PATHWAYS ANALYSIS OF INVASIVE PLANTS AND INSECTS IN THE NORTHWEST TERRITORIES

Project
PM 005529

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Preface

The movement of alien, or non-native, species into an area, either through intentional introduction or through natural range expansion, can have disparate effects on biodiversity. While some alien species are benign, or even beneficial, others can establish and spread rapidly, causing serious ecological damage by dominating natural habitats or consuming native species. There is growing concern in the Northwest Territories over the spread of alien insect pests and weedy plants, and the potential harm they may cause to northern species and ecosystems.

According to the Northwest Territories Biodiversity Team, the Territories lags behind other jurisdictions in North America in preventing the introduction of, controlling and eradicating invasive alien species. In the *Northwest Territories Biodiversity Action Plan*, the view is presented that government, industries and communities might have been too complacent towards the threats of invasive alien species to the North's ecosystems, assuming that the northern climate will prevent most species from establishing and spreading. However, with increasing development in the Northwest Territories, and an unprecedented increase in habitat changes expected in the Mackenzie Valley, the plan prescribes that all governments, industries, and communities should be prepared to increase their awareness of the risks related to invasive alien species and to contribute to the reduction of that risk.

The project for which this report has been prepared was conducted for the government of Northwest Territories, Department of Environment and Natural Resources. The Department of Environment and Natural Resources is collecting information on how alien plants and insects enter into and spread within the Northwest Territories to assist in developing constructive ways that communities and industry can prosper while protecting the natural resources of the Territories. This project represents the initiation of that task.

The project consists of two main components. First, through the delivery of a standardized questionnaire to government departments, industry and other organizations, information was gathered about alien species that are being imported into the Territories and activities that may be contributing to their spread. Information was solicited from industry and government departments involved in re-vegetation programs, from the landscaping industry, from the agriculture community and from Northwest Territories communities. Second, a literature review of pathway categories of entry and spread of invasive alien species in other northern jurisdictions within North America, Europe and Russia was undertaken, with an analysis of how these categories apply to the Northwest Territories. This report presents the results of these two approaches.

The report also gives a number of recommendations, based on questionnaire results, the literature review, and expert knowledge, concerning what tools should be provided to communities, industries and government departments in the Northwest Territories to assist their efforts to prevent the entry or spread of invasive alien plants and insects.

Introduction

This project was undertaken pursuant to the *Northwest Territories Biodiversity Action Plan Report Two: Gap and Overlap Analysis and Recommendations for Future Actions* (2006). A key recommendation of the action plan is that the Territories evaluate the potential threats of invasive alien plants and insects to territorial ecosystems. Section 6 of the plan gives particular recommendations as follows:

6.1 Perform, as a first step, a risk analysis to evaluate the potential threats of alien species to Northwest Territories ecosystems using an ecosystem-based approach.

6.2 Evaluate the potential threats of invasive alien species to Northwest Territories ecosystems using surveys and questionnaires to industry or groups that have the greatest capacity to contribute to potential solutions (landscaping industry, transportation, mining, oil/gas, seismic project companies, etc.).

6.3 Work with other jurisdictions to identify and eliminate the common sources of introduction of invasive species.

6.4 Cooperate and facilitate the collection of information on alien species in partnership with outside agencies with appropriate expertise.

6.5 Investigate how appropriate expertise (botanical and entomological) and species identification material could be integrated and shared with northern organizations.

6.6 Evaluate the potential threats of alien species to Northwest Territories ecosystems and investigate effective legislative tools to help control the introduction, eradication and management of alien invasive species.

These recommendations are intended to further the two goals expressed by the action plan's main objective concerning invasive alien species: Investigate how invasive alien species are a threat to native ecosystems and species in the Northwest Territories, and address that threat in a manner appropriate to its severity.

This project is primarily intended to satisfy recommendations 6.1 and 6.2. It employs an ecosystem-based approach, i.e. pathways analysis, to give a preliminary assessment of the most significant means of entry and spread of invasive alien plants and insects in the Territories. In addition, an effort has been made to collect this information by means of surveys and questionnaires delivered to industries, northern communities and professionals in botany, entomology, conservation biology and invasion biology.

The project also makes contributions towards the satisfaction of recommendations 6.3 and 6.4. In the course of gathering information for the project, contact was made with both government and non-government organizations in a number of other jurisdictions. These include Canadian government departments and agencies, Canadian provinces and territories adjacent to the Northwest Territories, the United States of America, Alaska, Finland, Norway, the Russian Federation and Sweden. The organizations consulted for this project provided a significant amount of information on invasive alien species in their respective jurisdictions, and invariably expressed a strong interest in receiving the results of the Northwest Territories analysis.

In order to achieve the goals given by recommendations 6.1 and 6.2, four tasks were identified during the initial planning stage of the project:

1. Provide a literature review of pathways of entry and spread of invasive alien species in other northern jurisdictions (within North America, Europe and Russia) with an analysis of how these pathways apply to the Northwest Territories.
2. Collect information about alien species that are being imported into the Territories, intentionally or unintentionally, and activities that may contribute to spreading alien species, from industry and

government departments involved in re-vegetation programs, from the landscaping industry, from the agriculture community, and from Northwest Territories communities.
3. Provide an analysis of how alien species are spread in the Northwest Territories, based on expert knowledge and on knowledge of Northwest Territories industry and activities.
4. Describe, based on questionnaire results, literature review, and expert knowledge, what tools are available in the Northwest Territories, and what tools are not yet available, but should be provided to prevent the entry or spread of invasive alien plants and insects.

The report for the project has been organized accordingly. The first section provides an overview of the methods employed by the project team in undertaking its literature review, and in developing and delivering a pathways analysis questionnaire. Section two summarizes the results of the review and the questionnaire, including consultations with experts. The third section provides recommendations for the prevention of entry and spread of invasive alien species in the Northwest Territories.

The report also includes a number of appendices. Appendix A contains the questionnaire. Appendix B is a list of project contributors, including both questionnaire respondents and experts consulted for the project. Appendix C includes two summary tables, one of literature review results, the other of questionnaire results. Appendix D gives provincial and territorial lists of forest pest insect and other arthropod taxa for which there are occurrence records, available from the Canadian Forest Service, within the Northwest Territories and adjacent provinces and territories. It also contains a map of record localities for these jurisdictions. Appendix E contains two maps: The first is of Northwest Territories ecozones, and the second is of land claim settlement regions.

Section1: Methods of Investigation

1.1. Literature Review

One of the two main tasks of the project was to conduct a literature review of pathways of entry and spread of invasive alien plants and insects in other northern jurisdictions.

The jurisdictions with which to compare the Northwest Territories were to be chosen from within North America and Europe, and were also to include northern regions of the Russian Federation on both sides of the Ural Mountains. With respect to North America, information was collected concerning the provinces of Alberta, British Columbia and Saskatchewan, and the Territories of the Yukon and Nunavut. Wherever they were available, which was primarily from European sources, facts about invasive species in Greenland were also gathered. Regarding Europe, information was collected about the European part of Russia and those Nordic countries the European territories of which are entirely or mostly north of sixty degrees latitude. These include Iceland, Norway, the Faroe Islands, Sweden and Finland. Asia is represented in this document entirely by the Russian Federation, including Western Siberia, Eastern Siberia and the Russian Far East.

The literature surveyed for the project encompasses a variety of information sources: published academic articles (paper and electronic), government reports and protocols, and databases and spreadsheets. Material was collected primarily from English references. However, information was also taken from a small number of sources in Bokmål, Suomeksi and Russian.

1.1.1 Pathways Categories and their Organization

The selection of pathways categories and their organization was largely dictated by the kind of information available from literature sources. Detailed information on the means of conveyance or spread of invasive plants and insects to, and within, the aforementioned jurisdictions was lacking in many cases. There are few instances of references, acquired for the purposes of the project, in which a definite pathways description is given. This is true whether for pathways transporting a particular plant or insect taxon, or a variety of taxa associated as members of a trophic guild or represented within the same ecodistrict. Nonetheless, some sources offer a characterization of pathways, or potential pathways, of entry into and spread within a jurisdiction, in terms of relatively broad pathways categories. These categories are given as, for instance, horticulture, forestry and natural spread. Hence, by necessity, these broad categories were applied in organizing the information gathered on pathways, and subsequently in undertaking an analysis of how pathways affecting other jurisdictions might be relevant to the Northwest Territories.

The result of this approach has been the imposition of a hierarchy of pathway categories to organize information collected from the literature. The first level of this hierarchy is divided into two categories: pathways by means of which plants and insects are intentionally introduced into, or transported within, a jurisdiction, and those by means of which this occurs unintentionally. The second level of the hierarchy consists of two subsidiary categories, in cases of intentional introductions, and four categories in cases of unintentional introductions. Intentional introductions are either by means of human transportation, i.e. means of transporting people and their personal possessions, or the shipping of living goods such as the commercial transport of plants for planting, non-devitalized seed or insects sold as biocontrols of garden pests. Unintentional introductions might occur as a result of human transportation, shipping of living goods and non-living organic goods, shipping of non-living goods, shipping conveyances and services, or natural spread. The third level of pathways categories is the most detailed. Examples of level three categories are the transport of plants as personal possessions (garden, house or aquarium plants), the transport of plants for agriculture, landscaping or remediation, recreational boat travel, cargo flights, the movement of float planes, the movement of barges and other boats for shipping goods, and so on. A complete list of level three categories is given in Appendix A.

1.1.2 Selection Criteria for Inclusion of Taxa

The literature to be reviewed for the purpose of this report was selected in part on the basis of the range of taxa it addressed. In particular, references were chosen because they dealt with either plants or insects. For the most part, information included in this document is restricted to that which relates to these taxonomic groups. However, a relatively small number of non-plant and non-insect taxa are also represented. All taxa listed from available literature sources are named in the results summary tables of Appendix C. These listed taxa are represented on four spreadsheets, which have been organized taxonomically. The first contains names of plants, including mostly vascular species (tracheophytes) along with some mosses (bryophytes), green algae (chlorophytes) and red algae (rhodophytes). The second table lists names of two plant-like taxa belonging to the division of brown algae (phaeophytes). Although not included with plants in recent phylogenetic classifications, the macroscopic members of this division have traditionally been regarded as members of the plant kingdom. Moreover, some have a similar ecological function to that of the plants; for example, in marine ecosystems, the kelps (*Laminariales*). The third table lists insect names. These include beetles (coleopterans), true bugs (hemipterans), sawflies and woodwasps (hymenopterans), butterflies and moths (lepidopterans), a midge (dipteran) and a thrip (thysanopteran). The fourth table gives names of other arthropods, including a small number of arachnids, all of which are species of mites, and crustaceans.

Of course, not all plant and insect taxa given by the sources referenced for this project are named in these tables. The task was to identify those plants and insects which are both alien and, potentially, pose a threat to Northwest Territories ecosystems. Accordingly, having been identified as a pest or an alien invasive, or potentially invasive, species for at least one of the jurisdictions mentioned in Section 1.1.1, was considered a necessary condition for inclusion in the tables. However, it was not considered a sufficient condition. For instance, some vascular plant species that are introduced to jurisdictions adjacent to the Northwest Territories were excluded. This is the case with tawny cotton grass (*Eriophorum virginicum* L.), for example, because although it is introduced to British Columbia, it is native to the Territories. Other vascular plant species, which some references identify as introduced, have more recently been judged to be native to the Northwest Territories. Seashore camomile (*Tripleurospermum maritimum* (L.) W. D. J. Koch) is an example. Insect taxa were excluded if they posed no threat to Northwest Territory ecosystems. This was judged to be the case, in reference to phytophagous species, if their major hosts do not occur in the Territories. Other insects were not included if they were identified as pests of households or stored goods such as dried foods or lumber, but not as consumers of living plants. For this reason, the hide beetle (*Dermestes maculatus* De Geer), for instance, has been excluded, although reported as being potentially invasive in Sweden. Known pests of agricultural ecosystems, including household vegetable gardens and greenhouses, have been included.

Notwithstanding the selectivity in choosing taxa named in the tables, not all taxa that have been included are certain to pose a threat of invasiveness in the Northwest Territories. It was beyond the scope of this project to undertake climate or ecological niche modelling to predict the establishment and spread potential of the listed taxa. Hence, it must suffice to emphasize that the northern jurisdictions with which the project team has been asked to compare the Northwest Territories all have less severe climatic zones represented within their respective territories. A comparison of United States Department of Agriculture Plant Hardiness Zones supports this statement. The Northwest Territories is entirely within zones 1 and 2. These zones apply to most of Nunavut and the Yukon, northeast British Columbia, northern Alberta and Saskatchewan, northern and interior Alaska, a small region of northern Norway and Finland, the northeast part of European Russia, almost all of Siberia and the western and northern Russian Far East. However, parts of all of these jurisdictions fall within warmer climatic zones. Even Nunavut includes some territory within zone 3, and Siberia has some within zones 3 and 4, although in both cases these are relatively small areas. Nonetheless, these differences should be taken into account during future efforts to revise the tables through the process of assessing the risk level of particular pathways.

1.1.3 Nordic Europe, Greenland and Russia

To establish a basis for the comparison of European countries with the Northwest Territories, published invasive species lists, spreadsheets and databases were sought from a number of different sources representing Nordic Europe and Russia. These sources include the European and Mediterranean Plant Protection Organization (EPPO) and the national plant protection organizations of Russia, Norway, Sweden and Finland. Other government institutions and agencies were also contacted, such as the Swedish Environmental Protection Agency and the Finnish Environment Institute. In addition, correspondence was initiated with a number of academic institutions, including affiliated museums, herbaria, botanical gardens and biodiversity information centers. A complete list is given in Appendix B.

The main source used for identifying invasive plants and insects of Nordic Europe, Greenland and Russia, and their pathways of entry into and spread within these regions, is the North European and Baltic Network on Invasive Alien Species (NOBANIS). NOBANIS has developed a network of databases on alien and invasive species of northern and central Europe, accessible through a common internet portal. The database network is searchable by species, higher-order taxa or ecological assemblages, ecosystem types and political jurisdictions. Genera, species or subspecies are classified as *invasive*, *potentially invasive*, *not invasive*, or *not known* for each jurisdiction in which they are reported. Participating jurisdictions are Denmark, Estonia, Finland, the Faroe Islands, Germany, Greenland, Iceland, Latvia, Lithuania, Norway, Poland, Sweden and the European part of Russia. In many cases, the pathways, or potential pathways, of entry into and spread within each jurisdiction, are characterized in terms of broad pathways categories such as forestry or the aquarium trade. For the purposes of this project, all invasive and potentially invasive taxa of Finland, the Faroe Islands, Greenland, Iceland, Norway, Sweden and Russia were reviewed, with the exception of the angiosperms. Time constraints prevented a complete review of the hundreds, if not thousands, of entries on flowering plants contained in the network databases.

A number of other sources were used to supplement the information available through the NOBANIS internet portal. The most significant of these are annotated lists and databases available from particular Nordic countries, Russia and EPPO. EPPO has published the *Plant Quarantine Data Retrieval System* (2007), a downloadable database accessible on the internet, which contains information on invasive plants, invertebrate pests of plants and plant pathogens. For many taxa, it has general information on pathways of entry and spread, especially plant commodities in international trade by means of which pests are transported. The Norwegian Biodiversity Information Center has published the *Norwegian Black List: Ecological Risk Analysis of Alien Species* (2007), which includes as an appendix a comprehensive list of alien species in Norway. It also maintains an online database of invasive species, in Bokmål, with search categories similar to those of the NOBANIS database network. However, the Norwegian database can also be searched by pathway. The Finnish Ministry of the Environment has published, in Suomeksi, a preliminary short-list of potentially invasive alien vascular plant species of Finland. The Zoological Institute of the Russian Academy of Science maintains, on the internet, the *Database of Aquatic Invasive Species of Europe - AquaInvader* (1998-2005). Dr. Maslykov of the academy's Institute of Geography, supplied a list of forest insects commonly displaced from one natural forest zone to another in northern Eurasia, published in Russian as part of his doctoral dissertation, *The Ecological and Geographical Features of Invasive and Introduced Species in the Territory of Russia* (2001).

Although significant progress was made towards identifying invasive plants and insects of northern Europe, Asia and Greenland, and their pathways of entry and spread, a number of information gaps remain. For instance, correspondence to botanists who are knowledgeable about invasive plants of Siberia has so far resulted in a single reply. Information might yet be forthcoming from these contacts; however, not in time for inclusion in this document.

1.1.4 Canadian Provinces, Territories and Alaska

As was done in the case of Nordic Europe and Russia, listed and databased information on invasive species was sought from several sources in northern North America. Inquiries were made to the Conservation Data Centers of Alaska, the Yukon, British Columbia, Alberta, Saskatchewan and Manitoba. Provincial and territorial environmental and natural resources ministries were queried for the Northwest Territories, the Yukon, British Columbia and Alberta. Within the Northwest Territories, the Department of Transportation, the Department of Industry, Tourism and Investment, and the Mackenzie Land and Water Board were also questioned. A number of Canadian federal departments and agencies were contacted, including Agriculture and Agri-Food Canada, Environment Canada, the Canadian Food Inspection Agency, the Canadian Forest Service, Fisheries and Oceans Canada, Indian and Northern Affairs and the Parks Canada Agency. In addition, information was solicited from the United States National Parks Service and the United States Forest Service offices in Alaska. Many of the United States Forest Service personnel contacted for this project are also affiliated with the University of Alaska at Fairbanks.

Two main sources of North American invasive species information were used for the purposes of this report. The NatureServe Canada network of Conservation Data Centers supplied a comprehensive annotated list of alien vascular plant species in the Northwest Territories and adjacent jurisdictions. Through the Canadian Forest Service of Natural Resources Canada, the Canadian Council of Forest Ministers has published an internet portal, the *National Forest Information System* (2007), providing access to Canadian data relevant to the sustainable management of forests. This includes access to databases containing information on the occurrence of forest pests in Canada. Using the online application, the Forest Service database can only be searched by species. However, the Atlantic Forestry Center, Forest Health and Biodiversity Section, queried the database by region to generate lists of insect pest species for which there are records in the Northwest Territories and adjacent jurisdictions. All such species recorded from within the Territories, and within five hundred kilometers of its boundaries, are included in the results summary tables of Appendix C. Time constraints prevented all species from being recorded in the tables with annotations. However, Appendix D contains the complete list for each jurisdiction.

A number of other sources were used to supplement the information available through the NatureServe Canada network and the Canadian Forest Service *National Forest Information System*. Those that were relied upon the most are published species lists, either of invasive or pest taxa recorded from jurisdictions of northern Canada, or from Alaska, or of forest pest insect species not known to be present in Canada but determined to be a potential threat to the country's forest resources. Michael Oldham's *Survey of Exotic Plants along Northwest Territories Highways* (2007) added a number of recently reported plant taxa to those recorded for the Northwest Territories. Dr. Suzanne Carrière's *Alien or Introduced Plants in the Northwest Territories with Notes on Invasiveness* (2006) supplied information on the distribution of plant species within the Territories. The British Columbia North East Invasive Plant Committee *Plan and Profile* (2006) provided useful information on which species in that province pose the most immediate threat to the Northwest Territories. The Alaska Natural Heritage Program's *Non-native Plants of Alaska* (2006) lists most alien plants known from the state. With respect to invasive alien insects, the Canadian Forest Service and Canadian Food Inspection Agency's list, published online as *Forest Invasive Alien Species* (2007), identified many taxa that could be a concern to the Northwest Territories, as did the Canadian Food Inspection Agency's *Exotic Forest Pest Guidebook* (2006).

Some data sources could not be accessed for the purposes of the project. One of these is the Canadian Forest Service Northern Forestry Centre's *Northern Forestry Research Collection* (NFRC), located in Edmonton, Alberta. It contains insect specimens collected by forestry personnel from the Prairie Provinces and the Northwest Territories over the last sixty years. However, it has not yet been digitized for inclusion in the *National Forest Information System*.

1.2 Questionnaire

The questionnaire was developed with the intent of ensuring methodological compatibility with the pathways analysis protocol published by the United States Aquatic Nuisance Species Task Force and National Invasive Species Council Prevention Committee Pathways Work Team. The American protocol is published as the *Training and Implementation Guide for Pathway Definition, Risk Analysis and Risk Prioritization* (2006). It has been adopted as the basis for the development of a North American pathways analysis standard by the North American Plant Protection Organization. Moreover, based on international consultations with several regional and national plant protection organizations, it appears to be the most comprehensive protocol for pathways analysis currently available.

There are three main parts to the questionnaire. The first part, "Ways Alien Species Arrive," requires respondents to classify the pathway, or pathways, about which they can offer information. The second part, "Risk Assessment of Pathways," is divided into three sections: (A) "Characteristics of Pathways," (B) "Pathway Impact Scope" and (C) "Risk Level of a Pathway." In part three, "General Comments," the respondent is asked to give recommendations on the kind of information and assistance that would be desirable to address to problem of invasive species in the Northwest Territories.

The risk assessment of pathways is discussed in Section 1.2.2, and recommendations for future action are addressed in Section 3. The approach to pathways classification taken in the questionnaire is summarized in Section 1.2.1.

1.2.1 Pathways Classification

Briefly stated, the questionnaire employs the same hierarchy of pathway categories used to organize information collected from the literature review component of the project. These categories were adapted from the *Training and Implementation Guide for Pathway Definition, Risk Analysis and Risk Prioritization*. The process of adaptation was intended to better delineate some of the categories and ensure their mutual exclusivity, to ensure consistency with the categories used for the purposes of the literature review, and to include means of transporting invasive species not identified in the *Training and Implementation Guide*.

As explained above, there are three levels to the pathways hierarchy. The first level is divided into pathways by means of which plants and insects are intentionally introduced into, or transported within, a jurisdiction, and those by means of which this occurs unintentionally. The second level of the hierarchy consists of four subsidiary categories: two under intentional pathways of introduction and spread, and four under unintentional. Intentional introductions and spread are either by means of human transportation or the shipping of living goods. Unintentional introductions and spread might occur as a result of human transportation, shipping of living goods and non-living organic goods, shipping of non-living goods, shipping conveyances and services, or natural spread. The third level of pathways categories is the most detailed. Level three categories of intentional introduction and spread include the purchase of plants and insects from retailers, travel or relocation with house and garden plants, the transport of plants or plant parts for agriculture, landscaping or remediation, and the trade in insects as biocontrols in agriculture. Level three categories of unintentional introduction and spread are too numerous to list here. Some examples are recreational boat travel, cargo flights, the movement of float planes and the movement of barges for shipping goods.

Additional information on the hierarchy of pathways categories can be found in the questionnaire, which is included in this report as Appendix A. There a complete list of level three categories can be found, along with more detailed explanations of higher pathways categories.

1.2.2 Risk Assessment of Pathways

The part of the questionnaire addressing risk assessment consists of three sections. In the first section, "Characteristics of Pathways," the respondent is asked to give a detailed description of the pathway, or

pathways, about which information is available. The second section, "Pathway Impact Scope," requires the respondent to characterize the potential magnitude of harmful impacts resulting from the pathway in terms of the ecological and political regions it might affect. In the last section, "Risk Level of a Pathway," respondents are presented with several questions concerning the level of risk that can be attributed to a pathway.

Under "Characteristics of Pathways," the respondent is required to identify a number of pathway properties that might contribute to, or impede, the transport of invasive species. The pathway's starting point, intermediate points and end points must be defined. Definitions are to include descriptions of all physical, geographical, ecological and any other characteristics relevant to the potential for invasive species to be transported by the pathway. For instance, a description might be: "Garden plants potted in soil, cultivated in outdoor plots at Calgary, Alberta, starting at a loading dock in Calgary where plants are shipped in wooden crates by a wholesaler, are then trucked to Yellowknife by the Mackenzie Highway, where crates are off-loaded by retailers, wood packing material is retained and both soil and plants are sold without implementation of phytosanitary measures." Respondents are also asked to identify all harmful insects and plants that should be considered as part of the pathway analysis. These are to be listed along with, if known, the pest or weed status of the species and information on their distribution in the Northwest Territories and other northern North American jurisdictions. The final part of the pathways definition is to provide information on official control procedures and treatment protocols, such as inspection or fumigation, which are in place to detect and eliminate harmful plants and insects.

In the section entitled "Pathways Impact Scope" it is assumed that, in most case, the more extensive a pathway is, in terms of distance and regions covered, the greater the magnitude of impacts the pathway will have. Hence, in this part of the questionnaire, the respondent is asked to assess how many regions – both ecozones and land claim settlement regions - are affected by the pathway under consideration. The ecozones referred to in this part are the Northern Arctic, the Southern Arctic, the Taiga Cordillera, the Taiga Plains, the Taiga Shield, the Boreal Cordillera and Boreal Plains. The land claim settlement regions include the Inuvialuit Settlement Region, the Gwich'in Settlement Area, the Sahtu Settlement Area, the Dehcho Region, the Tlicho/North Slave Region and the South Slave Region. These are mapped in Appendix E.

The last section of the risk assessment, "Risk Level of a Pathway," includes several detailed questions to elicit from the respondent information relevant to characterizing the risk associated with the pathway. The questions are intended to address such issues as the probability of entry of the species associated with a pathway into regions of the Northwest Territories, the probability of their establishment, the history of invasiveness of these species, available mitigation methods and impacts. Hence, respondents are asked to assign a level of risk to characterize the probability of a pathway transmitting alien species on a frequent basis, and in large numbers, of its providing an environment in which organisms of such species can remain viable and of these organisms being introduced at multiple entry points into ecosystems where they are capable of survival. For each question, respondents are asked to characterize risk by assigning a number between 0, indicating no risk, and 5, indicating an extremely high level of risk. If there is uncertainty associated with the assigned level of risk, it can also be ranked from 1 to 5, representing the range from slightly uncertain to highly uncertain. The basis of uncertainty can also be identified. The respondent can select lack of expertise, biological unknowns or insufficient information, or define any other basis that is applicable.

1.2.3 Delivery

Two means of delivery were employed to distribute the questionnaire. Email correspondence was relied upon to reach a large number of potential respondents in jurisdictions across western and northern Canada, and Alaska. Arrangements were made to contact those recipients by telephone who expressed a preference for this means of communication.

Recipients of the questionnaire can be divided into five professional or employment categories: government employee, representative of a non-profit organization, academic, environmental consultant

and industry representative. Approximately 70% of recipients belong to the first category, 12% to the second and 6% to each of the other three.

Nearly a 120 government employees were asked to complete the questionnaire. It was distributed to the Conservation Data Centers of Alaska, the Yukon, British Columbia, Alberta, Saskatchewan and Manitoba. Biologists in provincial and Territorial environmental and natural resources ministries of the Northwest Territories, the Yukon, British Columbia and Alberta were also included on the distribution list. Government of Northwest Territories employees with knowledge of Territorial industries and environmental regulations were contacted to give information from the perspectives of the Department of Transportation, the Department of Industry, Tourism and Investment, and the Mackenzie Land and Water Board. In addition, a selection of City of Yellowknife staff was distributed the questionnaire. Federal employees with relevant expertise, or experience in the Northwest Territories, were contacted in Agriculture and Agri-Food Canada, Environment Canada, the Canadian Forest Service, Fisheries and Oceans Canada, Indian and Northern Affairs and the Parks Canada Agency. Staff at the United States National Parks Service and the United States Forest Service offices in Alaska also received questionnaires to complete. Amongst Northwest Territories First Nations, representatives of the Dene, Gwitch'in and Sahtu were all distributed questionnaires.

With respect to non-government organizations and industries, representatives of which were delivered questionnaires, the distribution is more or less as follows. Ten academic staff, eight environmental consultants and twenty representatives of non-profit organizations received questionnaires. Five representatives of the horticulture industry, two of the mining industry, three of the gas industry and one of the tourism industry were likewise contacted.

In total, the questionnaire was distributed to approximately a 170 recipients.

Section 2: Results and Analysis

2.1 Insects and Plants that Threaten the Northwest Territories

A pathways analysis was undertaken for the Northwest Territories because Recommendation 6.1 of the *Northwest Territories Biodiversity Action Plan Report Two* prescribes that an ecosystem-based approach be employed to evaluate the risk of invasive plants and insects to the Territories. While this approach is, of course, strongly supported by basic scientific principles of ecology, its implementation is not without its difficulties. In particular, with respect to problems of ecosystem management involving either ecosystems that are maintained by anthropogenic influences or anthropogenic impacts on natural ecosystems, information from multiple disciplines is necessary to assess the problems and discover solutions.

For the purposes of this project, the use of a questionnaire, delivered individually to representatives of government, industry and other organizations that have the capacity to contribute to potential solutions, proved insufficient to overcome this difficulty. On the one hand, questionnaire respondents representing industry were, understandably, often unable to identify pest taxa to the species rank or, in the case of insects, below the taxonomic rank order. Furthermore, these respondents were likewise unable to assess the potential of organisms to remain viable during transport or following their release into Northwest Territories ecosystems. On the other hand, respondents in professional biological positions often avowed inadequate knowledge to provide a pathways definition and estimate risk levels, preferring therefore to take a taxon-based approach in their reply to the questionnaire. In other words, either lists of potentially harmful or invasive taxa were compiled, or project team members were advised to consult published lists known to the respondents.

Although this outcome did not allow the project team to undertake a pathways risk analysis at the level of detail initially envisioned for the project, it nonetheless contributed to the fulfillment of the team's task to collect information about alien species that are being imported into the Territories, intentionally or unintentionally. Of course, lists of taxa do not offer a model of the ecosystemic interrelations of organisms within pathways or endpoint ecosystems, which an ecosystem-based approach demands. Nonetheless, the available lists, whether published as lists or generated by online database searches, supply information that is necessary, if not sufficient, for constructing ecosystemic models. Furthermore, a number of these lists are annotated with general information about pathways of entry and spread, the trophic guild to which members of a taxon belong and the ecosystems of which they are components. Hence, with this information, it has been possible to correlate some taxa, in addition to trophic guilds of organisms and organisms that are characteristic of particular ecotypes, with pathways categories.

2.1.1 Plant and Plant-like Taxa

For the purpose of this report, the term "plant" has been interpreted relatively broadly to denote the entire plant kingdom (*Primoplantae*), not merely the land plants (embryophytes). The plant kingdom is understood to include the green plants (viridophytes), red algae and bluish-green algae (glaucophytes). No taxa of bluish-green algae were identified as potentially invasive in any information sources referenced for this project. However, three species of red alga were identified as were numerous green plant taxa. Information has also been included on two species of brown alga. This is because the macroscopic members of this division have traditionally been regarded as members of the plant kingdom, and the two species in question appear to be a potentially significant concern for the Northwest Territories. Amongst the green plants, mosses and green algae have been included in addition to vascular species. All plant taxa listed from available literature sources are named in the first and second spreadsheets of the results summary tables in Appendix C.

Based on the literature review, consultations with experts and questionnaire results, almost 900 plant taxa were identified as potential invasive threats to the Northwest Territories. These include three subspecies of a green alga species, *Codium fragile* (Sur.) Hariot, two mosses, two ferns (monilophytes), eight conifers (coniferophytes) and over 800 species of vascular plants. The vascular plants consist of almost

170 monocotyledons and just over 700 dicotyledons. Seventy five percent of the monocotyledons identified during the project belong to the family of grasses (*Poaceae*). Amongst the dicotyledons, the composites (*Asteraceae*) have the greatest representation at 127 species. Other families showing significant numbers of species are the mustard family (*Brassicaceae*) with 71 species, the legume family (*Fabaceae*) with 57 species, the pink family (*Caryophyllaceae*) with 49 species and the rose family (*Rosaceae*) with 39 species. Both the mint (*Lamiaceae*) and goosefoot families (*Chenopodiaceae*) are represented by 30 species, the smartweed family (*Polygonaceae*) by 29 species, the figwort family (*Scrophulariaceae*) by 28 species and the forget-me-not family (*Boraginaceae*) by 26 species.

Insufficient information was available to determine whether most of these potentially invasive plants are characteristic of particular natural ecotypes represented in the Northwest Territories. However, approximately 60% are referenced in at least one literature source as a weed, or more specifically, as an agricultural weed. Hence, plants belonging to most, if not all, of these taxa are likely ruderals that can be expected to establish in areas of anthropogenic disturbance.

As stated in Section 1, the risk posed by some of the taxa identified as potentially invasive in the Northwest Territories, might be determined to be negligible as a result of more in-depth investigation. It was beyond the scope of this project to undertake climate or ecological niche modelling to predict the establishment and spread potential of the listed taxa. Hence, in many cases, the plant taxa listed in Appendix C should be regarded as candidate invasive species to be taken into account during future efforts to assess the risk level of particular pathways.

2.1.2 Insect and other Arthropod Taxa

Insect orders found to contain species that are potentially invasive in the Northwest Territories include the beetles (*Coleoptera*), true bugs (*Hemiptera*), sawflies and woodwasps (*Hymenoptera*), and butterflies and moths (*Lepidoptera*). A single midge species, the European pineneedle midge (*Contarinia baeri* (Prell)), and the greenhouse thrip (*Heliothrips haemorrhoidalis* Bouché*)* are also named on the list of insects in Appendix C*.* Information is provided in this appendix on a small number of other arthropod taxa, which could potentially pose a risk to the Northwest Territories. These include three species of arachnid and ten crustaceans.

The thirteen non-insect arthropod taxa, named on the fourth spreadsheet of the results summary table in Appendix C, represent 11 families in four different taxonomic classes. The three arachnids include two spider mite species (*Tetranychus*) and the honey bee mite (*Varroa destructor* Anderson and Trueman). The crustaceans include two branchiopods, six malacostracans and two maxillopods. The branchiopods are both species of water flea or cladoceran (*Cercopagis pengoi* Ostroumov and *Cornigerius maeoticus maeoticus* Pengo). The two maxillopods are the acorn barnacle (*Eliminius modestus* Darwin) and a copepod (*Acartia tonsa* Dana). The malacostracans include a range of taxa: two amphipods (*Gammaridae*), two fairy shrimps (*Mysidae*), the signal crayfish (*Pacifastacus leniusculus* Dana) and Chinese mitten crab (*Eriocheir sinensis* H. Milne Edwards).

Over a 100 insect taxa were identified as potential invasive threats to the Northwest Territories. Approximately 45% of these are beetle species. Nearly 20% are butterflies or moths, and almost as many are true bugs. Approximately 14% are sawflies or woodwasps. Amongst the beetles, the families with the greatest representation are the longhorn beetles (*Cerambycidae*) and bark beetles (*Curculionidae*). The greatest number of moths is given by the families of lappets (*Lasiocampidae*) and totrix moths (*Tortricidae*). The majority of true bugs are adelgids (*Adelgidae*) and aphids (*Aphididae*).

Four different trophic guilds are represented by the insects. Most taxa named in the results summary table are phytophagous, feeding on plant hosts. In fact, this guild accounts for over 90% of the listed insect taxa. Only seven species are predaceous, four are fungivorous and two are saprophagous.

Over 70% of the insects identified as potentially invasive in the Northwest Territories are species of forests and woodlands. Only about 1% of the species are characteristic of agricultural ecosystems, including gardens and greenhouses.

As stated above in reference to plant taxa, some of the arthropod taxa identified as potentially invasive species in the Northwest Territories might be determined by more in-depth investigation to pose a negligible risk of harm. It should also be mentioned that a number of questionnaire respondents emphasized that baseline information on the presence and distribution of arthropod taxa is largely lacking for the Northwest Territories. Therefore, some of the taxa listed as invasive pests in natural ecosystems, or potential pests of such ecosystems, might not in fact be *alien* invasive species of the Territories.

2.2 Pathways of Introduction and Spread

Both the questionnaire and the literature review undertaken for this project supplied information on the pathways, and potential pathways, by means of which invasive alien species enter and spread within the Northwest Territories. Information was collected about alien species that are, or might be, imported into the Territories, intentionally and unintentionally, and the activities of industry, government and Northwest Territories communities that may contribute to their spread.

Based on the results of the project, it is difficult to say whether intentional or unintentional means of entry and spread are more significant. The literature review gives a *prima facie* indication that unintentional introductions are a greater problem, at least to the extend that the number of taxa known to be transported unintentionally is greater than the number known to be intentionally brought into the Northwest Territories or other northern jurisdictions. However, within the timeframe of the project, only about 12% of plant taxa recorded from the literature could be associated with a pathway category, or categories. With respect to insect taxa, the greater magnitude of unintentional introductions is more certain. Although the pathway category applicable to approximately 60% of these taxa is given as *unknown*, it can be inferred that forest pest insects, for example, are likely transported unintentionally by means of forestry products such as lumber, or woody plants sold in the horticultural trade. If such inferences are justified, it follows that all insect taxa identified during the project are, or are potentially, unintentional introductions. The questionnaire results suggest that respondents perceive unintentional pathways of entry and spread to be more numerous than intentional pathways. However, this perception cannot be readily interpreted as a measure of relative harm since, among other things, most pathways categories, and pathways descriptions, given by respondents do not include lists of potentially harmful taxa that can be compared with lists given for other pathways descriptions and categories.

Within the respective categories of *intentional* and *unintentional*, the literature review and the questionnaire results, taken together or independently, allow for some preliminary conclusions about which level three pathways categories appear to pose the most significant risk to the Northwest Territories. In this section, those pathway categories are discussed and, wherever possible, the taxa and trophic guilds of organisms found to be associated with particular pathway categories are identified.

2.2.1 Intentional Pathways

The second level two pathway category identified in the questionnaire, belonging to the category of pathways of intentional introductions, is the *shipping of living goods*. Shipping of living goods includes commercial transportation of plants for planting, seed that has not been devitalized, food goods of which viable propagules are an integral part of the product (for example, fresh fruit containing seeds), and trades in bait and insects for use in agriculture (for example, pollinators and bio-controls). From amongst these level two categories, both the literature review and questionnaire results indicate that the shipping of live plants appears to be the greatest concern for the Northwest Territories. In particular, the import of plants and plant propagules, either for remediation at construction and resource extraction sites, or for landscaping and gardening, was identified as the pathway category most likely to pose a risk. For instance, 77% of questionnaire responses concerning intentional introductions identified this pathway category. The non-commercial exchange of plant material for gardening is also believed by questionnaire respondents to be an important additional pathway that contributes to the impacts of the horticulture and landscaping trades.

Remediation at Construction and Resource Extraction Sites: Most questionnaire respondents indicated that plant taxa imported for the nursery and landscape trade, and for remediation projects, are a concern. Species and cultivars of plants used for remediation raised particular concern amongst several questionnaire respondents. Such taxa and cultivars are intentionally released into the environment for the purpose of seeding unstable slopes after construction projects, to reduce the impacts of ice roads, to prepare mine tailings for future vegetative growth, and to maintain cleared pipeline right-of-ways from succeeding to shrubby vegetation communities. The characteristics that make these species and cultivars attractive for remediation are characteristics often found in invasive plants; i.e. they are typically ruderals, readily establishing in disturbed ecosystems. Some examples are smooth brome (*Bromus inermis* Leyss.) and reed canary grass (*Phalaris arundinacea* L.). Even in cases of plant species that are native to the Territories, introduced and cultivated genotypes are a concern. In some cases, seed mixes consisting of cultivars of northern species are imported into the Territories for remediation projects. In other cases, remediation efforts with native species have used seed sources from disjunct wild populations, typically south of sixty degrees latitude, increasing the risk of genetic contamination of naturally established populations.

Horticulture and Landscaping: In the last 10 to 15 years, the greenhouse industry has grown by 400 to 600% in the Northwest Territories. There are presently nine commercial greenhouses in the Territories: four in Yellowknife, three in Hay River, one in Norman Wells and a community garden in Inuvik. Plants can also be purchased through large retail companies such as Walmart and Canadian Tire. These are mostly annuals sold for outdoor home gardens, and are typically the same cultivars sold in southern Canada as wildflowers. Wildflower seed mixes often contain problematic species, which are not in fact native North American plants, such as toadflax (*Linaria vulgaris* Mill.) and oxeye daisy (*Leucanthemum vulgare* Lam.). Trees and shrubs are also sold and some have become invasive; for example, Siberian peashrub (*Caragana arborescens* Lam.). Bedding plants are mostly imported from north and central Alberta. They are largely sold in the vicinity of Yellowknife, Hay River and Fort Smith, the latter being supplied by hardware and grocery stores. However, real estate development is taking place as far north as Inuvik, which may expand the market in that region. These plants are further spread within the Northwest Territories by people picking and transplanting from adventive populations or giving plants to others for their gardens.

2.2.2 Unintentional Pathways

As stated above, there are four level two pathway categories belonging to the category of pathways of unintentional introduction and spread. These level two categories are *human transportation*, *shipping of living goods and non-living organic goods*, *shipping of non-living goods*, *shipping conveyances and services*, and *natural spread*. The literature review and questionnaire identify the *shipping of living goods and non-living organic goods* as a potential source of invasive alien insect taxa being imported into the Northwest Territories. The import of plants and plant propagules, primarily for landscaping and gardening, is perceived as the most significant level three pathway category that might unintentionally introduce problematic insect pests. With respect to plant taxa, the *shipping of non-living goods*, *shipping conveyances and services* is considered an important pathway category. In particular, vehicles used by resource extraction industries to bring equipment into the Territories, and the mere existence of transportation corridors and infrastructure right-of-ways, were identified by both the questionnaire respondents and the literature review sources. Human transportation, i.e. personal travel in road vehicles from outside the Territories, was likewise implicated. Questionnaire respondents added maritime ships, barges and other boats for shipping goods as having potential to become a significant pathway category to the Northwest Territories, and recreational boating as a prevalent means of spreading plant material within the Territories. The results of the questionnaire also indicate that one level three category of *shipping of living goods* might be important with respect to the introduction and spread of invasive plants, namely, dog sledding.

Resource Extraction Industries: Activities of these industries raise concerns about the transport of plants and insects locally, within the Territories, and globally from other continents. The gas industry is said to transport drilling rigs and caissons from almost anywhere in the world. Although, most equipment is likely

transferred from the west coast of North America, it was claimed that equipment formerly used in Asia or the south Pacific is used the Beaufort Sea. Drills and equipment for use in the northern Alberta Tar Sands Project are shipped from Asia across the Pacific Ocean to the Mackenzie Delta and floated down the Mackenzie River on barges to be put together on site. Exploration activities confined to the Northwest Territories are likewise believed to pose a risk, having the potential to bring propagules into remote natural areas. The movement of heavy equipment for mining, and vehicles for geophysical exploration and scientific research, has a high probability of transporting propagules amongst ecozones. Endpoints of such vehicle movements are localities within the Mackenzie Delta. Intermediate points are Inuvik and Tuktoyaktuk. Exploration roads cause extensive disturbance to soils, allowing invasive species to establish and associated re-seeding efforts may introduce invasive plant species as contaminants of seed. There is also inter-provincial truck traffic associated with diamond mines. This is mostly from Alberta, bringing fuel, freight and equipment throughout the winter months. Travel is mostly by means of highways, not on dirt roads or off-road. The main endpoints are Hay River and Yellowknife. The Liard Highway provides an inter-provincial link from British Columbia to the Northwest Territories, but is very lightly used.

Road Maintenance Vehicles: The unintentional introduction of plants has occurred on heavy equipment used to keep the highway right-of-ways clear. Many weedy and invasive plant species are spreading along Northwest Territory roadsides, likely due to road maintenance activities that spread propagules. Probably the most significant problem species is white sweet clover (*Melilotus albus* Medik.). In the Yukon, this species has spread from roadsides to become very aggressive along river banks where it changes vegetation structure, increases fire frequency and intensity, and seems to eliminate passerine habitat.

Cars, Trucks and other Road Vehicles: Plant propagules in soil adhering to trucks and equipment, driven from Alberta or British Columbia to the Northwest Territories, is believed to be a potential means of introducing and spreading plants. This is supported by the fact that many plant taxa have been initially discovered in the Territories along roadsides. There is tourist traffic on the Dempster Highway ending at Inuvik. Tourists also drive from Alberta to Yellowknife.

Boats and Boating Accessories: Nothing specific is known about organisms transported on boats and boat trailers. Tourists do bring boats to the Territories for fishing, but there is uncertainty about how common this practice is. Some questionnaire respondents believe it is uncommon; others stated the opposite, asserting that tourists bring boats and trailers to Great Slave Lake for sport fishing from British Columbia, Alberta, Saskatchewan, and even Oregon and Montana. Recreational boat use is common and far-reaching by local people. Thus, this could be a significant pathway of further spreading species that are already present in the Northwest Territories.

Dog Sledding: Large numbers of sled dogs come into the Northwest Territories for races from all over North America, and Northwest Territories residents take dogs to Europe for alpine sledding events. Research undertaken by the United States Department of Agriculture, Agricultural Research Service, in Alaska has shown that a significant number of weed seeds are present in straw air-dropped along sled dog routes to be used as bedding for the dogs.

Horticulture and Landscaping: It is not merely the plant products sold in the nursery and landscaping trade that can be problematic. Nursery and greenhouse stock has been found to contain propagules of weedy alien invasive species including, for example, Canada thistle (*Cirsium arvense* (L.) Scop.), sowthistle (*Sonchus* spp.) and knapweed (*Centaurea* spp.). The horticulture and landscape trade can also be a pathway for insect pests. Most nursery stock trees imported into the Northwest Territories are typically from Alberta. Spruce (*Picea* spp.) and birch (*Betula* spp.) are the most common. It is widely believed that birch leafminer (*Profenusa thomsoni* (Konow)) was introduced to Yellowknife and Hay River this way.

2.2.3 Pathways Risk Levels

As explained in Section 2.1, in many cases, the method of delivery of the questionnaire was not conducive to supporting judgements, based on interdisciplinary communication, necessary to answer many of the questions. Although questionnaire respondents supplied a great deal of valuable information in other formats, only 15 questionnaires were returned and only three questionnaire respondents completed the last section, "Risk Level of a Pathway." Accordingly, no meaningful assignment of risk levels to different pathways affecting the Northwest Territories can be given in this report. Instead of delivering the questionnaire individually to representatives of government, industry and other organizations, a better model might be to conduct workshops that bring together representatives of various disciplines to engage the questions.

Section 3: Discussion and Recommendations

Based on questionnaire results, the literature review, and expert knowledge, the project team was asked to identify what tools are available in the Northwest Territories, and what tools are not yet available, but should be provided to prevent the entry or spread of invasive alien plants and insects. Many questionnaire respondents supplied valuable recommendations, which have been combined in this section with information on prevention from the literature.

Data Collection:

Additional information sources that could not be reviewed during the timeframe of this project should be accessed. For instance, the search of angiosperm species by means of the NOBANIS database portal should be completed and information should be sought on invasive plants of Siberia from other sources. The insect pest data available from the Canadian Forest Service *Northern Forestry Research Collection* (NFRC) should be acquired, if possible. Forest pest insect records will be made available through the NFIS database portal at a future date. Other insect pests must be identified by means of a search of the collection in Edmonton, Alberta.

There is a need to collect data relating to particular pathways that are believed to pose the greatest risks. While industry and government representatives can identify pathways that *potentially* facilitate the introduction and spread of invasive species, there is a lack of empirical research necessary to confirm that this potential is realized, and to characterize the magnitude of the risk arising from particular pathways and pathways categories. For example, there has been no effort to monitor and quantify the unintended propagule load of various types of equipment (fire-fighting equipment, seismic vehicles or helicopters) that are regularly moved around the Territories and deployed in remote areas.

Similarly, very few people are doing any detailed vegetation work in the Northwest Territories making it difficult to determine which alien species, already established in the Territories, show indications of becoming invasive. It would be beneficial to maintain an agricultural station in the north to research plants that could invade the arctic.

Baseline data on most of the taxonomic orders of insects that appear to pose the greatest risk to Territories ecosystems needs to be acquired through field surveys. Although some research has been done on butterflies, this does not appear to be the case with beetles, sawflies or aphids.

Risk Assessment:

A screening level risk assessment procedure should be developed and applied to the plant and insect taxa named in the tables of Appendix C. This would allow the government of the Northwest Territories to determine if the risk posed by some of these taxa is in fact negligible, and to establish priorities for addressing the remaining taxa.

More in-depth comparisons should be undertaken of the most significant pathways categories that relate to both the Northwest Territories and to Nordic countries or Russia. Amongst Eurasian jurisdictions, perhaps the greatest attention should be paid to Siberia given its climatic similarities to the Northwest Territories.

The last section of the risk assessment protocol developed for this project, “Risk Level of a Pathway,” should be completed by means of workshops, with the various disciplines that can contribute information represented. This would allow a better exchange of information between those having different areas of expertise, and more informed judgements about the potential risks of particular pathways and pathway categories. It would also allow for a more detailed examination of different modes of entry and spread within given pathways categories, which some government departments have said would be desirable.

Consultation and Communication:

There is a wide range of initiatives that can be undertaken to raise awareness of invasive species in the Northwest Territories, and engage industry, other government departments and citizens.

The profile of the invasive species issue could be raised in the North through a number of different outreach initiatives. For example, a government of the Northwest Territories invasive alien species website could provide information to citizens about the most problematic species. Other jurisdictions in Canada and the United States have produced fact sheets, invasive species field guides and, through partnerships with non-profit organizations, maintain invasive species telephone information lines.

The Northwest Territories could benefit by the establishment of an Invasive Plants Council, similar to the Alberta Invasive Plants Council and the Invasive Plants Council of British Columbia. Collaboration and information exchange with these councils, and the North East Invasive Plants Council of British Columbia is recommended.

With respect to insects, partnerships with the Canadian Forest Service and the Russian Academy of Science are recommended. Data sharing agreements and joint research projects would benefit the Northwest Territories and these potential partners.

Public campaigns were proposed by some questionnaire respondents. For instance, the Northwest Territories might initiate a campaign targeting citizens and tourists alike, asking them to clean vehicles of soil before entering pristine areas. Because there are relatively few roadway entry points, the Territories could feasibly erect voluntary vehicle cleaning stations at these locations. A similar clean machinery program directed at the mining and gas industries was also recommended. Significantly, the island of Newfoundland has mandatory inspection and cleaning of vehicles leaving the province.

Most early detection and control measures in Alaska are currently implemented by local cooperative weed management citizen's groups, who organize community weed pulls. A similar program could be initiated in the more populated localities of the Territories.

Policy and Practice:

Based on questionnaire results, a few areas were identified for improvement in best management practices and inspection.

For example, with respect to remediation efforts by seeding, it was recommended that mechanical means of stabilization be identified as a best management practice. If seeding is necessary, local collection of seed and plants should be undertaken for these efforts. Questionnaire respondents expressed the need for operational information, i.e. instructions, concerning methods of locally collecting seeds and plants, appropriate species mixes, propagation techniques and so on.

Regarding the importation of vehicles and equipment, improved resources are needed to undertake inspections in view of the large volume of traffic in this area. In 2007, 9-10,000 pieces of equipment were transported to the Northwest Territories.

Although some questionnaire respondents felt that improved awareness within government and industry is more important that policy development, others thought that an analysis of legislation and regulations would be beneficial to determine if there are regulatory needs.

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Appendix A – Questionnaire

Appendix B – Table of Respondents

Appendix C – Results Summary Tables

Appendix D – Canadian Forest Service, National Forest Information System

(map developed by Kevin Porter and Ian DeMerchant, Forest Invasive Alien Species Database and Document Library, Atlantic Forestry Centre, Canadian Forest Service, Fredericton, New Brunswick)

Appendix E – Northwest Territories Ecozones and Land Claim Settlement Regions

QUESTIONNAIRE:
HOW ALIEN SPECIES ARRIVE AND SPREAD
IN THE NORTHWEST TERRITORIES

This questionnaire is being conducted for the government of Northwest Territories, Department of Environment and Natural Resources. It is intended to collect information about how alien or exotic plants and insects enter into and spread within the Northwest Territories. The Department of Environment and Natural Resources is collecting this information to assist in developing constructive ways that communities and industry can prosper while protecting the natural resources of the territories from harmful pest insects and weedy plants. This is your first opportunity to point out problems that you have noticed and suggest solutions to this growing challenge for the north.

All your answers are confidential to the Department of Environment and Natural Resources and the contractor, NatureServe Canada. Results of this questionnaire will be summarized to draw general conclusions about how plants and insects arrive in the Northwest Territories.

There are three sections to this questionnaire: 1) Ways Alien Species Arrive; 2) Risk Assessment of Pathways; and 3) General Comments. Section One has four questions, while Section Two is divided into three parts: A) Characteristics of Pathways (5 questions); B) Pathway Impact Scope (3 questions); and C) Risk Level of a Pathway (15 questions). Section Three provides an opportunity for additional comments.

To begin with, I would like to ask for some information about you:

Personal Information	**Date:**
Name:	
Organization, government department, industry or community:	
Position title (if any):	
Duration of employment or northern community involvement:	
Reason for interest in alien species :	
Knowledge of alien insects, plants or both:	
Knowledge of what ways alien species arrive and spread:	

Section 1: Ways Alien Species Arrive

In this section I will ask you about the kinds of activities by government departments, industries or communities about which you can offer information. I have prepared questions, but if at any time you want to provide more information without following the prepared format, please do so. Also, don't hesitate to interrupt at any time if you need to ask about the intent of the questions. The questionnaire can take between thirty and forty minutes.

Question 1: Are you able to give me information on intentional introductions, unintentional introductions or both? (*Explanation: Suppose you have information about the importation of plants for example. A plant is introduced intentionally if it is imported into the Northwest Territories to plant in gardens, for instance, or for remediation. It is introduced unintentionally if it is imported as a seed contaminant of soil or grains being transported to the Northwest Territories, or spreads from plantings from one region to another.)*

Level 1 Classes			**Comments**
Intentional		→ Question 2a	
Unintentional		→ Question 2b	
Both		→ Question 2a & 2b	

Question 2a: Are you able to give me information on (i) human transportation or (ii) shipping of living goods, as it relates to intentional introductions of alien species? (*Explanation: Human transportation includes means of transporting people, their personal possessions and pets, locally, nationally or internationally. Shipping of living goods includes commercial transportation of plants for planting, seed that has not been devitalized, food goods of which viable propagules are an integral part of the product (e.g. fresh fruit containing seeds) and trades in bait, pets and insects for use in agriculture (e.g. pollinators, bio-controls).)*

Level 2 Classes			**Comments**
Human Transportation		→ Question 3a	
Shipping of Living Goods		→ Question 3b	

Question 2b: Can you give me information on (i) human transportation, (ii) shipping of living goods and non-living organic goods which are unprocessed or minimally processed, or (iii) shipping of non-living goods, shipping conveyances and shipping services, as it relates unintentional introductions of alien species? (*Explanation: Human transportation includes means of transporting people, their personal possessions and pets, locally, nationally or internationally. Shipping of living goods and unprocessed or minimally processed organic goods includes commercial transportation of plants for planting (with associated soils), plants sold as fresh produce, grains and seeds, raw logs, and trades in bait, pets and working animals, livestock and other food animals, and minimally processed animal parts sold as food. Shipping of non-living goods includes all other commercial trade. Shipping conveyances includes vessels, vehicles, containers, roads and canals, used for transporting all kinds of goods (living and non-living). Shipping services includes, for example, transport of garbage, and water for firefighting. Natural spread includes spread by wind, natural watercourses and wildlife vectors.)*

Level 2 Classes			**Comments**
Human Transportation		→ Question 4a	
Shipping of Living Goods & Non-living Organic Goods		→ Question 4b	
Shipping of Non-living Goods, Shipping Conveyances & Shipping Services		→ Question 4c	
Natural Spread		→ Question 4d	

Question 3a: On which of the following can you give me information? (*Explanation: This question asks about plants and insects such as terrarium 'pets,' food for terrarium pets and house plants, which are transported with human beings as personal possessions.)*

Level 3 Classes		Comments
IT1 Purchase of plants or insects from retailers		
IT2 Travel or relocation with insect pets or plants		

Question 3b: On which of the following can you give me information? (*Explanation: This question asks about plants and insects transported in shipments as commercial goods, rather than as personal possessions.)*

Level 3 Classes		Comments
IL1 Plants for agriculture, nursery and landscape trades, and remediation (e.g. seeding of ice roads)		
IL2 Plants parts for agriculture, nursery and landscape trades, remediation (seeds, roots, etc.) (including mail/internet shipping)		
IL3 Plants and plant parts for sale as food		
IL4 Pet trade in insects (including mail/internet overnight shipping)		
IL5 Trade in insects for agriculture (e.g. bees, lady beetles as bio-controls)		

Question 4a: On which of the following can you give me information? (*Explanation: This question asks about plants and insects transported unintentionally with human beings travelling as tourists, relocating to the Northwest Territories or travelling within the territories for business or personal reasons.)*

Level 3 Classes		Comments
UT1 Passenger flights (including pests on passengers, baggage, pets, plants, consumables)		
UT2 Cruise ships and recreational boats (hull fouling, stowaways on board)		
UT3 Cars, buses, trucks, ATVs, snowmobiles, trailers for boats		
UT4 Train		
UT5 Hikers, horses, dog sleds		
UT6 Military travel (baggage, gear, equipment)		

Question 4b: On which of the following can you give me information? (*Explanation: This question asks about plants and insects transported unintentionally as contaminants in food shipments or in soil of living plants, or as pests on livestock and so on.)*

Level 3 Classes		Comments
UL1 Plants for agriculture, silviculture, nursery and landscape trades, and remediation (e.g. seeding of ice roads)		
UL2 Plants parts for agriculture, silviculture, nursery and landscape trades, remediation (seeds, roots, etc.) (including mail/internet shipping)		
UL3 Potting soil, growing media, sods and similar material		
UL4 Plants and plant parts for sale as food		
UL5 Animal parts for sale as food (unprocessed or minimally processed products)		

UL6 Living animals for sale as food (livestock, live seafood)		
UL7 Pet, terrarium and aquarium trade (including mail/internet overnight shipping)		
UL8 Non-pet, non-food live animal trade (horses, sled dogs, fur farms, including fodder and bedding material)		
UL9 Bait trade		

Question 4c: On which of the following can you give me information? (*Explanation: This question asks about plants and insects transported unintentionally as stowaways in holds or packaging, in ballast, on vessel surfaces, etc. of commercial shipments, but not associated specifically with living or unprocessed organic goods. It also includes pest plants and insects in shipping services such as garbage transportation, and those spread as a result of infrastructure to facilitate shipping such as roads and canals.)*

Level 3 Classes		**Comments**
UN1 Cargo flights		
UN2 Water planes for fire fighting		
UN3 Maritime ships, barges and other boats for shipping goods (ballast, hull fouling, stowaways on board)		
UN4 Transportation of dredge spoil material (over water or land)		
UN5 Transportation of granular substrate material (e.g. gravel for airstrips)		
UN6 Movement of vehicles for geophysical exploration and scientific research (seismic vehicles, portable drill rigs, water trucks, barges, tracked/wheeled vehicles, portable watercraft)		
UN7 Construction, mining and municipal road vehicles		
UN8 Items used in commercial shipping process (containers, packing materials)		
UN9 Waterway connections (canals, domestic waste stream)		
UN10 Transportation and other corridors (highway, utility right-of-way, logging roads)		
UN11 Garbage transport		

Question 4d: On which of the following can you give me information? (*Explanation: This question asks about plants and insects spreading by natural means such as wind, rivers and streams, and wildlife (e.g. seeds in the intestinal tracts of birds and ungulates, or attached to the fur of the latter.)*

Level 3 Classes		**Comments**
UNS1 Wind		
UNS2 Natural watercourses		
UNS3 Wildlife Vectors		
UNS4 Successional Processes		

Section 2: Risk Assessment of Pathways

In this section I will ask you for information that relates to the three parts of the process for assessing the risk of alien plants and insects entering the Northwest Territories and spreading: 1) characteristics of a pathway; 2) pathway impact scope; and 3) risk level of a pathway.
A pathway is the way an alien plant or insect is introduced into or spreads within the Northwest Territories.

Part A: Characteristics of Pathways. In this part, it is critical to fully outline, but not yet assess, the characteristics of the pathway or pathways you know about. Pathway characterizations should be brief narratives or lists that give straightforward facts (not opinion) regarding pathway characteristics.

Question 1: What is the starting point of the pathway? (*Explanation: The description of the starting point of the pathway should include descriptions of all physical, geographical, ecological and any other characteristics relevant to pathway invasiveness (e.g. landscape and garden plants potted in soil, cultivated in Calgary, AB, outdoor plots, starting at trucking loading dock in Calgary where plants are shipped in wooden crates by a wholesaler).)*

Definition of Starting Point:

Question 2: What are the intermediate points of the pathway? (*Explanation: This question refers to any intermediate stop points (e.g. truck also loads in Edmonton, AB, but crates remain on board. Truck then travels to Yellowknife by Mackenzie Highway).)*

Definition of Intermediate Points:

Question 3: What is the end point of the pathway? (*Explanation: This question refers to where the pathway comes to an end (e.g. crates are off-loaded at Yellowknife retailers. Wood packing material is retained by retailers or used as a combustible. Soil and plants are sold without implementation of phytosanitary measures).)*

Definition of End Point:

Question 4: What alien plants and insects are transported by means of the pathway? (*Explanation: Identify all harmful insects and plants that should be considered for the pathway analysis. If you are able to do so, your list of alien plants and insects should be annotated with a description of the classification and biological characteristics of the species. For example:* ***Euphorbia esula:*** *A perennial of the Euphorbiaceae. Classified as a noxious weed in Alaska but not present there; occurs in all Canadian provinces except Newfoundland; known from northern Alberta; on provincial weed lists from Quebec to British Columbia.)*

Species List:

Question 5: What measures are used to detect and eliminate harmful plants and insects from the pathway? (*Explanation: Describe treatment protocols (e.g. fumigation) or official control procedures (e.g. inspection) that occur at any of the points used to define the pathway.)*

Detection and Control:

Part B: Pathway Impact Scope. This next part is to define the scope of the pathway's potential impacts within the Northwest Territories. Often the more extensive the pathway is, in terms of distance and regions covered, the greater the magnitude of impacts the pathway will have. Hence, in this part of the questionnaire, you are asked to assess how many regions – both ecozones and land claim settlement regions - are affected by the pathways you know about.

The ecozones referred to in this part are those represented in the ecozone map included with the questionnaire as Appendix A. These include: 1. Northern Arctic; 2. Southern Arctic; 3. Taiga Cordillera; 4. Taiga Plains; 5. Taiga Shield; 6. Boreal Cordillera; 7. Boreal Plains.

The land claim settlement regions in question include the following: 1. Inuvialuit Settlement Region; 2. Gwich'in Settlement Area; 3. Sahtu Settlement Area; 4. Dehcho Region; 5. Tlicho/North Slave Region; 6. South Slave Region. These are mapped in Appendix B.

Question 1: Does the pathway only impact a single ecozone and single land claim settlement region? (*Explanation: Will the pathway only cause a regional event within the foreseeable future. This is an event where one or more occurrences of a single alien species are detected within a single ecozone and a single land claim settlement region. It may also be an event in which there are occurrences of more than one alien species, but again, with evidence of movement only within a single ecozone and a single land claim settlement region. For example, the introduction of birch leafminer (Profenusa thomsoni) to the North Slave Region (Yellowknife) within the Taiga Shield Ecozone is a regional event.)*

Level 1 Pathway		**Comments**

Question 2: Does this pathway only impact two ecozones within a single land claim settlement region, or two land claim settlement regions within a single ecozone? (*Explanation: Will the pathway only cause a bi-regional event within the foreseeable future. This is an event where two or more occurrences of a single alien species are detected in two ecozones within a single land claim settlement region; or where the single alien species is detected in one ecozone within two different land claim settlement regions. It may also be an event in which there are occurrences of more than one alien species, but again, with evidence of movement only between and within two distinct ecozones within a single settlement region; or of movement between two different settlement regions within a single ecozone.)*

Level 2 Pathway		**Comments**

Question 3: Does the pathway in question impact three or more ecozones, or three or more land claim settlement regions? (*Explanation: The intent of this question is to determine if the pathway is likely to cause a territorial event within the foreseeable future. This is an event where three or more occurrences of a single alien species are detected in three or more ecozones; or where the single alien species is detected in three or more different land claim settlement regions. It may also be an event in which there are occurrences of more than one alien species, but again, with evidence of movement between and within three or more distinct ecozones or of movement between three or more different settlement regions.)*

Level 3 Pathway		**Comments**

Part C: Risk Level of a Pathway. In this step you are asked to give information relevant to the assessment of risk of alien species associated with the pathway or pathways identified above. The questions are intended to address such issues as probability of entry into a region, probability of establishment, history of invasiveness of a species, available mitigation methods and impacts. You will be asked to assign a number to characterize the risk of entry, establishment or spread of alien plants or insects. Do you want to participate in this step?

Question 1: What is the level of risk of this pathway having alien species transmitted by it on a frequent basis? *Explanation: An 'Extremely High' frequency ranking (i.e., a ranking of 5) means the pathway has alien species present during ≥ 90% of transmission events of products or people within it, medium means 50%; extremely low means ≤ 10%.*

Level No.	**Level Descriptor**	**Level Determination (i.e., 0, 1, 2, 3, 4, or 5) Please assign a whole number in the box →**	
Level 0	No Risk	**Rationale – Are there many interception records for the pathway in a given year?**	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there any uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	**Please check all that apply**	**Uncertainty level (Assign whole no. from 0-5 where 1= slightly uncertain; 5= highly uncertain) Please assign a whole number in the box →**	
Lack of expertise			
Biological unknowns			
Insufficient information			
Other-Define			

Question 2: What is the level of risk of this pathway transmitting a large number of different alien species? *Explanation: An 'Extremely High' ranking implies a pathway capable of transferring 25 or more alien species in a single event. An 'Extremely Low' ranking implies that only 1 or 2 alien species are transmitted. Note that the viability of the alien organisms is not in question at this point, just presence within the pathway.*

Level No.	**Level Descriptor**	**Level Determination (i.e., 0,1,2,3,4, or 5) Please assign a whole number in the box →**	
Level 0	No Risk	**Rationale - Are there many interception records of different species for the pathway?**	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there any uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	**Please check all that apply**	**Uncertainty level (Assign whole no. from 0-5 where 1= slightly uncertain; 5= highly uncertain) Please assign a whole number in the box →**	
Lack of expertise			
Biological unknowns			
Insufficient information			
Other-Define			

Question 3: What is the level of risk of this pathway transmitting a large number of individual organisms of each alien species (e.g. is it likely to introduce 300 birch leafminers or 1,000 seeds of reed canary grass (*Phalaris arundinacea*))? *Explanation: An 'Extremely High' ranking implies that the pathway transmits numerous, i.e. ≥ 100, individuals within at least one species in a single transmission event. An 'Extremely Low' ranking implies that only 1 or 2 individuals are present of each alien species transmitted by the pathway.*

Level No.	**Level Descriptor**	**Level Determination (i.e., 0,1,2,3,4, or 5) Please assign a whole number in the box →**	
Level 0	No Risk	**Rationale - Are there many interception records for each species in this pathway?**	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there any uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	**Please check all that apply**	**Uncertainty level (Assign whole no. from 0-5 where 1= slightly uncertain; 5= highly uncertain) Please assign a whole number in the box →**	
Lack of expertise			
Biological unknowns			
Insufficient information			
Other-Define			

Question 4: What is the risk that the pathway supports and potentially enhances (e.g. offers conditions for reproductive success) the viability of alien species (i.e. it provides good habitat for the species in transit)? *Explanation: An 'Extremely High' ranking amounts to certainty that alien species survive due to conditions of the pathway ecosystem. An 'Extremely Low' ranking indicates that some characteristic of the pathway, other than implementation of standard sanitary and phytosanitary measures, will result in alien species mitigation (e.g. travel in unheated enclosure during winter months).*

Level No.	**Level Descriptor**	**Level Determination (i.e., 0,1,2,3,4, or 5) Please assign a whole number in the box →**	
Level 0	No Risk	**Rationale – What characteristics of the pathway support viability?**	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there any uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	**Please check all that apply**	**Uncertainty level (Assign whole no. from 0-5 where 1= slightly uncertain; 5= highly uncertain) Please assign a whole number in the box →**	
Lack of expertise			
Biological unknowns			
Insufficient information			
Other-Define			

Question 5: Given the measures used to prevent alien species in the pathway (i.e. standard sanitary and phytosanitary treatment measures) what is the level of risk of the pathway transmitting viable alien plants and insects? *Explanation: A rating of 'No risk' means all alien organisms are dead upon arrival due to sanitary and phytosanitary measures; 'Medium' = most (60%) of the alien organisms that entered the pathway are still reproductively viable; 'Extremely High' = at least one alien species is thriving in transit and has increased population size, colony numbers or has enhanced its invasiveness capabilities.*

Level No.	**Level Descriptor**	**Level Determination (i.e., 0,1,2,3,4, or 5) Please assign a whole number in the box →**	
Level 0	No Risk	**Rationale – What measures are in place?**	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there any uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	**Please check all that apply**	**Uncertainty level (Assign whole no. from 0-5 where 1= slightly uncertain; 5= highly uncertain) Please assign a whole number in the box →**	
Lack of expertise			
Biological unknowns			
Insufficient information			
Other-Define			

Question 6: Given the alien species transmitted via this pathway, what is the relative level of risk of this pathway introducing viable organisms of alien species into hospitable ecoregions? *Explanation: A rating of 'No risk' indicates that the environment does not permit any establishment of the alien species. A rating of 'Extremely High' indicates that the environment is very similar to the alien species' natural habitat with respect to climate and resources to support critical life stages, but without natural predators or other controls.*

Level No.	**Level Descriptor**	**Level Determination (i.e., 0,1,2,3,4, or 5) Please assign a whole number in the box →**	
Level 0	No Risk	**Rationale – What characteristics of the receiving ecoregion are like those of the alien species' natural habitat?**	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there any uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	**Please check all that apply**	**Uncertainty level (Assign whole no. from 0-5 where 1= slightly uncertain; 5= highly uncertain) Please assign a whole number in the box →**	
Lack of expertise			
Biological unknowns			
Insufficient information			
Other-Define			

Question 7: What is the level of risk of this pathway introducing viable organisms of alien species at multiple entry points? *Explanation: An 'Extremely High' ranking implies multiple entry points (4 or more) that extend across the entirety of the scoped pathway impact area; whereas an 'Extremely Low' ranking implies a single, localized entry point.*

Level No.	Level Descriptor	Level Determination (i.e., 0,1,2,3,4, or 5) Please assign a whole number in the box →	
Level 0	No Risk	**Rationale – What are the intermediate entry points where alien species could be introduced?**	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there any uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	Please check all that apply	Uncertainty level (Assign whole no. from 0-5 where 1= slightly uncertain; 5= highly uncertain) Please assign a whole number in the box →	
Lack of expertise			
Biological unknowns			
Insufficient information			
Other-Define			

Question 8: What is the level of risk of this pathway transmitting alien species undetected in view of current interception or detection techniques applied to the pathway? *Explanation: A rating of 'No Risk' indicates that virtually all alien species are detected and mitigated prior to or during transit. A rating of 'Extremely High' indicates that there are no detection or mitigation methods for the alien species prior to or during transit.*

Level No.	Level Descriptor	Level Determination (i.e., 0,1,2,3,4, or 5) Please assign a whole number in the box →	
Level 0	No Risk	**Rationale – What detection protocols are in place at or past the Northwest Territories border?**	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there any uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	Please check all that apply	Uncertainty level (Assign whole no. from 0-5 where 1= slightly uncertain; 5= highly uncertain) Please assign a whole number in the box →	
Lack of expertise			
Biological unknowns			
Insufficient information			
Other-Define			

Question 9: What is the level of risk of the pathway transporting an alien species that is difficult to detect once in the endpoint ecosystem? *Explanation: A rating of 'No Risk' indicates that all alien species can be detected immediately at the pathway endpoint. A rating of 'Extremely High' indicates that the alien species is/are so difficult to detect; there is a ≥ 90% likelihood they will be disseminated without detection.*

Level No.	Level Descriptor	Level Determination (i.e., 0,1,2,3,4, or 5) Please assign a whole number in the box →	
Level 0	No Risk	**Rationale – What characters of the alien species make them difficult, or not difficult, to detect once in the endpoint ecosystem?**	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		

Level 4	Moderately High Level of Risk	
Level 5	Extremely High Level of Risk	

Is there any uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	**Please check all that apply**	**Uncertainty level (Assign whole no. from 0-5 where 1= slightly uncertain; 5= highly uncertain) Please assign a whole number in the box →**	
Lack of expertise			
Biological unknowns			
Insufficient information			
Other-Define			

Question 10: What is the level of risk of this pathway transmitting alien species that are capable of surviving in multiple ecosystems within an ecozone or ecozones? *Explanation: An assessment of 'No Risk' indicates that the pathway does not transmit any generalists capable of survival in northern climates. An assessment of 'Extremely High' indicates that the majority of alien species transmitted by this pathway are generalists capable of surviving in any of the pathway endpoints.*

Level No.	**Level Descriptor**	**Level Determination (i.e., 0,1,2,3,4, or 5) Please assign a whole number in the box →**	
Level 0	No Risk	**Rationale – What ecozones or ecosystems could the alien species survive in?**	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there any uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	**Please check all that apply**	**Uncertainty level (Assign whole no. from 0-5 where 1= slightly uncertain; 5= highly uncertain) Please assign a whole number in the box →**	
Lack of expertise			
Biological unknowns			
Insufficient information			
Other-Define			

Question 11: What is the level of risk of this pathway transmitting alien species into ecosystems conducive to natural spread (e.g. is an aquatic plant likely to end up in a river where its seeds will float downstream)? *Explanation: A rating of 'No Risk' indicates that the pathway transmits alien species with low reproductive rates or which are unlikely to survive long periods in the ecosystems to which they might be introduced. A ranking of 'Extremely High' indicates that the pathway transmits multiple (i.e. 10 or more) alien species that are highly mobile, spread by wind or water, or by animal vectors (other than human beings), and have high reproductive rates in multiple ecosystems.*

Level No.	**Level Descriptor**	**Level Determination (i.e., 0,1,2,3,4, or 5) Please assign a whole number in the box →**	
Level 0	No Risk	**Rationale – What characteristics of the ecosystem allow the alien species to spread?**	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there any uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	**Please check all that apply**	**Uncertainty level (Assign whole no. from 0-5 where 1= slightly uncertain; 5= highly uncertain) Please assign a whole number in the box →**	
Lack of expertise			
Biological unknowns			
Insufficient information			
Other-Define			

Question 12: What is the level or risk of this pathway transmitting alien species that are further spread by human activities? *Explanation: A rating of 'No Risk' indicates that humans or human activities do not spread the alien species. A rating of 'Extremely High' indicates humans or human activities are the primary agent for the rapid spread of the alien species.*

Level No.	**Level Descriptor**	**Level Determination (i.e., 0,1,2,3,4, or 5) Please assign a whole number in the box →**	
Level 0	No Risk	**Rationale – What human activities could spread the alien species once in the receiving region?**	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there any uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	**Please check all that apply**	**Uncertainty level (Assign whole no. from 0-5 where 1= slightly uncertain; 5= highly uncertain) Please assign a whole number in the box →**	
Lack of expertise			
Biological unknowns			
Insufficient information			
Other-Define			

Question 13: What is the level of risk of the pathway introducing a species or genotype that is known to be invasive (i.e. harmful) in similar ecosystems but is not yet in the Northwest Territories? *Explanation: A rating of 'No Risk' indicates that the pathway only transmits species that are already distributed throughout the endpoint ecoregion; a rating of 'Medium' indicates that the pathway transmits alien species that are in Northwest Territory ecoregions, but not in the endpoint of the pathway. A ranking of 'Extremely High' indicates that the pathway transmits viable alien species not present in the Northwest Territories.*

Level No.	**Level Descriptor**	**Level Determination (i.e., 0,1,2,3,4, or 5) Please assign a whole number in the box →**	
Level 0	No Risk	**Rationale – What species in the pathway are already in parts of the Northwest Territories, and which parts?**	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there any uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	**Please check all that apply**	**Uncertainty level (Assign whole no. from 0-5 where 1= slightly uncertain; 5= highly uncertain) Please assign a whole number in the box →**	
Lack of expertise			
Biological unknowns			
Insufficient information			
Other-Define			

Question 14: What is the level of risk of this pathway transmitting alien species on which there is a lack of scientific data upon which to develop control methods? *Explanation: A rating of 'No Risk' indicates there are comprehensive control options to mitigate all alien species transmitted. A rating of 'Extremely High' indicates there are no known control options for the alien species transmitted via the pathway.*

Level No.	**Level Descriptor**	**Level Determination (i.e., 0,1,2,3,4, or 5) Please assign a whole number in the box →**	
Level 0	No Risk	**Rationale – What control measures are available?**	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there any uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	**Please check all that apply**	**Uncertainty level (Assign whole no. from 0-5 where 1= slightly uncertain; 5= highly uncertain) Please assign a whole number in the box →**	
Lack of expertise			
Biological unknowns			
Insufficient information			
Other-Define			

Question 15: What is the level of risk of this pathway transmitting an alien species for which established control options are too expensive to implement? *Explanation: A rating of 'No Risk' indicates control options are a part of routine operations and therefore requires no additional funding. A rating of 'Extremely High' indicates control options are so expensive, it requires the petitioning of external agency/multi-source emergency funding.*

Level No.	**Level Descriptor**	**Level Determination (i.e., 0,1,2,3,4, or 5) Please assign a whole number in the box →**	
Level 0	No Risk	**Rationale – What kind of budget does your organization have to implement control options?**	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there any uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	**Please check all that apply**	**Uncertainty level (Assign whole no. from 0-5 where 1= slightly uncertain; 5= highly uncertain) Please assign a whole number in the box →**	
Lack of expertise			
Biological unknowns			
Insufficient information			
Other-Define			

Section 3: General Comments

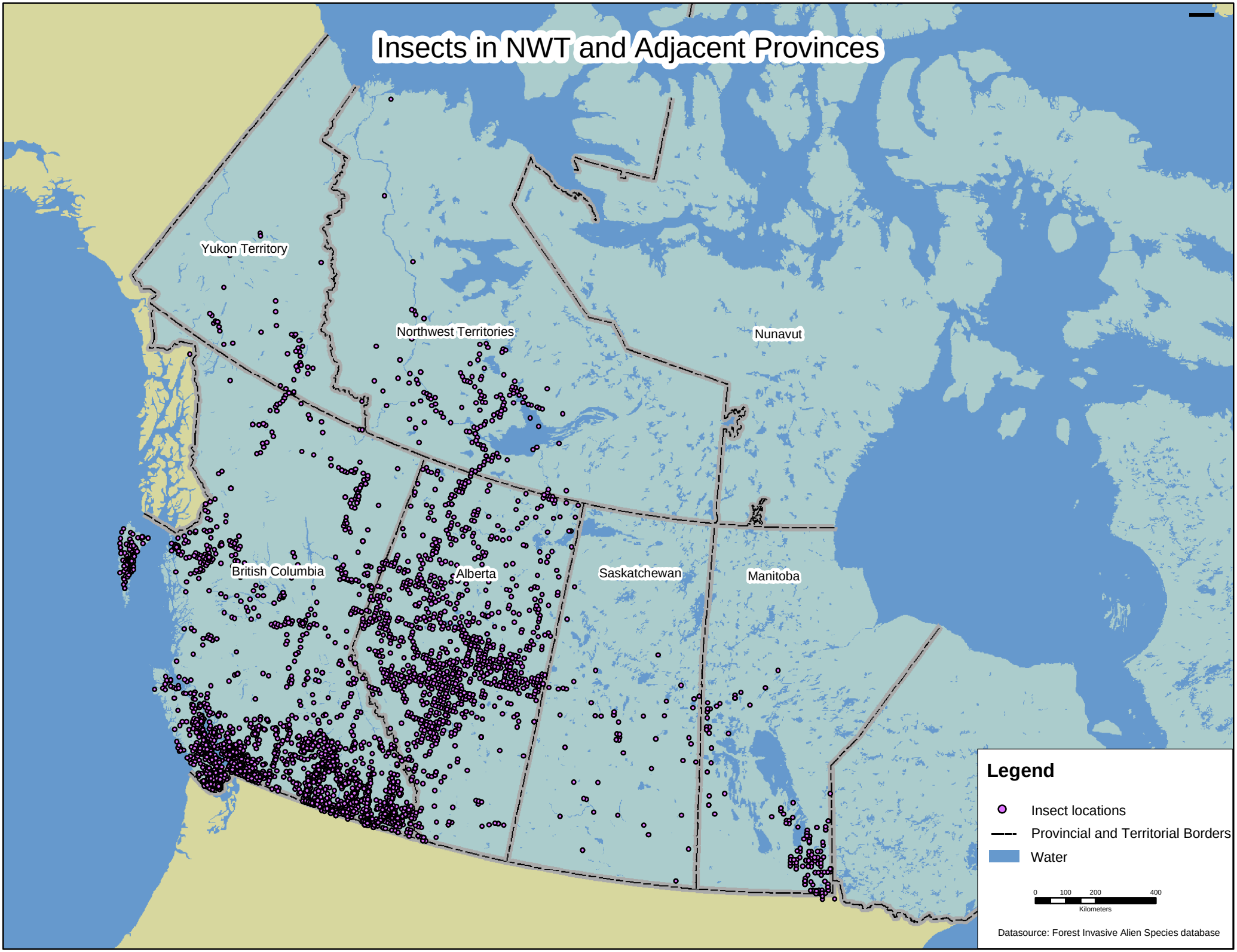
There are a few of additional questions which will assist the Department of Environment and Natural Resources in developing constructive ways that communities and industry can become part of the solution in efforts to protect the territories from harmful alien plants and insects.

Question 1: What kind of information and assistance would you like to have in addressing this problem?

Question 2: Who else should the Department of Environment and Natural Resources contact?

Question 3: The specific answers to this questionnaire will remain confidential, but we will produce a summary of questionnaire answers. Would you be interested in reviewing this summary? A review is important to ascertain that your answers are reflected in the summary, and can provide you with a further opportunity to add comments and suggestions.

Thank you for your time and patience in completing this questionnaire on such an important concern for the Northwest Territories!


Insects in NWT and Adjacent Provinces
Yukon Territory
Northwest Territories
Nunavut
British Columbia
Alberta
Saskatchewan
Manitoba
Legend
Insect locations
Provincial and Territorial Borders
Water
0 100 200 400
Kilometers
Datasource: Forest Invasive Alien Species database

ALBERTA

Insect Species	Common Name	Alberta Count
Pristiphora erichsonii	larch sawfly	1982
Adelges laricis	pale spruce gall adelgid	55
Scoliopteryx libatrix	herald moth	44
Caliroa cerasi	pear slug; pear sawfly; pear and cherry slug (Australia)	23
Mindarus abietinus	balsam twig aphid	23
Adelges abietis	eastern spruce gall adelgid/aphid	20
Orgyia antiqua	rusty tussock moth	20
Hemichroa crocea	striped alder sawfly	17
Tetranychus urticae	twospotted spider mite; glasshouse spider mite; carmine spider mite	12
Fenusa pumila	birch leafminer	7
Heterarthrus nemoratus	late birch leaf edgeminer	7
Nematus ribesii	imported currantworm	6
Parthenolecanium corni corni	European fruit lecanium; plum scale (Australia); brown scale, peach scale	6
Profenusa thomsoni	ambermarked birch leafminer	6
Cinara laricis	larch aphid	5
Euura atra	smaller willow shoot sawfly	5
Pulvinaria vitis		3
Trichiocampus grandis	poplar sawfly; hairy poplar sawfly	3
Zeugophora scutellaris	cottonwood leafmining beetle	3
Euceraphis betulae	birch aphid (Australia)	2
Fenusa dohrnii	European alder leafminer	2
Pterocomma salicis		2
Acyrthosiphon caraganae	caragana aphid	1
Dichrooscytus rufipennis		1
Eulecanium tiliae	brown gooseberry scale	1
Lepidosaphes ulmi	oystershell scale; apple mussel scale (Australia); mussel scale	1
Prociphilus xylostei	woolly honeysuckle aphid / conifer root aphid	1
Scolytus multistriatus		1

BRITISH COLUMBIA

Insect Species	Common Name	BC Count
Pristiphora erichsonii	larch sawfly	1016
Coleophora laricella	larch casebearer	768
Leucoma salicis	satin moth	605
Rhyacionia buoliana	European pine shoot moth	554
Adelges piceae	balsam woolly aphid/adelgid	495
Hemichroa crocea	striped alder sawfly	445
Operophtera brumata	winter moth; March moth	370
Archips rosana	European leafroller; rose leafroller, rose tortrix moth	294
Elatobium abietinum	green spruce aphid; spruce aphid	266
Xyleborus dispar		202
Adelges tsugae	hemlock adelgid; hemlock woolly adelgid	178
Strophosoma melanogrammum	nut leaf weevil	166
Scoliopteryx libatrix	herald moth	150
Lymantria dispar	gypsy moth	148
Mindarus abietinus	balsam twig aphid	146
Profenusa thomsoni	ambermarked birch leafminer	80
Eulecanium tiliae	brown gooseberry scale	68
Philaenus spumarius	meadow spittlebug	67
Otiorhynchus ovatus	strawberry root weevil	56
Otiorhynchus sulcatus	black vine weevil; European strawberry weevil (Australia); vine weevil	54
Scolytus multistriatus		50
Carcina quercana		49
Fenusa pumila	birch leafminer	46
Pandemis cerasana	fruit tree tortrix	44
Spilonota ocellana	eyespotted bud moth; apple bud moth; bud moth	41
Yponomeuta malinella	apple ermine moth; apple small ermine moth	37
Otiorhynchus singularis		36
Sitona lineatus	pea leaf weevil; pea weevil, pea and bean weevil	36
Amphipyra tragopoginis		32
Dichomeris marginella	juniper webworm	30
Otiorhynchus rugosostriatus	rough strawberry root weevil	28
Gossyparia spuria	European elm scale	27
Peridroma saucia	variegated cutworm	25
Phylloxera glabra		24
Adelges abietis	eastern spruce gall adelgid/aphid	23
Eriocampa ovata	woolly alder sawfly	23
Yponomeuta padella	cherry ermine moth	21
Stenotus binotatus	twospotted grass bug; timothy grassbug (England)	19
Cnephasia longana	omnivorous leaftier	18
Fenusa dohrnii	European alder leafminer	17
Xanthogaleruca luteola	elm leaf beetle	17
Acleris variegana		16
Cecidophyopsis psilaspis		15
Caliroa cerasi	pear slug; pear sawfly; pear and cherry slug (Australia)	14
Coleophora serratella	birch casebearer; cigar casebearer	14
Trachycera suavella		14
Carulaspis juniperi	juniper scale	13
Ditula angustiorana	red barred tortrix	13

BRITISH COLUMBIA

Phytomyza ilicis	holly leafminer	13
Lepidosaphes ulmi	oystershell scale; apple mussel scale (Australia); mussel scale	12
Choreutis pariana	apple-and-thorn skeletonizer	11
Allygus mixtus		10
Physokermes hemicryphus		9
Barypeithes pellucidus		8
Ocnerostoma piniariella	small ermine moth	8
Scolytus rugulosus		8
Adelges nusslini		7
Phyllobius intrusus	arborvitae weevil	7
Trichiocampus grandis	poplar sawfly; hairy poplar sawfly	7
Zeugophora scutellaris	cottonwood leafmining beetle	7
Adelges laricis	pale spruce gall adelgid	6
Aethes rutilana	pale juniper webworm	6
Aphis fabae	black bean aphid; bean aphid; beet leaf aphid	6
Parthenolecanium corni corni	European fruit lecanium; plum scale (Australia); brown scale, peach scale	6
Pristiphora rufipes		6
Nematus ribesii	imported currantworm	5
Periphyllus lyropictus	Norway maple aphid	5
Trachyphloeus bifoveolatus		5
Isochnus populicola		4
Periphyllus californiensis	California maple aphid (Australia)	4
Agonopterix nervosa		3
Parthenolecanium fletcheri	Fletcher scale	3
Phymatodes testaceus		3
Rhopobota naevana	blackheaded fireworm	3
Taeniothrips inconsequens	pear thrips	3
Aphis spiraecola		2
Athrips rancidella	cotoneaster webworm	2
Brachycaudus cardui	thistle aphid	2
Caloptilia syringella	lilac leafminer	2
Cinara pinea	pine aphid	2
Cladius difformis	bristly rose slug	2
Dynaspidiotus britannicus	holly scale	2
Endelomyia aethiops	roseslug	2
Epinotia nanana	European spruce needleminer; green spruce needleminer	2
Phyllobius oblongus	European snout beetle	2
Phyllonorycter blancardella	spotted tentiform leafminer; blotch miner	2
Pilophorus clavatus		2
Xylosandrus germanus		2
Aphis pomi	apple aphid; green apple aphid	1
Argyresthia conjugella	apple fruit moth	1
Brachycaudus helichrysi	leafcurling plum aphid	1
Cacopsylla peregrina		1
Caliroa annulipes	oak slug sawfly	1
Cavariella aegopodii	willow carrot aphid; carrot aphid (Australia)	1
Coccus hesperidum	brown soft scale	1

BRITISH COLUMBIA

Diaspidotus perniciosus	San Jose scale, California scale, Chinese scale, round pear scale; pernicious scale	1
Drepanosiphum platanoidis	sycamore aphid (Australia)	1
Enarmonia formosana	cherry bark tortrix	1
Eucallipterus tiliae		1
Euceraphis betulae	birch aphid (Australia)	1
Euceraphis punctipennis	European birch aphid	1
Eulachnus rileyi	pine needle aphid	1
Fenella nigrita		1
Gilpinia hercyniae	European spruce sawfly	1
Macropsis fuscula	raspberry leafhopper	1
Orgyia antiqua	rusty tussock moth	1
Pemphigus bursarius	lettuce root aphid; lettuce aphid; poplar gall aphid (Australia)	1
Phenacoccus aceris	apple mealybug	1
Pontania proxima	willow redgall sawfly	1
Prociphilus xylostei	woolly honeysuckle aphid / conifer root aphid	1
Pulvinaria vitis		1
Sirex juvencus juvencus	European blue horntail	1
Tetranychus urticae	twospotted spider mite; glasshouse spider mite; carmine spider mite	1

MANITOBA

Insect Species	Common Name	Manitoba Count
Pristiphora erichsonii	larch sawfly	128
Gilpinia hercyniae	European spruce sawfly	46
Coleophora laricella	larch casebearer	15
Hemichroa crocea	striped alder sawfly	11
Diprion similis	introduced pine sawfly	9
Profenusa thomsoni	ambermarked birch leafminer	8
Gilpinia frutetorum	nursery pine sawfly	6
Orgyia antiqua	rusty tussock moth	4
Caliroa cerasi	pear slug; pear sawfly; pear and cherry slug (Australia)	2
Mindarus abietinus	balsam twig aphid	2
Zeugophora scutellaris	cottonwood leafmining beetle	2
Adelges abietis	eastern spruce gall adelgid/aphid	1
Adelges laricis	pale spruce gall adelgid	1
Epinotia nanana	European spruce needleminer; green spruce needleminer	1
Fenusa dohrnii	European alder leafminer	1
Isochnus populicola		1
Monophadnoides geniculatus	raspberry sawfly	1
Otiorhynchus ovatus	strawberry root weevil	1
Pristiphora geniculata	mountain-ash sawfly	1

NORTHWEST TERRITORIES

Insect Species	Common Name	NWT Count
Pristiphora erichsonii	larch sawfly	176
Adelges laricis	pale spruce gall adelgid	7
Orgyia antiqua	rusty tussock moth	4
Hemichroa crocea	striped alder sawfly	2
Zeugophora scutellaris	cottonwood leafmining beetle	2
Tetranychus urticae	twospotted spider mite; glasshouse spider mite; carmine spider mite	1

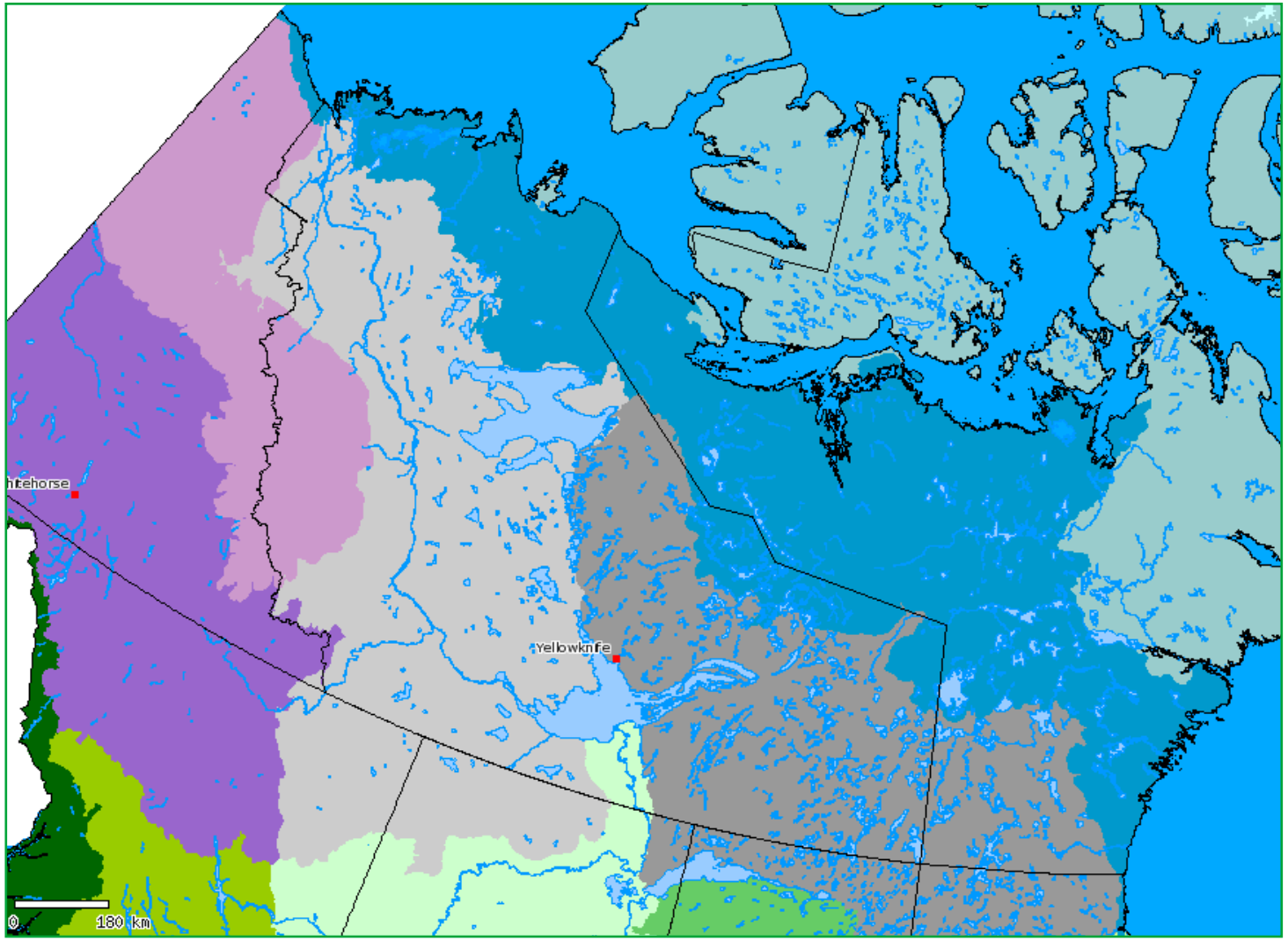
SASKATCHEWAN

Insect Species	Common Name	Sask Count
Pristiphora erichsonii	larch sawfly	20
Zeugophora scutellaris	cottonwood leafmining beetle	20
Profenusa thomsoni	ambermarked birch leafminer	8
Fenusa pumila	birch leafminer	4
Fenusa dohrnii	European alder leafminer	3
Hemichroa crocea	striped alder sawfly	2
Caliroa cerasi	pear slug; pear sawfly; pear and cherry slug (Australia)	1
Heterarthrus nemoratus	late birch leaf edgeminer	1
Mindarus abietinus	balsam twig aphid	1
Otiorhynchus ovatus	strawberry root weevil	1
Pemphigus bursarius	lettuce root aphid; lettuce aphid; poplar gall aphid (Australia)	1
Pontania proxima	willow redgall sawfly	1
Trichiocampus grandis	poplar sawfly; hairy poplar sawfly	1

YUKON TERRITORY

Insect Species	Common Name	Yukon Count
Pristiphora erichsonii	larch sawfly	36
Scoliopteryx libatrix	herald moth	8
Adelges laricis	pale spruce gall adelgid	5
Profenusa thomsoni	ambermarked birch leafminer	3
Otiorhynchus ovatus	strawberry root weevil	2
Physokermes hemicryphus		2
Adelges abietis	eastern spruce gall adelgid/aphid	1
Archips rosana	European leafroller; rose leafroller, rose tortrix moth	1
Caloptilia negundella		1
Hemichroa crocea	striped alder sawfly	1
Operophtera brumata	winter moth; March moth	1
Pterocomma salicis		1

National Ecological Framework for Canada



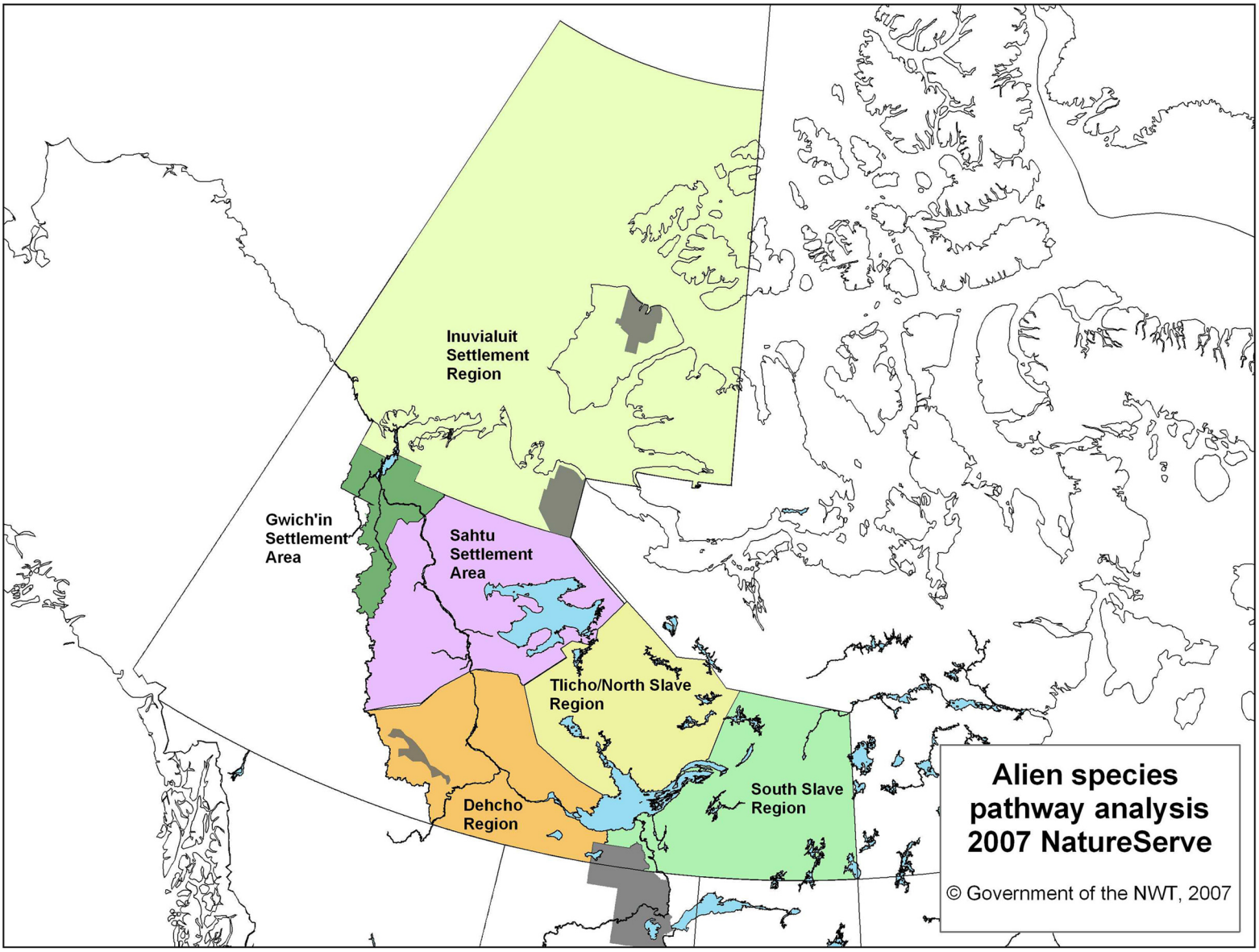
- Cities
- Provinces and Territories
- Ocean
- Lakes

Ecozones

- Arctic Cordillera
- Northern Arctic
- Southern Arctic
- Taiga Plains
- Taiga Shield
- Hudson Plains
- Boreal Shield
- Mixed Wood Plains
- Atlantic Maritime
- Taiga Cordillera
- Boreal Cordillera
- Pacific Maritime
- Montane Cordillera
- Boreal Plains
- Prairies

Contact Us:

General Information
National Land and Water Information Service, Agriculture and Agri-Food Canada
nlwis@agr.gc.ca


Inuvialuit
Settlement
Region
Gwich'in
Settlement
Area
Sahtu
Settlement
Area
Tlicho/North Slave
Region
Dehcho
Region
South Slave
Region
Alien species
pathway analysis
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