes the importance of category (1),

and suggests that resources are best allocated to prevention of new problems and addressing newly developing infestations.

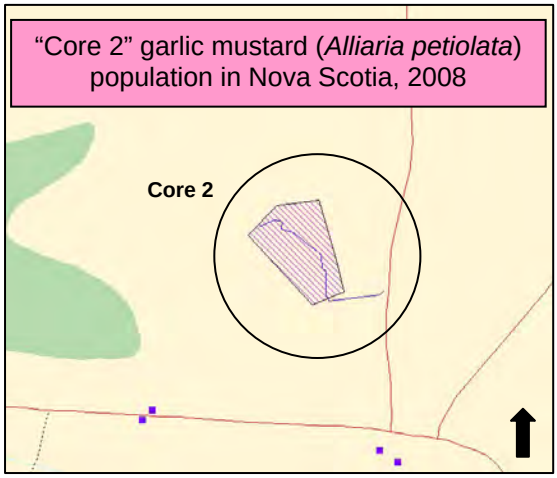
In the case of this weed management plan, garlic mustard is the only species being addressed. As such, prioritization of species is not required. However, it is important to note that within category (1), “species present as new populations or outliers of larger infestations, especially if they are expanding rapidly” are considered to be second priority, after “species not yet on the site but which are present nearby”. This concept of working from the outside in (outliers towards core) is common in invasive species management (e.g., Aldo Leopold Foundation 2007).

Though it is possible in theory to control garlic mustard with available technologies (see Nuzzo 2000), a long-term commitment is required. Prince Edward Island National Park is in its fourth year of control efforts, and is still conducting experimental control trials. It is suspected that in previous years they may have been inadvertently spreading seed during control treatments (Kirby Tulk, personal communication 2007). Experienced managers in Ontario emphasize that all management efforts absolutely require provision for multi-year follow-up (Sylvia Strobl, personal communication 2007, and Jim Rockwood, personal communication 2008). Though garlic mustard seed is commonly cited as having 5-year viability (e.g., Nuzzo 2000), botanists suggest that follow-up activities should continue well beyond that timeline (Sam Vander Kloet, personal communication 2008).

Appendix B – Map of Current Known Extent of Garlic Mustard in Nova Scotia (data collected in May – June 2008)



Map created by Marika Godwin, Clean Annapolis River Project (CARP), using fGIS. Data collected in May/June 2008 by Marika Godwin and Julianne Butt, CARP. “Core 1” is 57.49ha, and “Core 2” is 1.12ha. “Core 1 Roads” are 4.2km in length.



Appendix C – Notice Distributed by the E.C. Smith Herbarium (Acadia University) to Solicit New Reports of Garlic Mustard Occurrences

WANTED:

ADDITIONAL INFORMATION ON THE LOCATION OF

GARLIC MUSTARD ***ALLIARIA PETIOLATA***

First year rosettes

Second year plant with flowers and fruit

FAST FACTS

Biennial plant (1st and 2nd year have different forms)

Both forms are shade tolerant

2nd year plant has small white flowers and is 1m tall (average)

Close up shot of silique (seeds are inside pods)

FAST FACTS

May impact forest soils, native plants and wildlife

Can invade undisturbed forests

Known to inhabit disturbed sites in Grand Pré, NS

Please report new sightings of garlic mustard to the E.C. Smith Herbarium at Acadia University.

Email: ruth.newell@acadiau.ca OR Telephone: 902-585-1335

Appendix D – Informational Flyer Distributed by Clean Annapolis River Project to Increase Awareness of Garlic Mustard Identification and Impacts

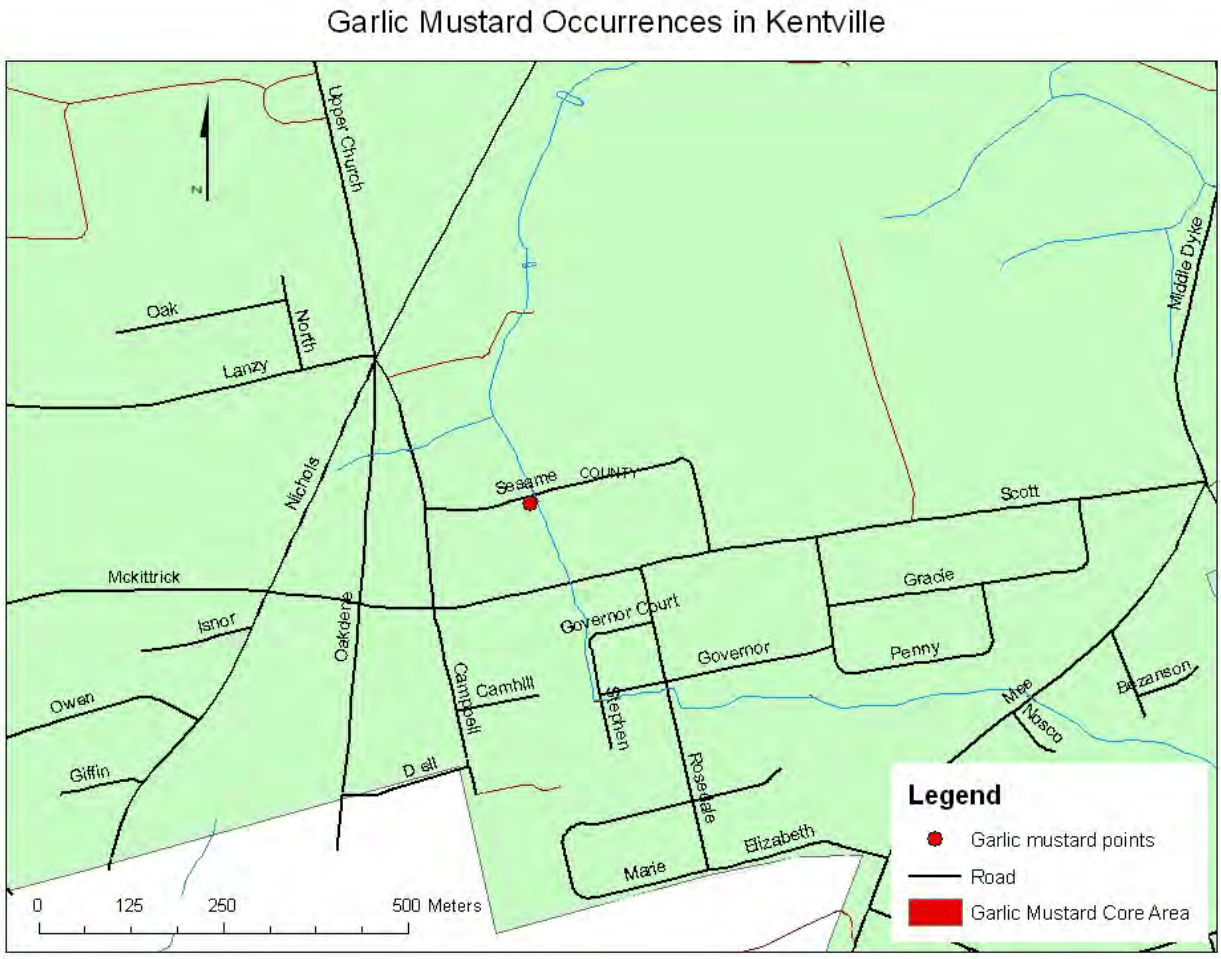
Outside:

Inside:

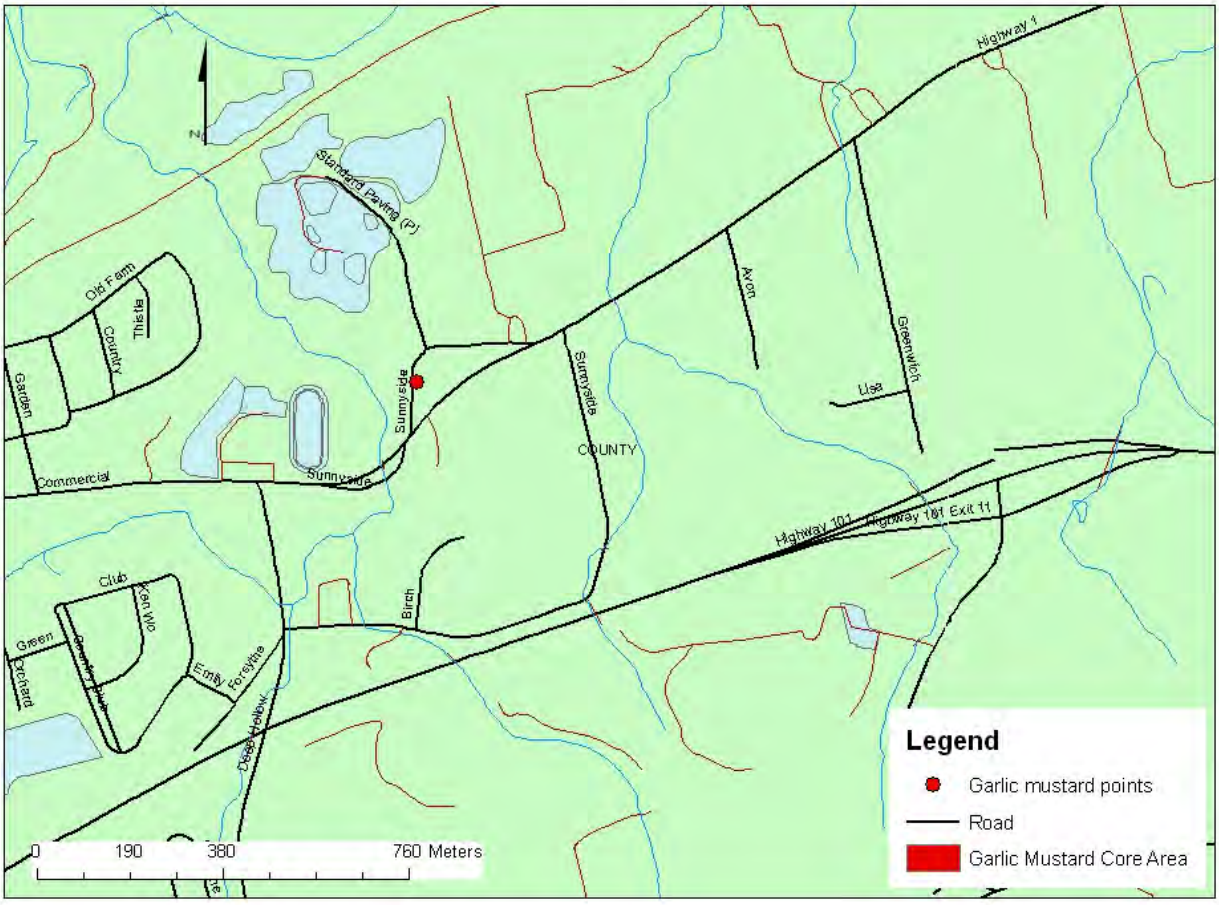

Identification
Use the pictures provided to identify various life history stages.
Occurs in disturbed AND undisturbed sites (forest understories) - keep your eyes open for white flowers in May and June.
Crushed stems and leaves smell like garlic!
Impacts
Can invade undisturbed forests, where it competes for light and space with native spring plants.
Inhibits the growth of a soil fungus that is important for the regeneration of native hardwood trees.
Prevents the development of some native species of butterfly larvae when eggs are laid on the foliage.
Currently threatens 2 native plant species-at-risk and 1 rare native butterfly in ON.
Invasive alien species threaten native biodiversity, species at risk, productive forests, farmland, water quality, human health, trade and our economy.
FRUIT
Oblong pods (siliques) contain up to thousands of seeds.
FIRST-YEAR PLANT
Basal rosette with regularly toothed, kidney shaped leaves.
FLOWER
Terminal clusters with four small white petals in a cross shape.
SECOND-YEAR PLANT
1m tall with alternate, coarsely toothed, triangular leaves.

Appendix E

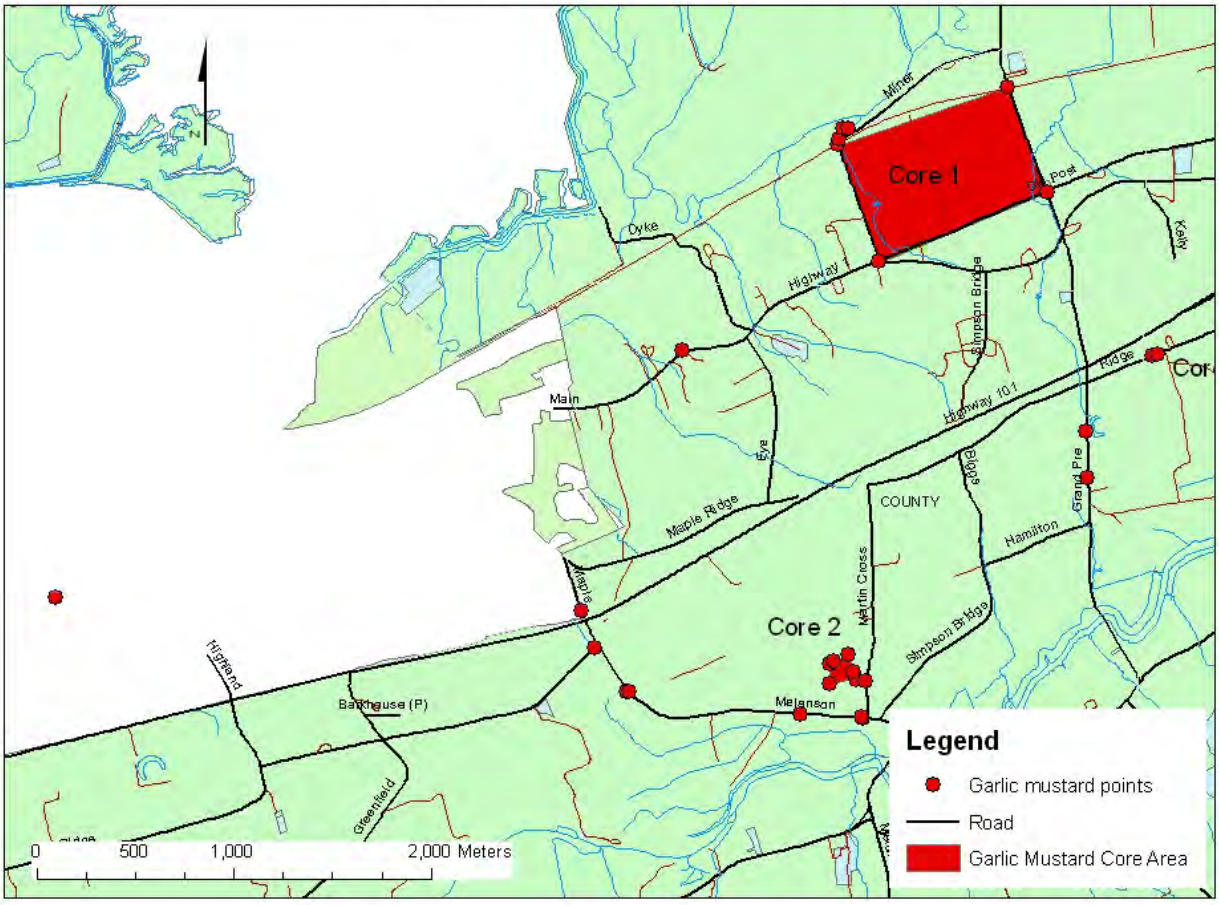
2009 Distribution Maps Generated by Alexandra Wade and Sondra Brehaut, NSYCC



Garlic Mustard Occurrences in Greenwich



Garlic Mustard Occurrences in Grand Pre



Garlic Mustard Occurrences in Hantsport