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# Phytosanitary monitoring of woody species from the banks of watercourses in Wallonia[1]

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## Abstract

The alder disease caused by *Phytophthora alni* has affected more than 25% of the alder trees along Walloon riverbanks. This epidemic has highlighted the fragility of the riparian ecosystem and the need to conduct phytosanitary monitoring (insect pests, mites, pathogenic fungi, bacteria and viruses) of the main woody species frequently found along the rivers and streams of Wallonia. The survey was undertaken in 2004 and 2005 on 17 species, the most dominant ones being alders, ashes, willows and maples. The objective was to provide an overview of the diseases and arthropod pests currently occurring in riverbank environments and to detect any new 'threat' to woody riverside plants. A network of more than 100 sampling units covering the southern part of the country was constituted from a database compiled by the Forestry Resources and Natural Environments Management Unit (FUSAGx). The sampling units were selected according to different criteria, notably the representativeness of each woody species, the representativeness of catchments, the watercourse categories and the geographic distribution. The survey rate reached 0.2 $^0/_{00}$. In each sampling unit, observations were made from the upstream side to the downstream side over a distance of 50 m around the centre of the plot, over a width of 2 m starting from the ridge of the riverbank. The plots were visited twice a year in April–June and July–October. Symptomatic plant tissues were collected and the causal pathogenic agents and insect pests were identified in the laboratory. In 2005, more than 1450 trees were examined. Many observations were related to pathogenic fungi (N=1010) and arthropods (N=4779). Generally, the phytosanitary state was found to be 'balanced'. The problems occurring in spring and summer were due mainly to larvae defoliating trees, sometimes to a significant extent (*Agelastica alni*). Later on, towards the end of the summer and in the autumn, some foliar and wood-destroying fungi appeared. Some diseases that can cause rapid tree decay were noted, namely the alder disease caused by *Phytophthora alni*, along with some types of rot (*Armillaria* sp.) and other wood-rotting fungi. These results were compiled in a database with information that could be relevant for epidemiological studies (weather data, environmental observations, frequency of diseases and insect pests). A provisional version of a visual guide with 51 illustrative leaflets to help identify insect and mite

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pests and diseases found on woody species along riverbanks was also produced as a source of information for watercourse managers.

## Introduction

In Wallonia, the hydrographic network covers more than 18,000 km. The riparian ecosystem consists of plants adapted to flooding; among them, the main woody species are alder, ash, willow and maple. These plants play a key role in riverbank stabilization. They also constitute refuge areas for insects, birds and mammals and have an undeniable landscape function. Some stresses, such as pollution (pesticides, waste water), human activities (artificial banks, international plant trade) and global warming, threaten this typical ecosystem by making the plants more susceptible to diseases and pests or by increasing the risk of occurrence of new diseases. In 1999, the alder disease caused by *Phytophthora alni* was reported in Belgium (CAVELIER *et al.*, 1999). A survey carried out in Wallonia in 2001 revealed that the disease was present along most Walloon rivers and streams (DEBRUXELLES *et al.*, 2004; DE MERLIER *et al.*, 2005). This epidemic highlighted the fragility of the riparian ecosystem and the need to conduct a survey of the diseases and pests that affect the woody species found along the watercourses. The objective of this study was to develop a monitoring methodology adapted to the riparian ecosystem and to describe the phytosanitary status of the woody plants growing on the banks of watercourses in Wallonia.

## Materials and methods

### SAMPLING STRATEGY

A sampling network of 105 plots in 2004 and 129 plots in 2005, covering the southern part of the country (Figure 1), was created to monitor 17 riparian woody species. The sampling units were selected from a database compiled by the Forestry Resources and Natural Environments Management Unit (DEBRUXELLES, 2004) based on various stratification criteria: the representativeness of each woody species, the representativeness of catchments, the watercourse categories and the geographic distribution. The survey rate was 0.16 $^{0}/_{00}$ in 2004 and 0.20 $^{0}/_{00}$ in 2005. For comparison, the rate for some European forest surveys varies between 0.10 $^{0}/_{00}$ and 5 $^{0}/_{00}$ (LECOMTE & RONDEUX, 1992) .

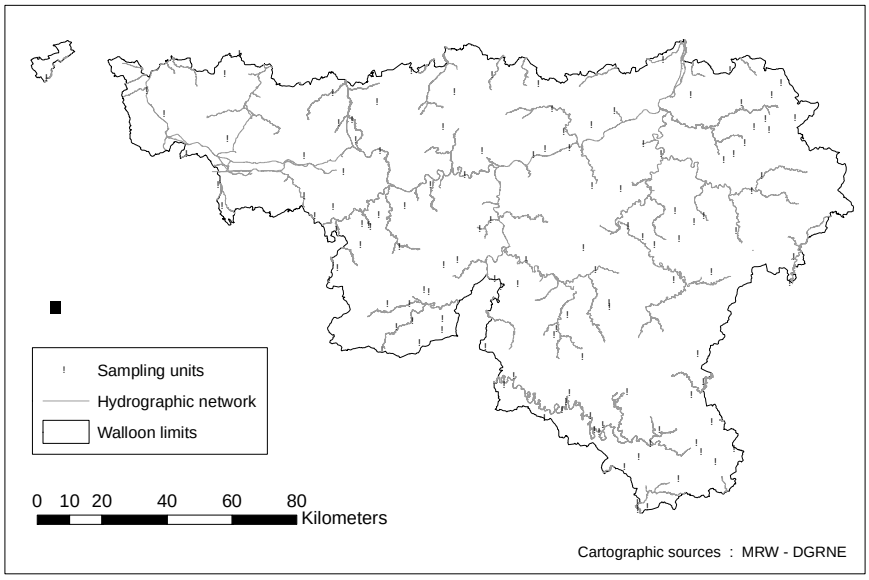


**Figure 1.** Location of sampling units (2005)

In each sampling unit, observations were made from the upstream side to the downstream side over a distance of 50 m around the centre of the plot, over a width of 2 m starting from the ridge of the riverbank. Each plot was visited twice a year in April–June and July–October. Various data were collected: weather and environmental data, tree and shrub data and phytosanitary data. Samples and pictures of symptomatic tissues, pathogenic agents and insect pests were collected. The collected data and the results of the analyses were included in a database containing 473 sampling unit observation forms and more than 20.000 symptom observations.

## INSECT PEST IDENTIFICATION

The insect larvae were put in small transparent boxes in a conditioned room at 18–22°C with a photoperiod of 12 hours. They were fed with pieces of leaves collected from their original host plant in order to obtain adult insects. When the larvae pupated, the temperature was adjusted (10–20°C) to assist adult emergence. All the adult insects were stored in a freezer (-20°C). They were examined with a stereomicroscope (magnification 8–50X) and identified at least up to the order and family (where possible, up to the species). They were then assembled in entomological boxes and classified in systematic order.

FUNGI IDENTIFICATION

Infected plant tissues were stored at 4°C before being analysed. Macroscopic observations of these tissues were sometimes enough to identify the causal agent. For those samples with non-specific symptoms, pieces of symptomatic tissues were observed under a microscope for fungi producing typical fructifications or the surface disinfected and put on an agar medium (Potato Dextrose Agar, Difco) at 22°C in order to isolate the pathogenic fungus.

## Results

From the pilot survey in 2004, a total of 3,896 identifications were made from observations of damage on plant tissues, pathogenic agents, arthropod pests and mammals. Insects and mites represented 86.4% and diseases 13.6%. In 2005, a total of 6,186 identifications were made. Insect pests represented 61.3%, fungi 16.0%, eriophyid mites 15.8%, useful insects 2.3% and aquatic insects 3.9%. Virus, bacteria and mammals represented less than 1% of the observations.

TEMPORAL EVOLUTION OF THE OBSERVATIONS (FIGURE 2)

Plant damage was divided into eight main categories: diseases causing foliar symptoms, cankers on wood, pathogenic and saprophyte agents causing decay in living wood, defoliator insects, leaf miners, gall pests, piercing/sucking insects and xylophageous insects. Each category was monitored in the 2005 vegetation season to determine the population variation.
In April and May most of the plant damage was caused by defoliator and piercing/sucking insects. During this time, geometrid caterpillars (Geometridae) were the most important defoliators. Weevils (Curculionidae) were also present. In June, piercing/sucking larvae and adult insects of the Hemiptera order were the pests observed most: leafhoppers (Cicadellidae), psyllids (Psyllidae), aphids (Aphidoidea) and spittlebugs (Cercopidae). During this time, another defoliator family of the Coleoptera order caused important damage: leaf beetles (Chrysomelidae). The alder disease caused by *Phytophthora alni* was readily observed from June to September. In July, the monitoring was interrupted for 10 days and the rate of observations decreased for many disease and pest categories. In August, galls and leaf miners (Gracillariidae and Nepticulidae) were very significant.

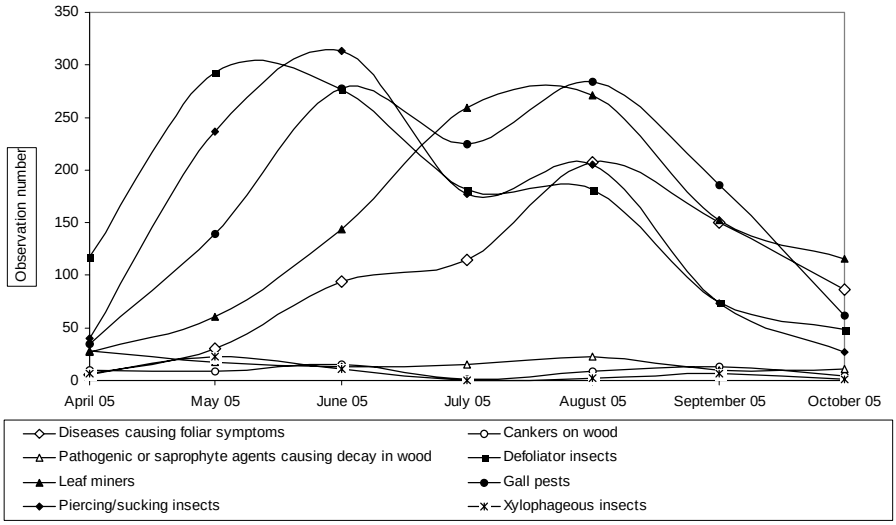


**Figure 2.** Temporal evolution of the plant damage categories (2005)

The Tenthredinidae family caused a lot of blotch mines, galls and defoliation. Foliar diseases such as powdery mildew (Erysiphaceae), rust (Melampsoracae), leaf curl (Taphrinaceae), black leaf spot (Rhytismataceae) and willow anthracnose (Dermataceae) were very common. In August and September, annual carpophores of some wood-rotting fungi (such as *Armillaria* sp.) were important. In October, pest observations decreased progressively due to leaf fall. However, some foliar diseases were important, particularly brown leaf spot (Botryosphaeriaceae).

## MAIN PHYTOSANITARY OBSERVATIONS ON ALDERS (*ALNUS* SP.)

Alder is the main woody species in the riparian ecosystem. In 2005, 560 alder trees were examined (Table 1). The most common disease on alder trees was *Taphrina tosquinetii* which causes leaf curl and gigantism. Rust (*Melampsoridium alni*) and powdery mildew (*Microsphaera alni*) were also sometimes observed. These three diseases cause premature leaf fall and a slow down in tree growth (LANIER *et al*., 1978 and CHAUVEL *et al*., 1995). One lethal disease caused by *Phytophthora alni* was also observed; its symptoms include leaf yellowing, leaf nanism, defoliation and trunk cankers.
With regard to the arthropod pests, eriophyid mites (Acari, Eriophyidae) were the most frequently ones found on alder leaves, causing various types of galls resulting in leaf distortion and premature leaf fall (ALFORD, 1994). The insect *Agelastica alni* (Chrysomelidae) was found to be dangerous, sometimes causing considerable tree defoliation. Other significant pests cau-

sing leaf fall and a slow down in growth were also reported: sawflies (Tenthredinidae), the larvae of which are leaf-feeding or form blotch mines; weevils (Curculionidae and Attelabidae); the alder psyllid (*Psylla alni*) which excretes vast quantities of sticky honeydew on shoots; and *Epinotia immundana* (Tortricidae) which rolls leaves up.

TABLE 1
Main phytosanitary observations on alder species (2005) [N = 560]

| | Division/Order | Family | Species | Representativeness | Threat * |
|---|---|---|---|---|---|
| Fungi | Ascomyceta | Taphrinaceae | *Taphrina tosquinetii* | 25,9% | 2 |
| | Coelomyceta | Pythiaceae | *Phytophthora alni* | 9,1% | 4 |
| | Basidiomyceta | Melampsoraceae | *Melampsoridium alni* | 1,6% | 2 |
| | Ascomyceta | Erysiphaceae | *Microsphaera alni* | 1,4% | 2 |
| | Basidiomyceta | Marasmiaceae | *Armillaria* sp. | 0,9% | 4 |
| Insects and mites | Acari | Eriophyidae | *Eriophyes* sp. | 53,6% | 2 |
| | Coleoptera | Chrysomelidae | *Agelastica alni* | 35,9% | 3 |
| | Lepidoptera | Gracillariidae | | 30,2% | 1 |
| | Hemiptera | Psyllidae | *Psylla alni* | 21,1% | 2 |
| | Hemiptera | Ciccadellidae | | 15,7% | 1 |
| | Hymenoptera | Tenthredinidae | | 13,4% | 3 |
| | Coleoptera | Curculionidae | | 10,4% | 2 |
| | Coleoptera | Attelabidae | | 8,8% | 2 |
| | Lepidoptera | Tortricidae | *Epinotia immundana* | 7,7% | 2 |
| | Acari | Eriophyidae | *Acalitus brevitarsus* | 7,5% | 2 |

* *Threat index* : 1 = Without risk for tree health; 2 = Tree weakening, slow down in growth; 3 = Consequent tree weakening, risk of death for young trees; 4 = Risk of death for trees

## MAIN PHYTOSANITARY OBSERVATIONS ON ASHES (*FRAXINUS EXCELSIOR*)

During the survey in 2005, 140 ash trees were monitored (Table 2). The most frequent disease was powdery mildew caused by *Phyllactinia guttata* which induces leaf fall. Cankers caused by *Nectria* sp. were also observed. Lesions develop on branches, withering the branch ends and leading to the death of young trees. The psyllid *Psyllopsis fraxini*, which causes leaflet roll galls, distorts leaflets and excretes sticky honeydew, was frequently observed. Another gall-forming insect (*Dasineura fraxini*, Cecidomyidae) was also observed along the leaflet's central nervure. Ash trees appeared to suffer from significant defoliation due to *Stereonychus fraxini* (Curculionidae). These pests cause premature leaf fall and a slow down in tree growth (ALFORD, 1994). Other defoliators sometimes observed included leaf beetles (Chrysomelidae) and geometrid caterpillars (Geometridae).

TABLE 2
Main phytosanitary observations on ash species (2005) [N = 140]

| | Division/Order | Family | Species | Representativeness | Threat * |
|---|---|---|---|---|---|
| Fungi | Ascomyceta | Erysiphaceae | *Phyllactinia guttata* | 10,7% | 2 |
| | Ascomyceta | Nectriaceae | *Nectria* sp. | 2,1% | 3 |
| | Basidiomyceta | Marasmiaceae | *Armillaria* sp. | 0,7% | 4 |
| | Coelomyceta | Botryosphaeriaceae | *Phyllosticta* sp. | 0,7% | 2 |
| Insects and mites | Hemiptera | Psyllidae | *Psyllopsis fraxini* | 45,7% | 2 |
| | Diptera | Cecidomyidae | *Dasineura fraxini* | 26,4% | 2 |
| | Coleoptera | Curculionidae | *Stereonychus fraxini* | 26,4% | 2 |
| | Coleoptera | Chrysomelidae | | 6,4% | 2 |
| | Hemiptera | Cicadellidae | | 5,7% | 1 |
| | Lepidoptera | Gracillariidae | | 5,7% | 1 |
| | Lepidoptera | Geometridae | | 5,0% | 2 |
| | Acari | Eriophyidae | *Eriophyes fraxinivorus* | 3,6% | 2 |

* *Threat index* : 1 = Without risk for tree health
2 = Tree weakening, slow down in growth
3 = Consequent tree weakening, risk of death for young trees
4 = Risk of death for trees

## MAIN PHYTOSANITARY OBSERVATIONS ON WILLOWS (*SALIX* SP.)

In 2005, 129 willows of various species were evaluated (Table 3). Anthracnose was the most significant disease found on willows. *Marssonina salicicola* and *Glomerella cingulata* were the two main fungi. They induce leaf spiral distortions, leaf withering and small cankers and lesions on leaves and branches. Rust caused by *Melampsora* sp. was also observed. Sometimes, this disease is severe enough to cause leaves to drop and growth to slow down (PIRONE, 1970). Among the other foliar diseases observed were *Uncinula salicis*, a powdery mildew, and *Rhytisma salicinum,* which causes typical black leaf spots. The main insect pests observed on willow were sawflies (*Pontania* sp., Tenthredinidae). The larvae live in galls on leaves, which distort the leaves and cause them to drop prematurely at the end of the summer. Other significant pests observed included leaf beetles (Chrysomelidae) and weevils (Curculionidae). Many species from these two families were present on willows and were responsible for important defoliation. A spittlebug typical of willows, *Aphrophora salicina* (Cercopidae*)* was observed. The larvae produce small patches of foam resembling saliva.

TABLE 3
Main phytosanitary observations on willow species (2005) [N = 129]

| | Division/Order | Family | Species | Representativeness | Threat * |
|---|---|---|---|---|---|
| Fungi | Coelomyceta | Dermataceae | *Marssonina salicicola* | 31,8% | 3 |
| | Basidiomyceta | Melampsoraceae | *Melampsora* sp. | 22,5% | 2 |
| | Ascomyceta | Erysiphaceae | *Uncinula salicis* | 5,4% | 2 |
| | Ascomyceta | Glomerellaceae | *Glomerella cingulata* | 3,1% | 3 |
| | Ascomyceta | Rhytismataceae | *Rhytisma salicinum* | 2,3% | 2 |
| | Basidiomyceta | Hymenochaetaceae | *Phellinus igniarius* | 1,6% | 4 |
| | Basidiomyceta | Marasmiaceae | *Armillaria* sp. | 0,8% | 4 |
| | Basidiomyceta | Meripilaceae | *Meripilus giganteus* | 0,8% | 4 |
| Insects and mites | Hymenoptera | Tenthredinidae | *Pontania* sp. | 34,9% | 2 |
| | Coleoptera | Chrysomelidae | | 25,6% | 2 |
| | Lepidoptera | Gracillariidae | | 24,0% | 1 |
| | Hemiptera | Cercopidae | *Aphrophora salicina* | 19,4% | 2 |
| | Acari | Eriophyidae | | 14,0% | 2 |
| | Hemiptera | Cicadellidae | | 12,4% | 1 |
| | Hemiptera | Aphidoidea | | 10,1% | 2 |
| | Lepidoptera | Geometridae | | 9,3% | 2 |
| | Coleoptera | Curculionidae | | 5,4% | 2 |

* *Threat index* : 1 = Without risk for tree health
2 = Tree weakening, slow down in growth
3 = Consequent tree weakening, risk of death for young trees
4 = Risk of death for trees

## MAIN PHYTOSANITARY OBSERVATIONS ON MAPLES (*ACER* SP.)

In 2005, 106 maples were evaluated (Table 4). The fungus *Rhytisma acerinum*, which causes typical black leaf spots surrounded by a thin yellow border, was observed on more than 50% of the trees. Among other foliar diseases often found were *Phyllosticta aceris*, which causes large brown leaf spots, *Uncinula aceris* and *Phyllactinia guttata*, which causes powdery mildew. These fungi affect the growth of the trees and accelerate leaf fall. Arthropods found often on the maple trees and causing galls on the leaf surfaces were eriophyid mites (Eriophyidae) and gall wasps *Pediaspis aceris* (Cynipidae). Also observed were some groups of Hemiptera which cause stings and discoloration on maple leaves, including aphids (Aphidoidea), leafhoppers (Cicadellidae) and mainly bugs (Coccidae). All these pests contribute to premature leaf fall.

TABLE 4
Main maple phytosanitary observations in 2005 [N = 106]

| | Division/Order | Family | Species | Representativeness | Threat * |
|---|---|---|---|---|---|
| Fungi | Ascomyceta | Rhytismataceae | *Rhytisma acerinum* | 57,5% | 2 |
| | Coelomyceta | Botryosphaeriaceae | *Phyllosticta aceris* | 18,9% | 2 |
| | Ascomyceta | Erysiphaceae | *Uncinula aceris* | 17,9% | 2 |
| | Ascomyceta | Erysiphaceae | *Phyllactinia guttata* | 1,9% | 2 |
| Insects and mites | Acari | Eriophyidae | *Eriophyes* sp. | 75,5% | 2 |
| | Hemiptera | Aphidoidea | | 34,9% | 2 |
| | Hemiptera | Cicadellidae | | 34,0% | 1 |
| | Hymenoptera | Cynipidae | *Pediaspis aceris* | 34,0% | 2 |
| | Lepidoptera | Gracillariidae | | 8,5% | 1 |
| | Hemiptera | Coccidae | | 7,5% | 2 |
| | Coleoptera | Curculionidae | | 5,7% | 2 |
| | Lepidoptera | Geometridae | | 3,8% | 2 |
| | Coleoptera | Attelabidae | | 3,8% | 2 |

* *Threat index* : 1 = Without risk for tree health
2 = Tree weakening, slow down in growth
3 = Consequent tree weakening, risk of death for young trees
4 = Risk of death for trees

## Discussion

A phytosanitary survey of the main woody species found along the watercourses in Wallonia was conducted in 2004 and 2005. Due to the time needed to collect and analyse samples, a relatively low sampling rate was established, preventing a quantitative analysis of the data. However, the first aim of this study was not to conduct an epidemiological study but rather to provide watercourse managers with information and advice on the main diseases and pests found on riparian trees. In this context, a visual guide with 51 illustrative leaflets to help identify insects, mites and fungi affecting the main woody species along the rivers was produced (ABRAS *et al.*, 2005) and will be updated regularly.

Although the study was descriptive, it revealed that the vast majority of pests and pathogenic fungi identified on the selected trees did not cause severe damage, suggesting that most of the riparian woody species have a 'balanced' phytosanitary status. The insect pests were most frequently observed in spring, while in summer and autumn the fungal diseases were more often reported. This study also highlighted the importance of the alder disease caused by *Phytophthora alni*. This epidemic constitutes a real threat to the Walloon riparian ecosystem because in the southern part of Belgium the common alder (*Alnus glutinosa* [L.] Gaertn.) is an important component of the riparian ecosystem (it accounts for 35% of the riparian species, according to MOUCHET *et al.*, 2004). In addition, it helps to stabilise the riverbank, can fix atmospheric nitrogen and has great conservation value. Among the fungal diseases affecting wood, the decay due to *Armillaria* sp. was observed on numerous woody species. As some *Armillaria* species behave as saprophytic fungi while others are aggressive pathogens (GUILLAUMIN, 2005), a PCR-

RFLP method developed by HARRINGTON & WINGFIELD (1995) has been validated and will be used in the surveys to be conducted in 2006 and 2007 to evaluate the distribution of various *Armillaria* species found along the rivers in Wallonia. Other root-rotting fungi such as *Phellinus ignarius* and *Meripilus giganteus* were also observed, but to a lesser extent. Insect pests also contributed to the weakening of riparian trees. Among these pests, the most significant defoliators were Chrysomelidae (particularly *Agelastica alni* on alders), Curculionidae, Tenthredinidae and Geometridae. Trees weakened by these insects might be more susceptible to other phytosanitary problems. Chrysomelidae and Curculionidae will be studied in greater detail during the next monitoring campaign.

From an ecological point of view, the survey data could be used to provide information on the biodiversity of pests and fungi affecting riparian trees in Belgium. However, in order to become a reliable tool, the database should integrate data gathered over several years to take account of the variations in environmental parameters (particularly meteorological conditions). A strategy for continuous monitoring would meet these requirements.

The sampling units distributed throughout the Walloon region could constitute a 'pre-alert' area to control the spread of quarantine pathogens or pests found in riparian ecosystems. As an example, specific research on the occurrence of the quarantine pathogen *Phytophthora ramorum*, found in river water in the United States (HANSEN & SUTTON, 2004), could take advantage of the unit network and the monitoring methodology set up in this study. Another example is the invasive insect species *Agrilus planipennis* which causes significant damage on ash trees. A survey of this exotic beetle could also be conducted within the framework of the monitoring in 2006 and 2007, which will focus on the four main woody species (alder, ash, willow and maple).

## Acknowledgements

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## Résumé

SURVEILLANCE PHYTOSANITAIRE DES ESSENCES LIGNEUSES
DES BERGES DES COURS D'EAU EN WALLONIE

La maladie de l'aulne, causée par *Phytophthora alni*, affecte plus de 25% des aulnes le long des cours d'eau wallons. Cette épidémie a mis en évidence la fragilité de l'écosystème rivulaire et la nécessité de réaliser une surveillance phytosanitaire (maladies et ravageurs) des principales essences ligneuses rencontrées le long des rivières et ruisseaux de Wallonie. Un monitoring a été réalisé en 2004 et 2005 sur 17 espèces parmi lesquelles les aulnes, frênes, saules et érables ont été les plus fréquents. L'objectif de cette étude était de fournir une image globale des maladies et ravageurs couramment rencontrés dans le milieu rivulaire et de détecter toute nouvelle « menace » phytosanitaire pour les ligneux des berges. Un réseau de plus de 100 unités d'échantillonnage couvrant toute la Wallonie a été constitué à partir d'une base de données réalisées par l'Unité de Gestion des Ressources forestières et des Milieux naturels (FSAGx). Ces unités ont été sélectionnées selon différents critères, notamment la représentativité de chaque espèce ligneuse, la représentativité des bassins versants, la catégorie de cours d'eau et la distribution géographique. Le taux de sondage était de 0,2 $^{0}/_{00}$. Sur chaque unité, les observations ont été réalisées d'amont en aval sur une longueur de 50 mètres autour du centre de placette et sur une largeur de deux mètres à partir de la crête de berge. Chaque placette a été visitée à deux reprises (en avril-juin et en juillet-octobre). Des échantillons de tissus présentant des symptômes ont été collectés. Les agents pathogènes et ravageurs responsables de ceux-ci ont été identifiés en laboratoire. En 2005, plus de 1450 arbres ont été examinés. De très nombreux champignons pathogènes (N=1010) et ravageurs (N=4779) ont été identifiés. L'état phytosanitaire observé a pu être qualifié d'« équilibré ». Les principaux symptômes rencontrés au printemps et en été ont été causés par des larves défoliatrices parfois très voraces comme c'est le cas avec *Agelastica alni*. Vers la fin de l'été et en automne, ce sont les maladies foliaires et les champignons lignivores qui ont occasionné le plus de dégâts. Certains agents pathogènes causant un dépérissement rapide des arbres touchés ont été observés: la maladie de l'aulne, les armillaires (*Armillaria* sp.) et autres pourridiés. Tous ces résultats ont été compilés dans une base de données avec d'autres informations qui peuvent être d'un intérêt pour des futures études épidémiologiques (données climatiques, observations environnementales, fréquences d'observation de maladies et ravageurs). Une version provisoire d'un guide visuel contenant 51 fiches illustratives pour l'identification des maladies et ravageurs rencontrés sur les ligneux a également été produite pour informer les gestionnaires des cours d'eau.

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