Impact and Distribution of Western Gall Rust Infection in Ontario Jack Pine Plantations

H.L. Gross and R.N. Irwin

The influence of western gall rust (*Endocronartium harknessii*) infection on tree quality and growth and on stand stocking and yield has been monitored since 1987 in four populations of jack pine (*Pinus banksiana*) that were planted in 1982 or 1983. Annual infection trends, based on gall age, show that favorable conditions for the disease occurred in 1984 and 1987. Tree position and infection status were mapped on 3-m-wide transects that extended away from the adjacent jack pine stands that contained the initial inoculum source. This provided a database for investigating infection gradients and the influence of the rust based on 4- and 6-m^2 units as well as providing per-hectare estimates.

Special Projects of the Mycology Section of the Forest Insect and Disease Survey Unit

D.T. Myren and C.N. Davis

In the mid-1980s a fungus was found that seemed to be acting as a parasite on the aecia of the rust *Chrysomyxa ledicola*. We are currently confirming the identification of the parasite and developing a method to inoculate black spruce with the rust. Once we can establish the rust on spruce in the greenhouse, we will be able to experiment with methods of inoculating its aecia with the parasite and evaluate its parasitic role more critically.

In 1990, we reported *Sphaeropsis sapinea* as a cause of dieback of stressed black spruce. We are now examining spores from these and other hosts of the fungus under the scanning electron microscope for variations in spore surface morphology. Inoculations to test host specificity will be conducted soon.

Isolates of *Armillaria* spp. are being collected from hardwood hosts in an effort to determine the species present, and their frequency, host range and geographic distribution. Laboratory work to determine species is scheduled to begin after the current field season.

A Northern Ontario Development Agreement project is now under way to develop a field guide to tree diseases. This guide is aimed at forestry technicians and other field workers. The project is being directed by Dr. D.T. Myren of the federal government and Dr. T.R. Meyer of the provincial government.

Forest Insect and Disease Survey Field Pathology Program

A.A. Hopkin

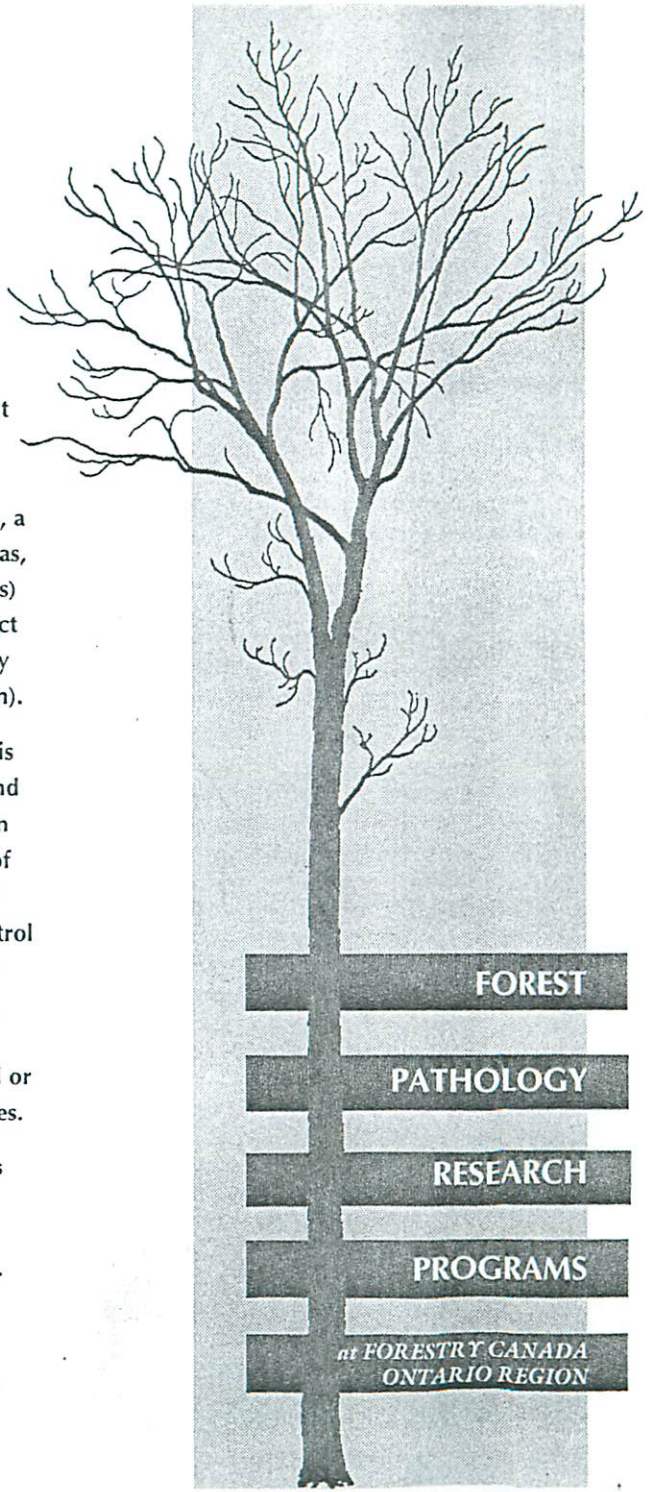
The FIDS field pathology program studies forest health and the biology and impact of fungal diseases. Current studies include monitoring the health of trees in oak and sugar maple plots and participation by FIDS in the Acid Rain National Early Warning System (ARNEWS) and the North American Maple Project (NAMP). This study also performs quality assurance work for the ARNEWS program at a national level. Research also comprises the development of methodologies to detect changes in tree condition and the use of geographical information systems to analyze forest health data and predict changes in forest conditions.

The field pathology program also conducts impact studies on the Scleroderris disease of red pine in collaboration with our economics section and the University of Guelph. A joint study with the university is developing biological and biorational control mechanisms for the suppression of grey mold on containerized black spruce. FIDS also assesses the impact of insects and diseases in seed orchards and young coniferous plantations in Ontario, especially that of *Sphaeropsis sapinea* in black spruce seed orchards. Another joint project with Forestry Canada's Northwest Region and Laval University is studying the biology of Armillaria root rot in seed orchards.

Forest pathology at Forestry Canada Ontario Region comprises two units, a Research unit (Dumas, Gross, and Richards) and the Forest Insect and Disease Survey unit (Hopkin, Myren).

The Research unit is involved in basic and applied projects on the development of biological control stategies for the control of forest diseases through classical, silvicultural and molecular biological or genetical approaches.

The Survey unit is involved in the identification of diseases and their impacts on the productivity of Ontario's forests.



Biological Control of Forest Diseases

M.T. Dumas and N.W. Boyonoski

The productivity of Ontario's forests and nurseries is affected by several root pathogens. In the regenerating stands in northern Ontario, *Armillaria ostoyae* is the most important disease whereas in the plantations of southern Ontario, *Heterobasidion annosum* and *A. ostoyae* are the most prevalent. In the bareroot nurseries, *Fusarium* spp. and *Cylindrocladium floridanum* are the most destructive root pathogens. Research currently being done at Forestry Canada–Ontario Region focuses on the biology of these pathogens and the development of biological control strategies.

Within our bareroot nurseries, several *Fusarium* species are present. Molecular genetic work is currently being done by Arti Duggal, a graduate student, to better understand the role of these fungi in initiating disease, to develop quick and accurate methods to forecast the potential population of each species prior to seeding or transplanting, and to develop biocontrol approaches for their management. Development of biological control strategies for *C. floridanum* centers on the use of antagonistic actinomycetes (*Streptomyces*), fungi (*Trichoderma* and *Penicillium* species) and bacteria (*Bacillus* and *Pseudomonas* species). Techniques to effectively introduce the antagonist into the soil have focused on seed dressings that maintain the populations of the biological agent and at the same time are compatible with the normal production practices of a commercial nursery. Field trials to evaluate the effectiveness of the biological control agents as well as the introduction methods are under way. The antifungal compounds produced by both the pathogens and antagonists are extracted, purified and identified in order to understand the modes of action and to use in the development of natural fungicides. In collaboration with Dr. G.M. Strunz, natural products chemist at Forestry Canada–Maritimes Region, we have isolated cyclo-heximide from some of the more active *Streptomyces*; 6-pentyl-pyrone from some *Trichoderma* species; and phenazine-1-carboxylic acid, 2-hydroxy-phenazine and oxychloroaphin from strains of *Pseudomonas fluorescens*. Research is ongoing in this aspect of the project. The ability of rhizobacteria to promote seedling growth is also evaluated.

Research into the development of control measures for *H. annosum* converges on the primary wood colonizers, bacteria and fungi, to make the freshly cut stump surfaces less receptive for germination of *H. annosum* basidiospores and more receptive to the beneficial wood decayers. Research has been ongoing to find bacteria that are primary colonizers as well as being inhibitory to *H. annosum*. Several such antagonists have been isolated.

In the boreal and boreal mixedwood forests of Ontario *A. ostoyae* is the most serious pathogen. A large number of antagonists capable of inhibiting mycelial growth have been isolated from soils. More importantly, they are capable of inhibiting the formation and growth of rhizomorphs, the primary method of infection utilized by this pathogen in Ontario. Endophytic bacteria and fungi, antagonistic to the growth of *A. ostoyae*, have been isolated from the roots and stems of our commercially important species. An inoculation technique that is effective and readily adaptable to greenhouse and nursery practices has been developed to ensure that the outplanted seedlings are infected with an inhibitory strain of the endophyte.

In Ontario the development and progression of *A. ostoyae* is very dependent on site conditions. Field experiments are being conducted to evaluate the beneficial or harmful effects of various silvicultural treatments on the establishment and spread of *A. ostoyae* and their influences on the populations and biodiversity of soil microbes.

Molecular Approaches to Forest Disease Control

W.C. Richards

Fungi are the primary microorganisms responsible for infecting our forests and nurseries in Canada. The major fungal pathogens include *Cronartium ribicola* (white pine blister rust); *Gremmeniella abietina* (Scleroderris canker of pine); *Ophiostoma ulmi* (vascular wilt of elm); *Ceratocystis fagacearum* (vascular wilt of oak), *C. clavigera, C. minor, and C. huuntii* (blue stain of pine); *Hypoxylon mammatum* (Hypoxylon canker of aspen); *Heterobasidion annosum* (annosus root rot); and *Fusarium* spp. and *Cylindrocladium floridanum* (damping-off and root-rot of nursery seedlings). Through various types of fungal spores, dissemination of each of these pathogens is capable of establishing epidemic levels of disease.

Novel non-sporulating strains of the Dutch elm disease fungus, *O. ulmi*, have been recently isolated. The initial strain was obtained as a natural mutant that developed as a sector from a highly pathogenic wild-type sporulating strain. Since then, various non-sporulating strains have been isolated from trials of the fertility of crosses between various strains. All non-sporulating strains are incapable of causing internal and external symptoms associated with Dutch elm disease. This has been clearly demonstrated through artificial inoculation into white elm, *Ulmus americana*. The lack of disease spread within the host is directly related to the inability of these strains to produce asexual spores. It is this growth phase (the spores) of the fungus that is instrumental for rapid spread of the pathogen and distribution of the toxin cerato-ulmin within the host's vascular system. Segregation analysis of the meiotic products that resulted from fertility trials has provided solid evidence to clearly confirm that the mechanism(s) that control non-sporulation is genetic and under the control of a single nuclear gene.

Strains with this unique characteristic have provided an opportunity upon which to build a research study to elucidate the molecular determinants responsible for blocking a pathogen's ability to sporulate. This innovative molecular approach may lead to the development of biological methods for controlling against sporulating fungal pathogens and is an integral part of the overall forest pathology program at Forestry Canada–Ontario Region for the development of biological research strategies.

Guidelines for Rating Root Rot Hazard Based on Ecological Site Character and Inoculum Level

H.L. Gross, A.M. Wiensczyk and R.N. Irwin

Ecological site relationships with the incidence of Armillaria root rot caused by *Armillaria* spp. are being investigated with the goal of providing useful guidelines for the selection of planting sites and other forest management considerations. The project is being supported by the Northern Forestry Program of the Northern Ontario Development Agreement and has the interest and participation of industrial and provincial forest managers.

Young black spruce (*Picea mariana*) plantations are being sampled for the presence and abundance of Armillaria root rot. The plantation sites are classified according to an existing forest ecosystem classification that characterizes sites based on the major vegetation, as well as soil texture, moisture regime and other site characteristics. Additional items such as the amount of competing vegetation, aspect, and slope position are also sampled. Our plans are to produce a manual that can be used with the existing ecosystem classification manual and that will contain information about sites where Armillaria root rot damage can be expected and root rot management considerations applicable to these sites.

The planting records for all black spruce plantations 5 to 15 years old in the Thunder Bay and Nipigon districts were reviewed to obtain a selection of 50 plantations stratified by the major vegetation type of the previous forest. These plantations are currently being sampled to rate the various items noted above. Armillaria root rot activity is rated by extracting a sample of spruce trees that show symptoms of root rot and a sample of apparently unaffected trees. Some measure of food base availability for the pathogen is being recorded in terms of the number of tree stumps and amount of debris present on the site. We plan to use factor analysis and ordination analysis to examine the data.