Canadian Council of Forest Ministers
Conseil canadien des ministres des forêts

National Forest Insect and Disease Diagnostic and Taxonomic Resources and Tools

Current Situation and Future Considerations

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Executive Summary

The historical occurrence and distribution patterns of native forest pests have been modified, or are expected to be modified in the next decade, as a result of climate change. At the same time, the risks posed by invasive alien species are expected to increase as international trade and traffic grow. These forecast trends are a concern because forest pests and invasive alien species can lead to significant losses in forest ecosystems and to economic hardship for forestry-dependent communities.

This report represents a first step in a continuum of steps required to ensure that adequate levels of forest pest diagnostic and taxonomic resources exist across Canada.

DIAGNOSTIC AND TAXONOMIC SERVICES: ESSENTIAL TO RISK-BASED FOREST PEST MANAGEMENT

In Canada, the National Forest Pest Strategy (NFPS) promotes a proactive, risk-based approach to forest pest management. The success of this approach is contingent on several factors, one of the most important being the early detection (through monitoring) and identification of native and invasive alien species. In turn, identification relies on the availability of diagnostic and taxonomic resources and tools.

Because the provinces and territories are tasked with monitoring forest health conditions in their jurisdictions, it is essential that they be supported with ready access to these resources and tools. Lack of essential diagnostic and taxonomic resources, including diagnostic tools and materials, could result in insects and diseases having major impacts on forested ecosystems, and on the communities that rely on affected forests for their goods and services. At present, there is a lack of a coordinated approach to diagnostic and taxonomic services (including the cataloguing of resources) across jurisdictions and agencies.

CURRENT DIAGNOSTIC AND TAXONOMIC CAPACITY AND AVAILABILITY

Considerable concern exists at present in the forest pest management community over the current and future capacity of diagnostic and taxonomic resources at a provincial, territorial and national level. Existing capacity and availability are being affected by staff attrition, changing government mandates and a challenging economic climate.

To address this concern, the NFPS Monitoring and Diagnostics Technical Advisory Group conducted various stock-taking exercises (including surveys) between 2009 and 2011. This advisory group reports to the Canadian Council of Forest Ministers' Forest Pest Working Group.

The main findings of this investigation:

- The capacity and availability of pathologists, particularly taxonomists, are limited at all levels of government in Canada.
- Demand for pathology diagnostic and taxonomic services is high in several jurisdictions, and critical shortages exist in the Atlantic Provinces.
- All provinces and territories require diagnostic and taxonomic services or support for monitoring invasive alien species and less common native pests, as well as requiring taxonomy services for all pests.
- The availability of external diagnostic and taxonomic services is lowest in the Prairie Provinces.

- Demand for native forest insect diagnosis is minimal based on current staffing levels, expertise of provincial and territorial forest health staff, and level of forest pest monitoring.

FUTURE DEMAND FOR DIAGNOSTIC AND TAXONOMIC SERVICES

Future demand for diagnostic and taxonomic services in Canada is expected to vary as provincial and territorial monitoring efforts could decrease due to limited funding, or increase to account for enhanced surveillance due to climate change.

However, availability by the provinces and territories to federal diagnostic and taxonomic services may be limited because of other work commitments of federal specialists. The ability of those specialists to provide identification services in a timely manner may be impeded.

Capacity in the short term may also be reduced given that approximately one-third of federal specialists are eligible for retirement within the next five years.

OPTIONS FOR CONSIDERATION

This report concludes with two options for consideration, one aimed at providing for the long-term accounting and sharing of inter-governmental forest pest diagnostic and taxonomic resources, and the other at promoting the ongoing improvement of diagnostic and taxonomic skills and resources across Canada.

Option 1 – Develop a coordinated, multi-agency approach to providing and tracking diagnostic and taxonomic resources.

Ways to do this:

- Encourage NFPS partners to develop agreements or memorandums of understanding among themselves to ensure that all partners are actively updated and informed of diagnostic and taxonomic capacity, availability and needs. Sharing existing resources and facilitating succession planning of diagnostic and taxonomic expertise would create efficiencies and ensure that adequate levels of such services exist across Canada.
- Consider adopting the NFPS's Pest Strategy Information System as the means to track these resources and assist managers with identifying gaps.

Option 2 – Support the maintenance of existing diagnostic and taxonomic tools and the development of new tools, and identify training opportunities in diagnostic and taxonomic skills:

- Maintain and support federal pest collections.
- Support the development of new tools for improved diagnostics, including molecular diagnostic tools, web-based tools, and applications for smartphones and tablets.
- Provide mentoring and training opportunities to develop forest pest diagnostic and taxonomic skills.
- Develop and deliver training modules on diagnostic and taxonomic skills and techniques.

Background

In 2006, the Canadian Council of Forest Ministers (CCFM)[1] endorsed the vision, principles and approach for a National Forest Pest Strategy (NFPS). The NFPS promotes a proactive, integrated response to the threat of forest pests through a national risk-analysis framework to guide decision-making by the many jurisdictions involved in pest management in Canada.

In 2008, the CCFM's Task Force—consisting of representatives from the Canadian Forest Service (CFS) of Natural Resources Canada (NRCan), Canadian Food Inspections Agency (CFIA), and all provinces and territories except Nunavut—released an NFPS implementation plan. The plan identified five broad components of the strategy..

1. Risk Analysis
2. Monitoring and Diagnostics
3. Information and Information Management
4. Science and Technology Priority-Setting
5. Reporting, Communication and Outreach.

Recommendations for implementing each component were developed by technical advisory groups made up of federal, provincial and territorial officials. The advisory groups report to the CCFM's Forest Pest Working Group.

This report focuses on the diagnostics part of the second component of the implementation plan. The work described here contributes to:

- the CCFM Forest Pest Working Group objective of disseminating best practices to facilitate forecasting, preparedness and coordination of pest management activities in Canada; and
- the long-term NFPS implementation objective of ensuring adequate diagnostic capacity to meet present regulatory and management requirements.

[1] Abbreviations used in this report are listed in Appendix 1.

Introduction

The historical occurrence and distribution patterns of native forest pests have been modified, or are expected to be modified in the next decade, as a result of climate change. At the same time, the risks posed by invasive alien species are expected to increase as international trade and traffic grow.

Climate may be altered such that native pests spread beyond their historical ranges, as the mountain pine beetle has now done by moving into Alberta. To ensure early identification of changes to disturbance regimes and of new pest introductions, adequate levels of forest pest monitoring, supported by timely and accessible diagnostic and taxonomic services, are required. Furthermore, national diagnostic and taxonomic capacity should reflect the current and anticipated increased demand for diagnostic and taxonomic services due to changes in pest patterns resulting from climate change.

THE IMPORTANCE OF EARLY DETECTION AND IDENTIFICATION

Diagnostic and taxonomic specialists must have access to diagnostic tools that are appropriate for identifying both native and exotic pest threats.

What can happen if tools are inadequate is shown by the example of the brown spruce longhorn beetle (*Tetropium fuscum*), a native of Eastern Europe. A sample collected in Halifax in 1990 was misidentified as a related native species. Not until 1999 was this exotic wood-boring insect correctly identified. It has since caused extensive mortality of red spruce in Point Pleasant Park in Halifax and continues to spread and kill trees in central Nova Scotia. Subsequent surveys have indicated that since its introduction—including the period before it was properly identified—populations of the insect continued to spread to areas well outside the park and across central Nova Scotia. In 2011, the beetle was found for the first time at a location in New Brunswick, approximately 360 kilometres from where it had originally been noted.

DEFINING DIAGNOSTICS AND TAXONOMY

Diagnostics **refers to the task of identification (with or without keys) of organisms on the basis of distinguishing characteristics (appearance or symptoms). It usually requires practical field experience. A forest pest diagnostician does not require formal training.**

Taxonomy **is the science of identification, classification, cataloguing and formal description of organisms according to internationally accepted standards. It relies on the use of laboratory-based tools, such as keys and bar-coding. Taxonomists require advanced training, and generally practise within a limited range of taxa.**

Had this invasive alien species been accurately identified a decade earlier, efforts to control the insect could have reduced its impact and potential spread into urban and forested areas of North America.

PROVISION OF DIAGNOSTICIAN AND TAXONOMIST RESOURCES

Before 1995, diagnostic and taxonomic services were provided by specialists at the CFS who worked directly with the Forest Insect and Disease Survey (FIDS) program. Often these specialists referred to in-house voucher specimens from historical FIDS collections (i.e., national collections) to confirm identification. Currently, monitoring of biotic and abiotic forest disturbances is undertaken by the provinces and territories through a combination of ground and aerial surveys (Figure 1). Field personnel who conduct these surveys are generally capable of identifying common or major pests using diagnostic tools. Pests that are less frequently encountered require the skills of in-house forest entomologists or pathologists. However, these specialists are not available in all provinces and territories; and, even if they are, do not necessarily have the time, expertise, facilities or reference materials to provide diagnostic services.

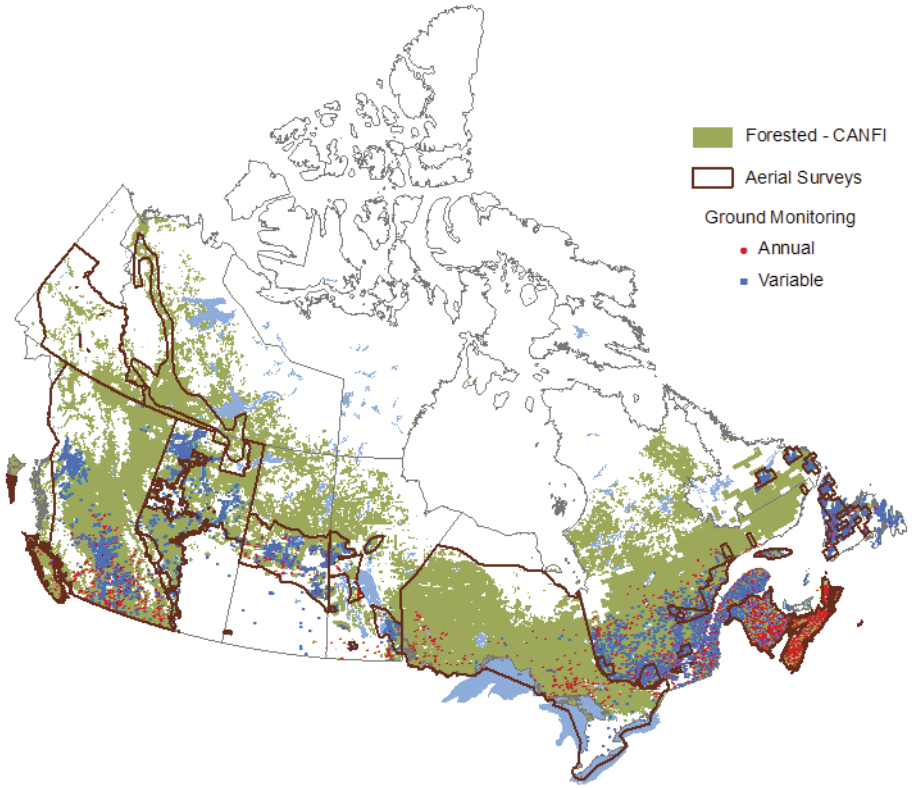


Figure 1. Ground and aerial monitoring of biotic and abiotic forest disturbances currently conducted across Canada (based on 2008, 2009 and 2011 surveys). CANFI = Canada's National Forest Inventory 2001.

Since the FIDS program ended in 1995,[2] many of the specialists have retired and not been replaced, or have been assigned to different areas that provide in-house program and research support but have limited capacity for dealing with external submissions. As only two provinces provide in-house taxonomic support for entomology and none for pathology, this means that many jurisdictions rely on the expertise of external taxonomists. External services are also required for identifying forest pathogens and invasive alien species. Furthermore, in some jurisdictions, the recent reduction in federal pest identification services has placed increased demands on the limited capacity of the provinces and territories.

PERCEPTIONS ABOUT ACCESS TO SUPPORT

The general perception among forest health practitioners in Canada is that access to insect and disease diagnosticians and taxonomists who can provide timely services is steadily diminishing. The same is felt about the availability of resources such as curators necessary to maintain and support CFS collections and their associated data.[3]

PURPOSE OF THIS REPORT

Given the concerns outlined above, the Monitoring and Diagnostics Technical Advisory Group of the NFPS undertook several nationwide surveys in 2009 (on capacity) and 2011 (on availability). The objective was to:

1. provide an overview of diagnostic and taxonomic capacity, availability and needs in Canada;
2. identify current and future gaps that need to be addressed to ensure adequate diagnostic and taxonomic resources; and
3. identify existing diagnostic and taxonomic resource materials and tools.

This report summarizes the findings of those surveys and offers two overall options for consideration.

Current National Diagnostic and Taxonomic Capacity, Availability and Needs

Existing diagnostic and taxonomic capacity and availability were estimated by using a number of information sources:

- a nation-wide survey of individuals listed in entomological and phytopathological membership databases;
- an email survey targeting provincial and territorial specialists; and
- an informal CFS presentation on taxonomy, identification and collections in Canada.[4]

(The latter two sources were used to supplement the nation-wide survey where capacity was known to exist but was not captured in the responses.)

Figure 2 summarizes the employer profile of recipients of the nation-wide survey. In all, 58% reported being employed by the federal government, just over half of whom are with the CFS.

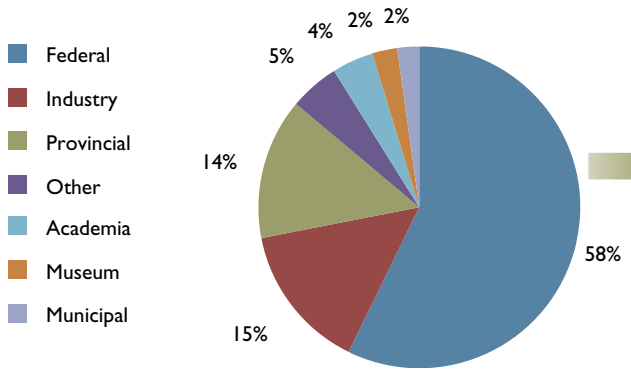
CAPACITY

Of the 539 survey recipients, 98 (18%) responded. Seventy-two reported being insect or disease diagnosticians or taxonomists. To that dataset were added 49 individuals—most from the provinces and territories and the National Identification Service (NIS) of Agriculture and Agri-Food Canada (AAFC)—for a total of 121 insect or disease diagnosticians and/or taxonomists.

[2] Following CFS Program Review, Ontario developed a forest health monitoring program which included many FIDS components as part of its partnership with the CFS. Both parties initially conducted joint field programs. The partnership evolved and continued to develop efficiencies as mandates changed. As of 2009, the program integrated monitoring and research, with Ontario solely responsible for the former and the CFS leading the latter. Québec has had its own monitoring program since 1984. Since the departure of FIDS in 1995, other provinces and territories have developed and implemented pest monitoring systems according to their own needs and capabilities.

[3] Bowers, W. et al. 2000. Biosystematics-Bioinformatics Needs. CFS internal report .

[4] Taxonomy, Identification, and Collections in the CFS. Presentation delivered by John Huber by webinar, November 2011.



	Federal recipients (%)
Natural Resources Canada–Canadian Forest Service (NRCan-CFS)	52
Canadian Food Inspection Agency (CFIA)	25
Agriculture and Agri-Food Canada (AAFC)	15
Pest Management Regulatory Agency (PMRA)	4
Other	4

Figure 2. Employer profile of recipients receiving the nation-wide capacity survey.

Of that survey population, 88 (72%) identified themselves as specializing in forestry: 46 employed by the federal government, 38 by the provincial government and 4 by municipal government, academia or industry (Figure 3).

Of those 88 forest-specialist individuals, 58 reported having an entomology background, 23 a pathology background, and 7 both (Figure 4).

- 51% of the forest entomologists reported being employed by the federal government (CFS, AAFC, CFIA, PMRA), 44% by the provincial government and 5% by academia or industry
- 50% of forest pathologists reported being employed by the federal government (CFS, AAFC, CFIA), 46% by the provincial government and 4% by industry.

The majority of federal respondents were found to be located in or near Ottawa. Responses were also received from each of the CFS forestry centres: Pacific, Northern, Great Lakes, Laurentian and Atlantic, including Corner Brook, Newfoundland.

At a provincial and territorial level, British Columbia was found to have the highest number of forest entomologists and forest pathologists, most of whom consider themselves diagnosticians (Figure 5).

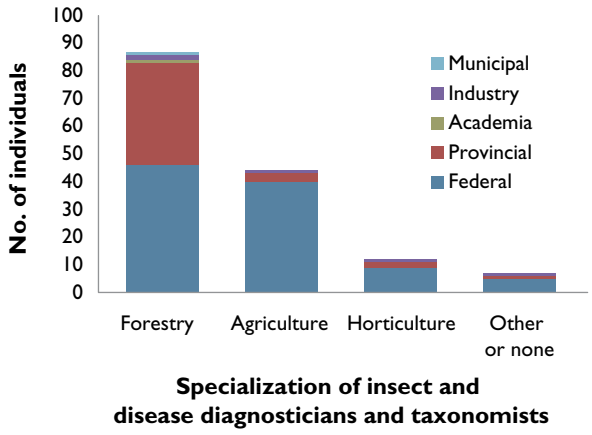


Figure 3. Summary of national entomology and pathology diagnostic and taxonomic capacity, by specialization and by employer. (Note that some respondents reported having more than one area of specialization.)

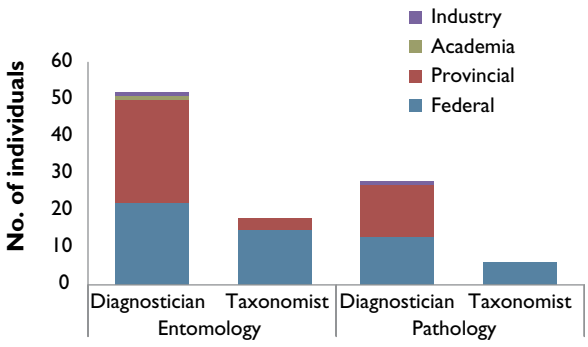


Figure 4. Summary of national forest entomology and pathology diagnostic and taxonomic capacity, by employer. (Note that some respondents reported having more than one area of specialization.)

None of the provinces or territories employs disease taxonomists, and only two have insect taxonomists.

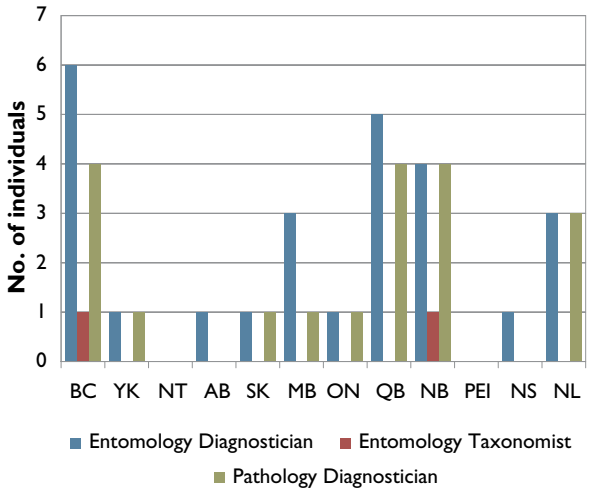


Figure 5. Entomology and pathology capacity, by province and territory, 2011.

A number of individuals responding to these surveys are eligible for retirement within the next five years. At a federal level this includes, but may not be limited to:

- four forest entomologists and four forest pathologists with the CFS
- eight insect taxonomists at the NIS.

This represents a loss of about one-third of the existing federal entomology and pathology capacity.

Attrition data is not available for the provinces or territories, but they have expressed concern over the ability to maintain existing capacity. The impacts resulting from retirements will depend on whether vacancies are filled and what is included in the job description of replacement positions.

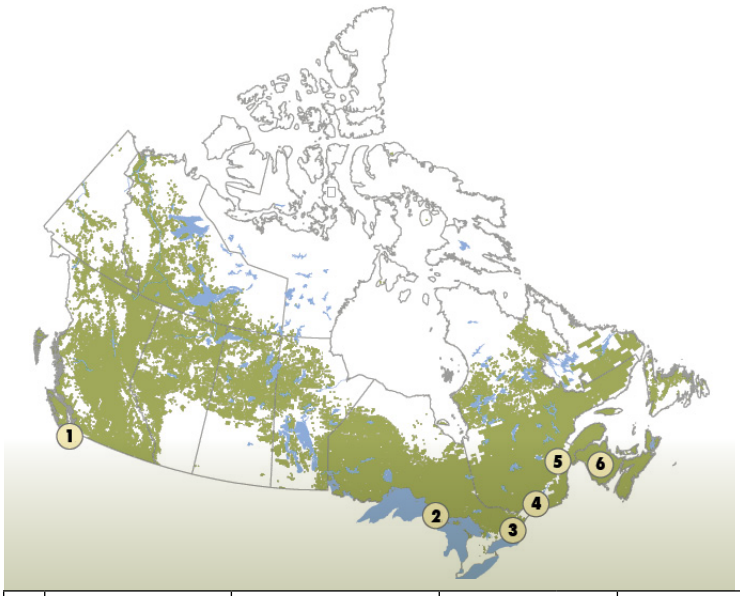
AVAILABILITY

The availability survey was conducted in the winter of 2011 to determine what diagnostic and taxonomic services are available to the provinces and territories should they require external support for those resources. Such support is available most often from federal agencies and less frequently from academia. The survey was sent to the individuals who responded to the capacity survey.[5]

Approximately 35 external specialists indicated their availability to provide D and/or T services to the provinces or territories. Most of these individuals were found to be located in eastern Canada and to specialize in entomology (Figure 6).

A few reported having both diagnostic and taxonomic skills, and one reported having both entomology and pathology diagnostic skills.

[5] The capacity survey results may not adequately reflect availability given that some of the organizations and individuals that chose not to respond to the survey may still be able to provide diagnostic and taxonomic services—or not, if they are unavailable to do so because of other demands.



	Location	Facility	Type of Service		Entomology		Pathology	
			In-house or free	Fee	Diagnostics	Taxonomy	Diagnostics	Taxonomy
1	Victoria	CFS-PFC	√		2		1	1
2	Sault Ste. Marie	CFS-GLFC/OMNR	√		1		2	
3	Ottawa	CFIA/NIS/AAFC	√		2	21		
4	Laval	MAPAQ		√	1		1	
5	Quebec City	SCAQ/CFS		√	1		1	
6	Fredericton	CFS-AFC	√		2			
	Total				**9**	**21**	**5**	**1**

CFS-PFC – CFS-Pacific Forestry Centre; CFS-GLFC/OMNR – CFS-Great Lakes Forestry Centre/Ontario Ministry of Natural Resources; CFIA/NIS/AAGC – Canadian Food Inspection Agency/National Identification Services/Agriculture and Agri-Food Canada; MAPAQ – Ministère de l'Agriculture, des Pêcheries et de l'Alimentation (Québec); SCAQ/CFS – Service de consultation antiparasitaire du Québec; CFS-AFC – CFS-Atlantic Forestry Centre

Figure 6. Location of facilities and number of individuals available to provide forest pest diagnostic and taxonomic services in Canada as of January 2011. (Area in green depicts forested land. Note that some individuals provide both diagnostic and taxonomic services.)

Two facilities providing entomology services did not specify their taxonomic area of expertise. Of the other facilities or individuals responding: eight reported specializing in Coleoptera, five in Hymenoptera, three in Lepidoptera and one each in Hemiptera, Homoptera, Orthoptera and Heteroptera.

Two of the pathologists reported specializing in DNA sequencing, and one did not indicate a specialty (Table 1). One facility reported specializing in horticultural pests (MAPAQ).

Over half of the available specialists indicated there may be restrictions on their services. These restrictions include the following (the number in brackets denotes number of specialists):

- turnaround time of four to six months because of other work commitments, although suspected invasive alien species would be expedited (1)
- budget limited or not available; time limited or no time; seasonal availability (6)
- availability dependent on the demands of the position (sample submissions would be dealt with if and when time was available) (1)
- able to supply services one day a week (1)
- will accept suspected invasive alien species; native species identification limited to that outlined in the survey (1).

As well, the NIS, which employs approximately 20 insect taxonomists, indicated it would process samples as

long as the submissions did not exceed the provincial or territorial demand outlined in the availability survey.

Table 1. Summary of specialty of available pest diagnostic and taxonomic services in Canada as of January 2011. (Note that some individuals have more than one specialty.)

Discipline	Order/Specialty	Diagnostics	Taxonomy	Both
Entomology	No noted specialty	1		
	Coleoptera	6	6	1
	Diptera		4	
	Hemiptera	1		
	Homoptera		2	
	Heteroptera		1	
	Hymenoptera	2	5	1
	Lepidoptera	2	3	
	Nematoda		1	
	Orthoptera	1		
Pathology	Molecular-DNA sequencing	1		1
	No noted specialty	2		
Both	Horticultural pests	1		
Total		**17**	**22**	**3**

PROVINCIAL AND TERRITORIAL DEMAND FOR DIAGNOSTIC AND TAXONOMIC SERVICES

Demand for diagnostic and taxonomic services by the provinces and territories can be summed up as follows:

- The current demand for external or federal diagnostic and taxonomic services is estimated to be from none to six submissions per jurisdiction a year. Expected turnaround times vary from one to four weeks (may be shorter for suspected invasive alien species).
- Demand for external diagnostic and taxonomic services for native insect pests is minimal compared with those for tree diseases in many jurisdictions and for taxonomy services for all pests.
- There is potential demand for diagnostic and taxonomic services for invasive alien species and less common native pests, varying depending on the introduction of invasive alien species and the influence of climate change on pest distribution and behavior.
- Demand is estimated to be highest during the spring and summer months, and during wetter years.

Diagnostic and Taxonomic Resource Materials, Tools and Expertise

Diagnostic and taxonomic resources and tools exist in many forms—including software, field guides, national collections and expertise—and are invaluable to forest health practitioners across Canada, particularly field personnel.

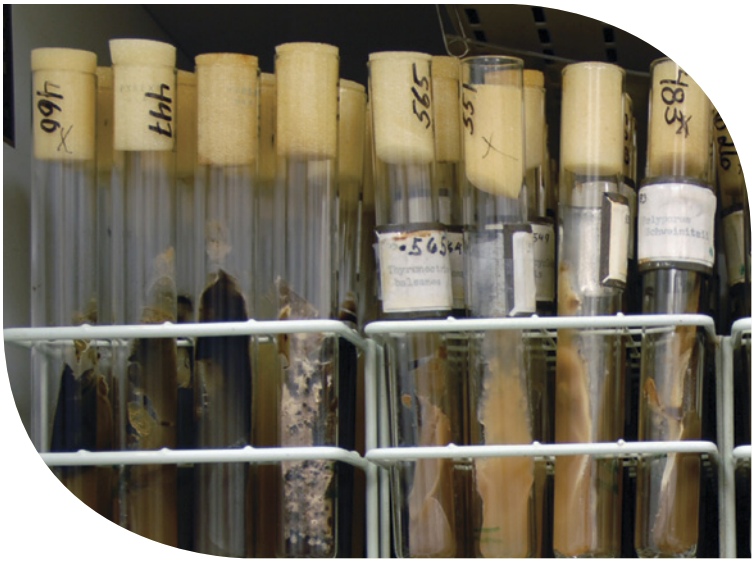
However, while many diagnostic tools are available, awareness of their existence is generally limited to the agency or jurisdiction that developed the tool. In many cases, these tools could be of value to neighbouring jurisdictions. The same is true of diagnostic and taxonomic expertise: it exists across Canada but is not easily identified or accessible by jurisdictions when they need it.

DATABASE OF RESOURCES

The NFPS Information and Information Management Technical Advisory Group has developed a diagnostic and taxonomic resource database within the Pest Strategy Information System (PSIS) of the NFPS to facilitate access to such resource materials.[6] The PSIS will be available by mid-2012 to provinces and territories. The PSIS will have several components, some of which will be completed and available at the onset, and others, like the national collections query, which will be available in the near future.

The PSIS database includes resource materials provided by provinces and territories, as well as links to websites that feature diagnostic tools or information (Table 2) and a list of currently available diagnostic and taxonomic resources. This database will benefit all jurisdictions by providing quick and easy access to a variety of diagnostic tools, pest management materials,

[6] Forest Pest Knowledge and Exchange: Pest Strategy Information System. 2012. Report for the Information and Information Management Technical Advisory Group of the National Forest Pest Strategy.



methodologies, survey forms and pest brochures. The database is by no means meant to be exhaustive or static, but rather dynamic, interactive and searchable. It will continue to grow as NFPS partners contribute additional information.

NATIONAL SPECIMEN COLLECTIONS

Authoritatively identified reference specimens in national collections are an exceptional and irreplaceable resource. Some of these collections exist at each of the five CFS forestry centres. In all, the CFS collections include:

- insects – over 730 000 pinned specimens, 30 000 vials and hundreds of microscope slides
- diseases – approximately 110 000 dried specimens and 5000 cultures.

While these materials are not currently available through the PSIS, future plans include the ability to query the collections database, which is currently being digitized (completion depends on ongoing funding).

Voucher specimens and associated insect or herbarium collections are vital tools. Continued investment in these collections is therefore necessary to ensure they are maintained, updated and catalogued.

Other collections located outside the CFS include the National Canadian Collection of Insects, Arachnids and Nematodes of Agriculture and Agri-Food Canada, and various local museums at major centres throughout Canada.

SPECIALIST EXPERTISE

A diagnostic and taxonomic expertise database is available within the PSIS. Currently this database contains the names of those individuals and organizations that have identified themselves as available to provide diagnostic and taxonomic services. The database will include information on area of expertise, contact information, preferred shipping dates, fees and other relevant details.

Database functionality will include a means to track diagnostic and taxonomic specialists through an annual email requesting those individuals to indicate their availability. A "new recruit" tool will also soon be available to enable new specialists to add their name and services to the diagnostic and taxonomic database.

Table 2. Summary of diagnostic tools and information resources in the Pest Strategy Information System by category and pest type.

	Pest Type					
Category	**All pests**	**Insects**	**Diseases**	**Exotics**	**Host-specific**	**Nursery pests**
Annual reports, pest alerts, fact sheets, brochures	5	1	1			1
Diagnostics (including online)	10	12	1	5		
General	9	4	5	3		
Impact		1				
Management	3	2	6		1	
Survey methodology	13	59	2			
Training	1					
Textbooks		67	8			
Total	**41**	**146**	**23**	**8**	**1**	**1**

A suggested sample submission form and protocol for this purpose was prepared by the British Columbia Ministry of Forests and Range in collaboration with the Canadian Forest Service in Victoria. It was modified for use by individuals seeking to submit samples to external agencies (Appendix 2). The form was designed to ensure compatibility with attributes used in FIDS enclosure slips, thereby facilitating a smooth integration with the FIDS Infobase, which will form part of the PSIS.

Discussion

Information-seeking surveys like the ones used to collect information for this review have an inherently low response rate. That was the case for these surveys: the one on national capacity had an 18% response rate and the one on national availability had a 26% response rate. These low rates may in part indicate reluctance by survey respondents to self-identify as a diagnostic or taxonomic specialist without knowing what the potential demand for services could be.

Because of the low response rate, however, it is difficult to draw meaningful conclusions about national capacity and availability. The results of these surveys therefore likely underestimate both.

Nonetheless, based on current pest monitoring and conditions, it appears that:

- National diagnostic and taxonomic capacity may be sufficient for entomology, particularly for common native forest insects.
- The availability of federal specialists to assist with timely identification of invasive alien species, less common native pests and forest diseases may be limited by other work commitments those specialists have in their program area.
- The capacity and availability of pathologists, particularly taxonomists, is limited at all levels of government. These shortages are currently most critical in the Atlantic Provinces, and are of particular concern nation-wide given the likelihood of new pathogen occurrences as an outcome of climate change and increased international trade and travel.
- The availability of local diagnostic and taxonomic services for both insects and diseases is lowest in the Prairie Provinces.
- Attrition in the federal government over the next five years may lead to a decrease in capacity across the country. The impacts resulting from these retirements will depend on whether vacancies are filled, and what skills and responsibilities will be assigned to replacement positions. Many other factors are likely to influence future demand and potential gaps as well, including extent of staffing and expertise in all levels of government, and pest monitoring levels and pest activity. It is anticipated, for example, that changing climate conditions will lead to an increase in the frequency and severity of biotic and abiotic disturbances, which in turn could lead to an increase in demand for diagnostic and taxonomic services.

A comprehensive diagnostic and taxonomic database, including expertise, has been compiled and will be available by mid-2012 through the Pest Strategy Information System (PSIS) of the NFPS. This database will benefit all jurisdictions by providing quick and easy access to a dynamic catalogue of diagnostic tools and expertise, pest management materials, methodologies, survey forms and pest brochures. A centralized database will also facilitate identification of priorities for the development of new or improved diagnostic tools by one or several agencies. These priorities could include identification of training opportunities as new or improved diagnostic tools are developed.

Options for Consideration

The surveys and actions undertaken over the last few years by the Monitoring and Diagnostics Technical Advisory Group have improved our understanding of the national capacity and availability of diagnostic and taxonomic services.

Similarly, the Information and Information Management Technical Advisory Group, through its development of the diagnostic and taxonomic resource database of the PSIS, has provided users with the ability to access and contribute to a dynamic list of resources.

The two options for consideration presented below aim at achieving the long-term provision and sharing of inter-governmental diagnostic and taxonomic resources,

as well as ongoing improvements and enhancements to diagnostic and taxonomic skills and resources.

Option 1 – Develop a coordinated, multi-agency approach to providing and tracking diagnostic and taxonomic resources.

The components of a coordinated multi-agency approach could include agreements or memorandums of understanding between participants and other agencies (such as academia), to ensure that all partners are actively updated and informed of diagnostic and taxonomic capacity, availability and needs. Similar to the mutual-aid resource-sharing agreement of the Canadian Interagency Forest Fire Centre (CIFFC), such an agreement would identify where diagnostic and taxonomic expertise exists and where there are shortages. Unlike CIFFC, however, there would be no movement of resources from one jurisdiction to another—just simply the sharing of existing resources.

A tiered approach to diagnostic and taxonomic support should be promoted. The PSIS database would serve as the initial resource for diagnostic assistance (pictures, queries, guides, etc.). Access to federal expertise would be the next level of support should the diagnostic and taxonomic resources fail to assist the user with identification. Protocols for access to federal specialists may have to be developed depending on the agency providing the services. The sample submission form and associated protocols that have already been developed could be considered for this function. Again it would depend on the agency providing the services.

The benefits of a coordinated approach include gains in efficiencies through the sharing of resources, and a better means to track and assess national diagnostic and taxonomic capacity. The PSIS database would provide a means of tracking resources, and would assist managers in identifying gaps that could then potentially be addressed through augmentation or enhancement of existing capacity as identified within the database.

Option 2 – Support the maintenance of existing diagnostic and taxonomic tools and the development of new tools, and identify training opportunities in diagnostic and taxonomic skills.

- Maintain and support federal pest collections.
- Support the development of new tools for improved diagnostics, including molecular diagnostic tools, web-based tools, and applications for smartphones and tablets.
- Provide mentoring and training opportunities to develop forest pest diagnostic and taxonomic skills.
- Develop and deliver training modules on diagnostic and taxonomic skills and techniques, with consideration to universities or technical schools which offer forestry programs where they exist.

Conclusions

These results represent a snapshot of the current demand for, and capacity and availability of, diagnostic and taxonomic resources in Canada. Inherent weaknesses associated with information-seeking surveys have likely underestimated capacity and availability. While demand can be expected to vary with provincial and territorial monitoring efforts, the ongoing need for diagnostic and taxonomic expertise will most likely grow at all

levels of government. Among the reasons for this: staff attrition at all levels of government, changing government mandates, and changes in pest incidence, frequency and distribution as a result of climate change.

Immediate needs include diagnostic and taxonomic support for pathology in the Atlantic Provinces. Elsewhere in the country, current diagnostic and taxonomic demand could potentially be filled with existing resources, although attrition could result in some service gaps within the next five years.

There is no formal commitment to track or update diagnostic and taxonomic capacity and availability in the future. This lack of coordinated national effort is a concern given the need to ensure that the required level of support and expertise is sufficient to deal with current and emerging pest problems. The diagnostic and taxonomic expertise database within the PSIS is a first step. However, it needs to be a dynamic list, updated to reflect both capacity and availability and so facilitate succession planning of diagnostic and taxonomic expertise.

All levels of government need to recognize the key role of diagnostic and taxonomic services and expertise in forest pest risk management. They also need to ensure that mechanisms are in place to identify national capacity, address shortages and gaps and, where possible, make efficient use of existing resources. The establishment of national multi-agency resource-sharing agreements offers a potential way to start.

Timely identification of forest pests is a critical component of risk management. Availability and access to qualified diagnosticians and/or taxonomists is therefore imperative. The lack of these essential services could result in significant losses in forested ecosystems and hardship to communities that rely on these forests for their goods and services.

The ideal level of forest pest monitoring and diagnostic and taxonomic support should reflect the:

- size of the forested land base and management objectives
- increasing risk from invasive alien species
- potential for changes in native pest range
- increased frequency and magnitude of epidemic events that may be accentuated by climate change.

As forest pests could pose a potential threat to the sustainability of Canada's forests and carbon reserves, it is critical that sufficient levels of diagnostic and taxonomic resources be maintained and supported at all levels of government, now and into the future.

This report represents a first step in a continuum of steps required to ensure that adequate levels of forest pest diagnostic and taxonomic resources exist across Canada. Ongoing consultation with participants and implementation of the considerations, or variations thereof, are critical to achieving the long-term NPFS objective of ensuring adequate diagnostic capacity to meet present regulatory and management requirements.

APPENDIX 1. ABBREVIATIONS

AAFC	Agriculture and Agri-Food Canada
CCFM	Canadian Council of Forest Ministers
CFIA	Canadian Food Inspection Agency
CFS	Canadian Forest Service
CIFFC	Canadian Interagency Forest Fire Centre
FIDS	Forest Insect and Disease Survey
NFPS	National Forest Pest Strategy
NIS	National Identification Service
NRCAN	Natural Resources Canada
PMRA	Pest Management Regulatory Agency
PSIS	Pest Strategy Information System

National Forest Insect and Disease Collection and Identification

A

PROVINCE | COLLECTION LOCATION (be specific)

LATITUDE (decimal degrees) | LONGITUDE (decimal degrees) | ELEV. (m) | **B** COLLECTION DATE Y M D | **C** COLLECTOR

C

AGENCY | STREET | CITY | PROVINCE

POSTAL CODE | EMAIL | PHONE | FAX

D HOST/SUBSTRATE

SCIENTIFIC NAME

COMMON NAME

HOST TYPE

☐ 1. Seedling (nursery) ☐ 3. Seedling (forest) ☐ 5. Immature ☐ 7. Mature ☐ 8. Over-mature
☐ 9. Dead standing ☐ 10. Dead fallen ☐ 11. Wood product

NON-PLANT SUBSTRATES: ☐ 12. Duff ☐ 13. Mineral Soil ☐ 4. Insect ☐ 15. Fungus

OBJECT SAMPLED

☐ 1. Flower ☐ 2. Fruit ☐ 3. Buds ☐ 4. Old foliage ☐ 5. New foliage
☐ 6. New shoot ☐ 7. Branch ☐ 8. Stem ☐ 9. Butt ☐ 10. Root
☐ 11. Bark ☐ 12. Whole plant ☐ 13. Trap ☐ 14. Non-plant substrate ☐ 15. Other: _____

E STAND TYPE

☐ 1. Nursery ☐ 2. Ornamental ☐ 3. Plantation (native) ☐ 4. Plantation (exotic) ☐ 5. Shelterbelt
☐ 6. Hedgerow ☐ 10. Scattered indiv. ☐ 12. Spaced ☐ 13. Fertilized ☐ 14. Pruned
☐ 15. Comm thinned ☐ 16. Untreated ☐ 17. Sprayed ☐ 18. Urban ☐ 19. Even- aged
☐ 20.Uneven aged

TREE HEIGHT (m) | AGE | DBH (cm)

SAMPLING TECHNIQUE

☐ 1. Beating ☐ 2. Hand-picked ☐ 3. Pheromone trap ☐ 4. Other trap (describe) _____ ☐ 5. Light trap ☐ 6. Other (describe) _____

F DISTRIBUTION OF PEST

☐ Individual tree ☐ Patches ☐ Uniform ☐ Scattered

INCIDENCE (% of host affected) | SEVERITY (% of tree affected) | AREA (~ hectares affected)

G TENTATIVE IDENTIFICATION / REMARKS

H PHOTO NUMBER (if available)

YEAR | FACILITY ID REGISTRATION NUMBER | **THIS SECTION FOR USE BY IDENTIFICATION FACILITY ONLY** | ☐ INSECT ☐ DISEASE ☐ FUNGUS | PAGE___OF___

No. of specimens	Final Identification	Insect Stage	Disease Stage	Remarks

IDENTIFICATION FACILITY COMMENTS:

FORM INFORMATION

Note: Some numbers on the form are not sequential. The attributes associated with the numbers were removed, but for the purposes of providing consistency with the FIDS Infobase the original numbering system has been maintained.

All specimens submitted should include the National Forest Insect and Disease Identification and Collection form or equivalent, noting the following minimum data (letters correspond to those on front of form mentioned above):

A Geographic location of collection, latitude and longitude (in decimal degrees) and elevation (metres).

B Date of collection:(year-month-day format, e.g., 2012 06 04).

C Collector's name and contact information: name of agency (if applicable), mailing address, email address, telephone and fax numbers. Note: If the submitter is someone different from collector, include submitter name in remarks section (G).

D Host/substrate information: host species Latin and common names; host type; if substrate is not a plant, type of substrate; and location of damage on host.

E Stand description: type, tree height, age, and DBH; and sampling method used by collector.

F Distribution of pest: pest pattern on the landscape, incidence, severity, and approximate area (hectares) affected.

G Tentative identification and remarks: Also note unusual conditions or contributing factors (e.g. heavy frost, drought, chemical applications, proximity to roads). Attach extra sheet if needed for remarks.

H Photo number: number and folder on computer where image is stored (if applicable).

SPECIMENS AND SHIPMENT

Special care must be taken to collect an adequate specimen and to prevent deterioration of material in transit. Inadequate or spoiled material cannot be processed. Ship live material by Priority Post, Xpress Post or courier, and use crush-resistant containers (e.g., mailing tins). For labels on vials, notes and enclosures, use an HB pencil or permanent marker to ensure printing cannot wash or rub off. Use only high quality paper for labeling. For labels in liquid use an HB pencil and waterproof paper.

Never use plastic bags or wrap for shipping specimens (the one exception is defoliating insects; see below), and do not moisten specimens. For fresh disease or fleshy fungi collections, prevent mould contamination by using paper envelopes, paper wrapping and cardboard boxes for shipping. If dead insects are shipped, send them on pins or in alcohol vials.

Insects

Larvae of defoliators: Ship 10-20 live larvae in a tied plastic bag with sufficient foliage for 3-5 days of feeding. Additional larvae can be washed in 70-80% ethanol (preferred) or isopropyl (rubbing) alcohol beforehand and stored in a saline solution or food-grade propylene glycol for shipment. Vials must be well sealed and packaged with sufficient absorbent material and a waterproof wrap to prevent contamination or leakage if a container should break.

Adult defoliators: To disable insect, use a killing jar or squeeze thorax just at a point where wings meet thorax. Fold wings together above insect and place in scrap paper or celluloid (stamp) envelope, one specimen per envelope. Place envelope (or envelopes) in bubble wrap for shipment.

Larvae of bark beetles or woodborers: Collect borers in small-diameter (<10 cm) stems or shoots. Ship larvae from larger material as instructed above for "larvae of defoliators". Enclose a sample of typical damage, packaged separately.

Pupae and hard-bodied insects: Ship *live material* in small containers. Include packing in containers to protect the material during shipping. Ship *dead adult specimens* between layers of tissue paper (no cotton) in a rigid container with sufficient packing to prevent any movement of material within the container. Before shipping parasitic Hymenoptera, kill specimen by dropping it into 70% ethanol. Then follow instructions above for shipping defoliator larvae.

Diseases

*General***:** Keep all specimens in a cool place until shipped. For young diseased trees, include samples from roots in plastic bag.

Foliar diseases: Collect 20-cm length branches with leaves. Press flat between newsprint or, for bushy specimens, wrap in a paper bag. Include a cutting of healthy foliage (labeled) for comparison, and flowers or fruit of host plant, if identity unknown. For spring collections, include over-wintered, old foliage from ground litter or from tree as these may contain mature fruiting bodies.

Stem and branch diseases: For small-diameter material, cut a 20-cm length of affected stem material and a generous section of healthy stem material. For larger-diameter material, cut a section of at least 10 x 10 cm from the edge of a canker. Include affected and healthy-appearing tissue, and a section of bark with any apparent fruiting bodies.

Decay in wood, root disease and blowdown trees: Determine the tree species. Collect any conk or mushrooms closely associated with decay. At any fungal conks or areas of breakage or suspected decay (including decayed or diseased roots), cut a wood section of at least 15 x 15 x 15 cm that includes decayed, stained and apparently sound wood. Describe the decay. For suspected root disease, select trees that recently died, fell or exhibited signs of tree decline (symptomatic). Avoid trees or roots that have been dead for one or more years. Sample fresh roots with disease features such as pitching, mycelia or stain. Package wood samples and conks separately. Label and wrap the samples in newsprint.

Fleshy Fungi: Collect several specimens, especially of varying maturity. For ground specimens, pry as much of the mushroom as possible out of the ground with a knife. For specimens on wood, also collect a specimen of any underlying wood decay, as described above. Dry all fleshy fungi before shipping. Air-dry small fragile specimens in a warm dry place. For larger fungi, heat-dry at 50°C. Spore prints from fresh collections can be submitted with dried specimens. Package in dry material to protect in transit. Alternatively, ship fresh mushrooms in cardboard boxes or paper bags to avoid humidity and associated moulds.