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Web-based Diagnostic Tool for Insects and Diseases of British Columbia's Forests and Forest Nurseries

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Strategic Importance and Management Implications

Correct identification of insects and diseases, whether in the forest or the nursery, is essential to sustainable management of forests. During the 15 years from 1980 through 1994, insects and diseases damaged an estimated 6.72 million ha of forest land in Canada. Over the same period, an estimated 20 million ha have regenerated naturally and some 5.59 million hectares have been planted. Forest insects and diseases can reduce growth, degrade lumber, and cause mortality, thereby disrupting or invalidating harvesting and other management plans. They also have a negative impact on non-commercial values and uses of public and private forests. In nurseries, insects and diseases not only affect the quantity and quality of forest nursery seedlings, but can disrupt reforestation plans and reduce survival of outplanted stock.

Insects and diseases are an integral part of forest ecological processes and most contribute to recycling forests without adverse effects. From a management perspective, problems occur when conditions result in insect and disease outbreaks.

Therefore, understanding the relationship of forest insects and diseases to their hosts is fundamental to sustainable management plans and provides the foundation for Integrated Resource Management strategies. These strategies must be consistent with continuing social and economic demands for effective methods of managing insect and disease problems with minimal reliance on chemical methods.

The ability of forest managers to recognize and inventory common tree diseases and insects is often inadequate, and this means they are unable to use predictive models and cost-benefit analysis of management treatments. To answer this need, the Canadian Forest Service has developed a knowledge base and diagnostic framework of common tree diseases and insects, using expert systems to link diseases with host species and distinctive signs or symptoms. Information on the Web is accessible to most common personal computers and can be easily updated to broaden its scientific and practical applications. The Web Diagnostic Tools are available in both French and English. Use of electronic diagnostic tools is increasing and will facilitate the development of Integrated Resource Management strategies.

Biological Significance

The most important diseases in British Columbia's forests are caused by fungi and dwarf mistletoes. The magnitude of damage depends on the relative susceptibility of the tree (host), the virulence of the causal agent and its life history, as well as the environmental and other factors that influence the resistance of the host. Consequently, a disease may vary in importance among tree species in one region or in the same tree species in neighboring regions.

Enter the Forest Insect and Disease Diagnosis Program through **http://www.pfc.cfs.nrcan.gc.ca/hforest/**

Enter the Nursery Insect and Disease Diagnosis Program through **http://www.pfc.cfs.nrcan.gc.ca/nursery/**

More than 90% of seedlings in British Columbia are grown in the Styroblock Reforestation System, largely replacing conventional bare-root stock. While nursery

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production using styroblocks has resulted in competitive costs for producing and transporting seedlings, the stock is grown closely together in a very controlled environment. An outbreak of insects or disease, if not diagnosed early, could have major impact on seedling production. A key feature of the nursery pest diagnosis system is its ability to integrate the interaction of nursery conditions and biological considerations. This system also includes a section of "look alikes" for each disease to draw attention to potential misdiagnoses, and a section describing the enhancement of diseases by particular nursery conditions.

Hypermedia and expert systems

The Insect and Disease Diagnostic Tool and the Nursery Diagnostic Tool presented here have been built using hypermedia (hypertext extended to include other media such as images) as an adjunct to an expert system. The expert system was included to guide the choice of links to access the most suitable information for diagnosing unknown problems. Consequently, diagnosis can be facilitated by answers to database-type questions. The combination of hypermedia and expert systems overcomes many of the limitations of using an expert system alone. This enables relevance checking, bias and accuracy evaluation, and organization and synthesis by the system user. Hypermedia incorporating data, graphics or sound is analogous to the traditional method of storing information on 3 X 5-inch cards and is defined as the creation and representation of links among discrete pieces of data. In hypermedia systems a screen of information is the analogue of the card.

Information Retrieval

Extensive information can be obtained by browsing the main menu (Figure 1). (Figure 1 is based on the HForest system; the two systems are very similar in most features.)

Select Species by Scientific Name
Select Species by Common Name
Diseases and Insects by Host
Diseases and Insects by Region
Diseases by Signs and Symptoms
Problem Diagnosis

Figure 1. The main menu, HForest (Forest Insect and Disease Diagnosis)

Information on specific pathogens can be obtained by three main routes:

1) The Scientific or Common Name Index lists diseases and pathogens by name;
2) The Host Index lists organisms that cause disease by host (commercial species); and,
3) The Symptom Index lists pathogens by distinctive signs or symptoms.

For example, Figure 2 illustrates a browse path through the Symptom Index. The user begins this search with the main menu and selects topic paths.

Diagnosis

A diagnosis can be carried out by selecting host species and signs and symptoms on a form available through the "Problem Diagnosis" link on the opening page, and then selecting the "Submit Query" button at the bottom of the form.

As an example, a group of Engelmann spruce trees in the Cariboo Region of British Columbia are showing defoliation, and the remaining foliage is brown with a somewhat scorched appearance. Figure 3 illustrates the query approach using these observations. The result of the query shows no exact match but presents four candidates that match all but one criterion ("exclusions, class #1")

Insects and diseases are ranked based on the number of signs or symptoms which exclude them as possible diagnoses. The number of exclusions on the table of results is itself a link that, when selected, shows a summary of the signs and symptoms that support or deny the species as a possible diagnosis. It is possible to determine both the most probable diagnosis and why a particular disease is not a possible diagnosis.

The above description is based on HForest. The Diagnostic Nursery System works in the same manner but has additional criteria such as nursery type, season and seedling age.

The Web Diagnostic Tools were designed and tested with Netscape Navigator 4.0, and make use of Netscape's navigation abilities. For example, if you wish to change your query entry, press the back button of your browser to return to the diagnosis form, showing the last information entered.

Discussion

These diagnostic programs are an extension of previous work on forest insect and disease diagnosis and management using expert system-guided hypermedia. As the World Wide Web is a form of hypermedia based on a Hypertext Markup Language (HTML), our experience with these earlier systems helped in the development of the

Figure 2. Example of a search through the Symptom Index of the nursery system.

Select Diseases by Signs and Symptoms from Main Menu

Tree Sign or Symptom

Needle Problems
Foliage Discoloration
Shoot Problems
Root Problems
Seed-borne Diseases
Additional Signs

Foliage Dicoloration

brown needles
purple needles
orange needles
chlorotic needles

Brown Dicoloration

Botrytis cinerea
(Gray mould)

Colletotrichum acutatum
(Colletotrichum blight)

Colletotrichum gloeosporioides
(Colletotrichum blight)

Cylindrocarpon destructans
(Cylindrocarpon root rot)

Didymascella thujina
(Cedar Leaf Blight)

(Others)

Gray mould

Hosts and damage
Life history
Management
References
Look Alikes
Summary

Links to figures, photos and visual signs and symptoms

Figure 3. Example of a diagnostic query from the main menu of the Hforest system.

Select Tree Disease Diagnosis from main menu

Query

HOST SPECIES:	Englemann spruce,
REGION:	Cariboo,
FOLIAGE DISCOLORATION:	brown,
CROWN DAMAGE:	defoliation scorched appearance

Diagnosis Results

Species	Exclusions
Acleris gloverana (Western Blackheaded Budworm)	1
Choristoneura spp. (Spruce Budworms)	1
Lambdina fiscellaria (Western Hemlock Looper)	1
Melanolophia imitata (Green-striped Forest Looper)	1
Isthmiella crepidiformis (Isthmiella Needle Blight of Spruce)	2
Leptographium wageneri (Black Stain Root Disease)	2
Phellinus weirii (Phellinus (Poria) weirii Root Rot)	2

Sample of information provided:

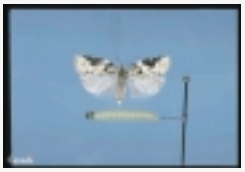
The Western Blackheaded Budworm, *Acleris gloverana* is a defoliating insect occurring throughout British Columbia that periodically causes extensive defoliation of coniferous forests.

Hosts and Distribution: In B.C., most abundant west of the Cascade Mountains and in interior wet belt areas. The preferred hosts are western hemlock and the true firs; spruce and Douglas-fir.

Damage: The larvae at first confine their feeding to new growth, but when numerous they will feed on older foliage. The heaviest concentrations of larvae are usually in the upper crowns of trees. Severe defoliation for one or two years may result in top-kill. If an outbreak continues for more than two or three years, the risk of tree mortality becomes high. Such damage can reduce harvestable wood volume by up to 20%. Many trees recover and attain normal foliage complements within a few years.

Pictures and figures. E.g. Figure 239-0056. Adult and larva of blackheaded budworm

Figure 239-0056. Adult and larva of black headed budworm.



The Western Blackheaded Budworm, *Acleris gloverana*

Excluded	Not Excluded
Scorched Appearance	Brown foliage Cariboo Engelmann Spruce - *Picea engelmannii* Defoliation

present systems, which, being Web-based, will provide flexibility and will be easy to update.

Some diseases are covered by more than one diagnostic system. In the same way that you can have several publications on a particular topic, you can have more than one web-based system that can provide information on that topic.

There are other systems on the Pacific Forestry Centre site which can assist in making diagnosis or can provide more information once a correct diagnosis has been achieved. Examples include:

Common Tree Diseases of British Columbia was described in Technology Transfer Note No. 9.
http://www.pfc.cfs.nrcan.gc.ca/health/td_web/index.html

Forest Health Network aerial detection survey coverage of pests in British Columbia can be selected in three different ways: by mapsheet, by region, or for the whole of British Columbia. They are stored as an ArcInfo coverage format and are converted to an ArcInfo export file format for FTP purposes.
http://www.pfc.cfs.nrcan.gc.ca/health/pests/

The British Columbia Host/Fungus Index is compiled from 60 years of Canadian Forest Service records, augmented from published literature records and data provided by Agriculture Canada. This Index has been designed to assist in the formal identification and documentation of fungi occurring on native plants in British Columbia.
http://www.pfc.cfs.nrcan.gc.ca/biodiversity/herbarium/Herb_Search.html

Pacific Forestry Centre's **Forest Pathology Herbarium** (DAVFP) is an internationally recognized collection of over 35 300 forest fungi and disease specimens, representing over 3000 different fungal species.
http://www.pfc.cfs.nrcan.gc.ca/biodiversity/herbarium/Voucher_specimens.html

The **Canadian Forest Researchers Directory** links forestry researchers in Canada (many of whom are working on forest insects and diseases) and allows the forestry community to locate and contact experts working in forestry research.
http://www.pfc.cfs.nrcan.gc.ca/cfrd/

Additional Reading

Thomson, A.; Allen, E.; Morrison, D. 1997. Web Diagnostic Tool for Common Tree Diseases of British Columbia. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre. Technology Transfer Note No. 9.

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