32441

Archives PDF

NODA • EDNO

CANADA ONTARIO

Northern Ontario Development Agreement

Entente de développement du nord de l'Ontario

Forestry • Foresterie

FILE REPORT 52

Regression Model Identifies Site Factors, Stock Type and Basal Area of Stumps as Significant Factors in *Armillaria* Infection Levels in Black Spruce Plantations

A.M. Wiensczyk, M.T. Dumas and R.N. Irwin

Natural Resources Canada | Ressources naturelles Canada

Canadian Forest Service | Service canadien des forêts

Ministry of Natural Resources | Ministère des Richesses naturelles

Ontario

Canadä

Regression model identifies site factors, stock type and basal area of stumps as significant factors in *Armillaria* infection levels in black spruce plantations

A. M. Wiensczyk, M.T. Dumas and R.N. Irwin

Category: Disease management

Key Words: Black spruce, armillaria, FEC, plantations

(Black spruce compendium note)

INTRODUCTION

Armillaria ostoyae [Romagnesi] Kerink. is the most widespread and destructive root disease of trees in Ontario. Studies of black spruce (*Picea mariana* [Mill.] B.S.P.) plantations, aged 7 to 20 years, revealed that 5 percent average annual mortality occurs as a result of Armillaria root rot. Groups of dead trees cause gaps in the stand and, as the disease pockets can spread at a rate of 1–2 m per year, future wood will be reduced.

This technical note reports on a study that aimed to identify some key factors contributing to *A. ostoyae* infections. With improved understanding of conditions that favour infection, forest managers can better plan regeneration treatments and forecast relative stand productivity at rotation age. This study found that infection levels in regenerating black spruce plantations were significantly related to site factors, stock type, and the basal area of residual stumps.

SITE FACTORS

Site characteristics play an important role in the incidence and spread of *Armillaria* root disease both directly, through their effects on the fungus and indirectly, through their effects on the host. Redfern and Filip (1991) discuss several environmental factors including soil temperature, pH, moisture, organic matter content and nutrient status which may directly affect the growth of *Armillaria* rhizomorphs through the soil. Damage by *Armillaria* root disease is known to increase in severity of attack when trees are stressed either by abiotic or biotic factors (Wargo and Harrington 1991), and certain site characters such as soil texture and moisture regime relate to stress susceptibility. As well, tree vigour and the resistance of the tree to infection may be a function of site.

Photo: Groups of dead trees in forest stand - to be provided by M. Dumas

STUDY APPROACH

To help identify the role of various site factors in *Armillaria* infection, the study examined black spruce seedlings planted on different Treatment Units (TUs) as identified by the Northwestern Ontario Forest Ecosystem Classification (NWOFEC) system. TUs are defined as "management-oriented aggregations of defined soil and vegetation conditions that possess similar species composition, productivity, macro climate, or ecological properties" (Racey et al. 1989).

XXXXX

Eight plantations in each of TUs B, C, D, E, and F were selected (refer to Racey et al. 1989 for a description of each TU). Stock type (paperpot vs. bareroot) was confirmed for each plantation. Five transects (4 m wide x 50 m long) were established in each plantation, along which soil samples were taken and analyzed for macro and micro nutrients, pH, cation exchange capacity, and texture. Soil moisture regime was determined. A minimum of 40 trees were sampled in each transect and categorized as healthy or symptomatic. The roots of a sample of healthy trees and all symptomatic and dead trees were examined for signs of *Armillaria* infections, which were confirmed by isolation of the fungus. For each transect the number of residual stumps from the last harvest were assessed to determine tree species, diameter, and presence of mycelial fans, rhizomorphs, and the state and type of decay.

Non-linear regression techniques were used to construct a predictive equation using the TU, soil composition and seedling regeneration method to predict *Armillaria* infection levels. The stepwise method for multiple linear regression analysis was used to determine the significant environmental variables to be used in the non-linear model.

Photos: *Armillaria* rhizomorphs, sampled trees

- to be provided by Mike Dumas

MODEL RESULTS

Significance of TUs B and D

When the percent infection by *Armillaria* was adjusted to a common tree age of 15 years, the model indicated that TUs B and D generally had lower infection levels if all other factors were held constant. This is supported by the mean *Armillaria* infection level by TU which shows that plantations in these units had the lowest infection levels (Wiensczyk et al. 1996). Plantations in TU B were dominated by aspen stands prior to harvest and planting to black spruce while those in TU D were dominated by balsam fir and/or white spruce. It was originally thought that disease severity was greater in conifer stands planted on sites originally dominated by hardwood as compared to those planted on sites originally supporting conifer (Redfern and Filip 1991). Recently, however, increasing numbers of reports have documented high levels of *Armillaria* infection on second generation conifer sites (Redfern and Filip 1991).

Photo: TU B, D, sites - to be provided by Mike Dumas

Clay content in the C-horizon

The model indicated lower levels of *Armillaria* infection as percent clay increased in the C-horizon. The soil texture of the A-horizon was generally coarser than that of the C-horizon and was not a significant factor in explaining the severity of the disease. Clay in the C-horizon probably had more influence on the condition of the black spruce than on the growth of the *Armillaria* rhizomorphs. It is possible that trees growing on the finer textured soils were subjected to less moisture stress during dry periods of the growing season than those growing on the drier coarser textured soils.

Another possibility relates to changes in the root form of black spruce planted in different textured soils. On drier, sandy soils black spruce may develop a more fibrous root system with extensive feeder roots in order to increase moisture uptake as opposed to the development of a more compact root system in the finer textured soils. A more fibrous root system may increase the probability of contact between tree roots and the fungus thereby increasing the chances of infection.

Stock type

Plantations planted with bareroot stock had higher infection levels than those planted with paperpot stock. Similar results were found by Singh (1975) in a survey of softwood plantations in Newfoundland. One explanation is that the planted bareroot stock may be subjected to more planting stress than container stock. During the outplanting process bareroot stock loses direct contact with the soil and often loses a proportion of its fine roots during lifting from the nursery beds (Tinus 1974, Sutton 1978). Container stock, on the other hand, maintains root contact with the soil and has an external source of moisture and nutrients in addition to it's internal supply which results in reduced planting stress as shown by increased initial survival and growth (Tinus 1974). J-roots and other deformations of the root system may also make the trees more susceptible to infection (Sutton 1969). Both container stock and bareroot stock may exhibit root deformation, the former as a result of container design and the latter as a result of poor nursery and/or planting practices (Van Erden 1978).

Photo: root deformation resulting from poor nursery and/or planting practices

- to be provided by Mike Dumas

Basal area of all stumps and Phosphorus in the A-horizon

Positive parameter estimates were also obtained for total basal area (BA) of stumps per hectare and for the soil phosphorus levels indicating that as the total BA of all stumps or phosphorus level increased so too did the *Armillaria* infection level. It is interesting to note that it was the total BA of all stumps and not the BA of infected stumps that showed a significant relationship with infection level. Inclusion of stump data separated into conifer and hardwood components did not affect the model.

Photo: stumps on cutover - to be provided by Mike Dumas

Phosphorus in the soil may have resulted in increased rhizomorph growth (Morrison 1975) and influenced the levels of *Armillaria* infection. Phosphorus levels are also known to affect the root development of plants, especially the development of lateral and fibrous rootlets (Brady 1984). The increased lateral and fibrous root development as a result of higher phosphorus levels may have increased the probability of root contact with *Armillaria* rhizomorphs or infected stump material and resulted in higher infection levels. Phosphorus level explained only a small proportion of the variance in *Armillaria* infection levels and omitting it from the model reduced the R^2 value by only 0.5% and increased the MSE by 0.0001. The use of P in the model may not be useful from the stand point of field practicality and applicability.

CONCLUSIONS

Although a previous study found no statistically significant differences in *Armillaria* infection levels amongst FEC site treatment units (Wiensczyk et al, 1996), dummy variables for TU's B and D (NWOFEC) were significant factors in the regression model developed for predicting *Armillaria* infection levels in the plantations sampled. Stock type, the total basal area of stumps, percent clay in the C-horizon and phosphorus level in the A-horizon were also significant. Because of the complexity of the relationship between this disease, its hosts and the environment, further studies are to be conducted to verify these results. Stands will be sampled before harvest to determine *Armillaria* infection levels, and the ensuing plantations monitored over time to assess the progression of the disease.

Northern Ontario Development Agreement (NODA) provided the funding for this project.

References

Brady, N.C. 1984. The Nature and Properties of Soils. 9th edition. Macmillan Publishing Company. New York, N.Y.

Morrison, D.J. 1975. Ion uptake by rhizomorphs of *Armillaria* mellea. Can.J. Bot. **53**:48-51.

Racey, G.D., Whitfield, T.S., and R.A. Sims. 1989. Northwestern Ontario Forest Ecosystem Interpretations. Ontario Ministry of Natural Resources, Thunder Bay. NWOFTDU Tech. Rep. 46.

Redfern, D.B., and Filip, G.M. 1991. Inoculum and Infection. *In Armillaria* Root Disease. *Edited* by C.G. Shaw III and G.A. Kile. U.S. Dep. Agric. Agric. Handb. 691. pp 48-61.

Sims, R.A., Towill, W.D., Baldwin, K.A., and Wickware,G.M. 1989. Field Guide to the Forest Ecosystem Classification for Northwestern Ontario. 1989. Ontario Ministry of Natural Resources, Toronto.

Singh, P. 1975. *Armillaria* root rot: Distribution and severity in softwood plantations in Newfoundland. Acta. Phytopath. Acad. Sci. Hung. **10**:389-406.

Sutton, R.F. 1969. Form and Development of Conifer Root Systems. Commonw. For. Bur., Oxford, England. Tech. Commun. No. 7.

Sutton, R.F. 1978. Root system development in young outplants, particularly white spruce. *In*

Al Wiensczyk, formerly a forest pathology researcher at Canadian Forest Service - Great Lakes Forestry Centre, is now with the British Columbia Ministry of Forests.

Dr. Michael Dumas, a research scientist with the Canadian Forest Service - Great Lakes Forestry Centre, conducts research into biological control methods for nursery and decay fungi.

Rob Irwin, a research technician with the Canadian Forest Service - Great Lakes Forestry Centre, provides technical support for research studies into forest insects.