Forest fungal pathogen management – best practices for Regional Parks

Project Report

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Executive Summary

Kretzschmaria deusta, commonly known as “brittle cinder” or “burn crust” fungus, is an Ascomycete fungus that affects broadleaved trees. It is considered one of the most important root and butt decay pathogens in urban trees. It causes soft rot type II and has a broad host range. Within Metro Vancouver Regional Parks maple trees appear to be the primary host for the disease. The purpose of this project was to estimate the extent and virulence of *K. deusta* within selected Metro Vancouver Regional Parks, to characterize the rate of spread of the disease within and between trees, to determine if climate change may be a contributing factor to its virulence, and to identify strategies for the management of the disease within Regional Parks.

The survey performed showed that the fungus is affecting maple trees in all the Metro Vancouver Regional Parks. Diseased trees tended to belong to the large and very large diameter classes. There are no chemicals available to eliminate the brittle cinder fungus. Once the fungus is established, the tree will be lost in a relatively short period of time. The management tasks are focused on reducing the spread of the pathogen and minimizing the impact of the fungal infection. Regular monitoring of trees in high risk areas where big leaf maple trees are abundant, minimize the access of vehicles, public and pets to affected areas, and removal of old fallen stems to avoid the spread of the fungal spores is recommended. It is important to evaluate the possible use of *Trichoderma* spp. or bacterial endophytes with biocontrol traits in the management of the disease.

According to forest paleoecology studies and analysis of Mid-Holocene deposits, *K. deusta* outbreaks should be expected under a climatic change scenario. This conclusion is also supported by the biological and physiological characteristics of the fungus. As future directions, it would be important to measure the expansion of the fungal infection in the BC forests using specific molecular techniques (PCR), sampling trees and forest soil for more accurate results. In the same way, studying the biology and virulence of the fungus under climate change conditions (increased temperature and CO_2 levels) would allow us to make specific predictions about a future scenario.

Introduction

Fungal pathogens are natural components of healthy forest ecosystems, where they play a significant role in eliminating weak and unfit trees. Nevertheless, they can have a negative environmental and ecological impact when large areas of forest are affected. It is estimated that Canada loses around 65 million cubic meters of wood yearly due to forest diseases, with decay fungi being the the primary cause (Canadian Forest Service, 2001).

Kretzschmaria deusta, commonly known as brittle cinder fungus, is an Ascomycete fungus that belongs to the family Xylariaceae. It is considered one of the most important roots and butt decay pathogen in urban trees. It causes soft rot type II and has a wide host range among the broadleaved trees (Luley, 2017). Within Metro Vancouver Regional Parks maple trees appear to be the primary host for the disease.

The purpose of this project was to estimate the extent and virulence of *K. deusta* in the Metro Vancouver region, to characterize the rate of spread of the disease within and between trees, to determine if climate change may be a contributing factor to its virulence, and to identify strategies for the management of the disease within Regional Parks.

Background

Kretzschmaria deusta, also known as “Brittle cinder” or “Burn crust” fungus is one of the f more difficult root rots to detect on hardwood host species, and it is specifically difficult to detect during tree hazard assessments. This fungus often leaves the outer bark layer of the tree intact even in an advanced stage of decline (Nilsson et al., 1989).

The species name *deusta* means "burned up" because of the blackened appearance of the fungus. It causes soft rot type II and can be found solitary or scattered on stumps or bases of hardwoods, primarily maples or wide leaves trees.

Part of tree colonized: Roots and lower bole (but can develop everywhere)

Edibility: Inedible.

Colonization strategy: Molecular methods and isolation assays done on stem sections at different heights showed a predominant heart rot mean of expansion (Guglielmo et al., 2012).

Occurrence on wood substrate: The presence of black, charcoal-like crust containing the fruiting bodies indicated the fungal infestation. When the crust is crushed with the fingers, it turns into dust. It is also frequently observed the presence of grey asexual fruiting bodies that look like an old lichen (Figure 1). The symptoms in the plants, before the appearing of the fruiting bodies, are very non-specific. Can even be missed in an advanced stage of decline. The most common symptom, but still difficult to identify, is the decrease in the foliage due to the restriction of nutrients from the roots.

Figure 1. Fruiting bodies of *Kretzschmaria deusta* growing in the trunk of a maple tree.

Dispersion: It is believed that the spores present in the soil and the wood are dispersed by the rain (Brandstetter, 2007). The infection occurs when the spores reach small wounds in the tree base or the roots where the fungus germinates and invades the woody stem. The pathogen can also use injuries produced by fires as an entrance to the root (Giordano and Gonthier, 2015).

Dimensions: Fruitbody 4-10 cm wide, 3-5 mm thick, forming sheets up to 50 cm long that are irregular in shape.

Research Approach

A survey was performed in the forests of the Metro Vancouver Regional Parks to determine the extent of the disease. It included sampling plots of 25 x 25 m (625 m^2) distributed as shown in Figure 2.

Every maple tree in each plot was counted, measured the diameter at breast height (DBH)[1], and assessed. The occurrence of the fungal pathogen was evaluated by visual inspection of the tree base. The presence of black, charcoal-like crust containing the fruiting bodies or the vegetative colony confirmed the fungal infection.

To determine if the climate climatic change would affect the spreading of the pathogen, and to identify strategies for the management of this fungus this fungus within Regional Parks, a

[1] Maple trees by DHB class: <10 cm: small, 10-24 and 25 – 36 cm: medium, 37 – 48 and 49 – 60 cm: large, >60 cm: very large

literature review on the biology of the organism and the management of forest diseases was performed.

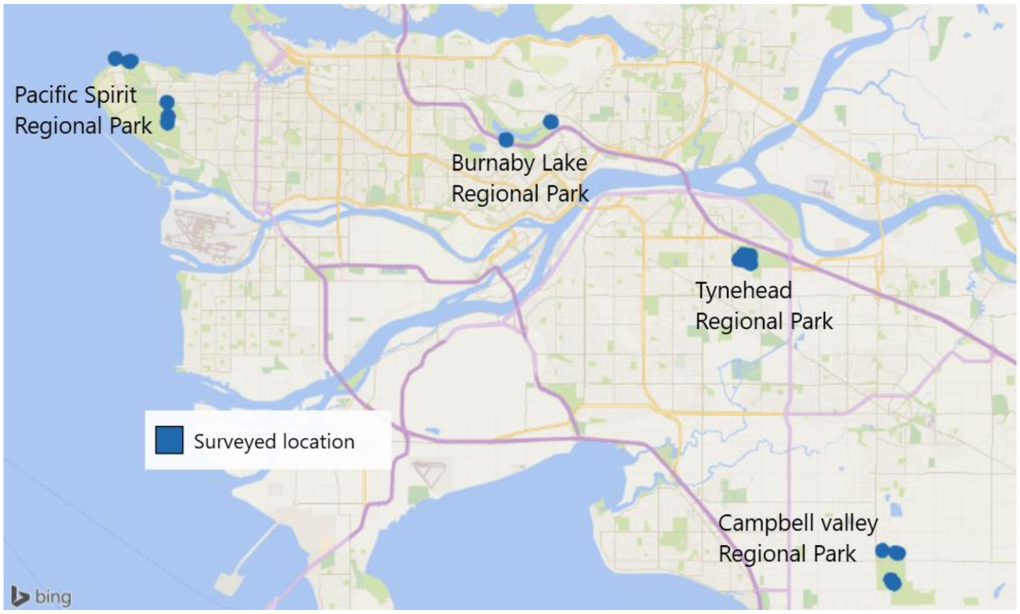

Figure 2. Location of the surveyed areas.

Distribution of *K. deusta* in the Metro Vancouver Regional Parks, main findings:

- 22 plots were evaluated for the presence of the fungus, with a total area of 13, 750 m^2.
- A total of 234 Maple trees were examined. There was evidence of brittle cinder fungus infection in 12 trees, which represent the 5 % of the total trees included in the study. However, other affected trees were spotted out of the studied areas.
- The distribution of the disease (within and between the trees) does not follow a regular pattern. However, the presence of affected trees appeared to be correlated with

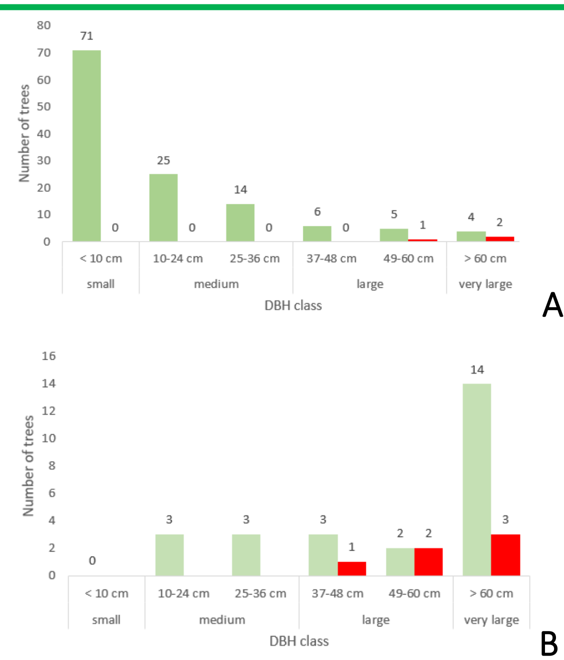

Figure 3. Distribution of trees affected by *Kretzschmaria deusta* in the Pacific Spirit Regional Park (A) and Burnaby Lake (B). Legend: red: affected trees, green: not affected.

the trails and zones more visited by the public. People, pets and vehicles could have an active role in the spreading of the pathogen.

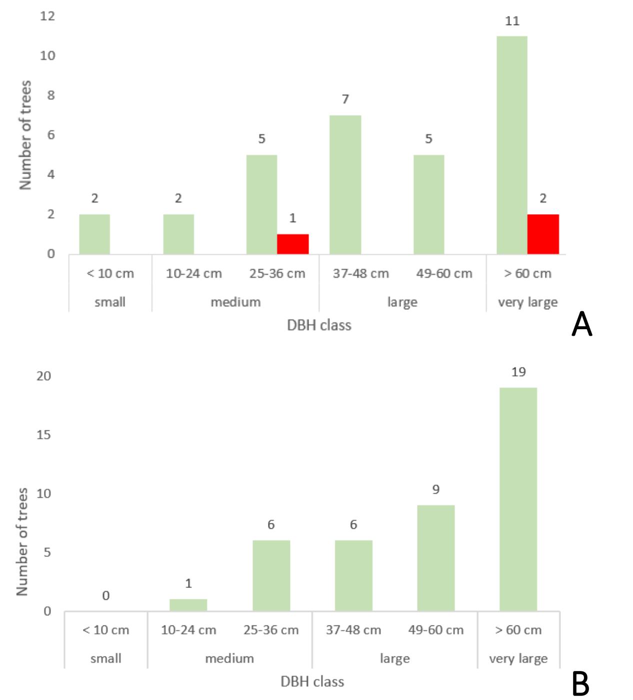

Figure 4. Distribution of trees affected by *Kretzschmaria deusta* in the Tynehead Regional Park (A) and Campbell valley (B). Legend: red: affected trees, green: not affected.

- Of Regional Parks surveyed Burnaby Lake was most affected by the fungus, whereas the least affected was Campbell Valley.
- Infected trees tended to be large or very large trees (Figure 3 and 4). This may be due to the large amount of time required for the fungus to exhibit external symptoms , which occurs in the late stages of the disease when the tree has already been very damaged.
- The declining of the very large trees is of concern. The key ecological services they provide to the forest structure cannot be replaced by younger trees. For this reason, it is important for the management of the disease, to find an adequate balance among conserving and removing potentially infected trees.

Prevention and management strategies

Chemical control of brittle cinder fungus appears to be not possible after infiection. Once the fungus is established, the tree will be lost in a relatively short period of time. Treatment with phosphoric acid is not effective. The management tasks are focused on reducing the spread of the pathogen and minimizing the impact of the fungal infection.

Fungal pathogen survey and monitoring: Regular monitoring of trees in high risk areas where big leaf maple trees are abundant is recommended. A complete visual inspection of the trees would be ideal. Identify the trees infected by brittle cinder and implement management practices as required. Keep the record of this information in a map or database for future directions.

Avoid the weakening of trees through wounds or improper pruning practices during forest operations: Damaging the trees makes them more susceptible to infection.

Avoid or minimize the access of vehicles to areas containing infected trees.

Removal of old fallen stems to avoid propagation and spread of fungal spores. This work should be done in a season when the soil is dry, as water can spread the spores of the pathogen: Vehicles, tools, and machinery should be cleaned before moving from areas of infection to a new ones.

The removed stems affected by the fungus should not be used to produce mulch

No infested material (trees, soil) should be moved from the affected area of any park to a new one.

Scrub and clean footwear as much as possible before leaving an affected area.

If diseased trees are close to parking lots or trails, the access to that area should be restricted, or the trees should be removed: Humans, vehicles, and pets are principally responsible for the spread.

Community Education: Residents, visitors, and park staff should be informed of the presence of the brittle cinder, how it affects trees, and what can they do to minimize the spread of the pathogen to non-affected areas.

Regarding the management of the infected trees, they should be evaluated one by one for potential hazards. Unstable or weakened trees may damage property or harm humans due to branch or tree failures. In high risk areas (eg. close to a trail, parking lot or property, etc.) trees infected by the pathogen, and showing signs of decline should be removed. The wood debris and the surrounding litter generated by the tree or stump removal should also be cleaned and taken for treatment.

Different studies have shown that keeping high biodiversity levels in the soil, help plants to withstand pathogens and abiotic stresses (Meena et al., 2017). This can be accomplished by the following practices:

- Keeping a variety of native understory plants around the affected trees.
- Maintaining the litter in the forest soil to boost the growth of beneficial microbial communities.
- Introducing native strains of mycorrhizal fungi
- Adding compost or mulch
- Avoid the monoculture of trees susceptible to the pathogen. Tree species diversity increases the resilience of the forest to a different kind of pathogens outbreak.

In contrast, large or very large trees located inside the forest or in a landscape with low hazard risk should be conserved. Old trees provide unique services to ecosystems and are natural shelters for forest animals.

It may be worthwhile to evaluate the possible use of *Trichoderma* spp. in the management of the disease. *Trichoderma* spp. is a soil fungus largely used as a biocontrol agent. It produces natural antifungal compounds that can destroy the cells of pathogenic fungi. They are highly competitive for space and ecological niches, having rapid growth and producing several asexual generated conidia and chlamydospores. *Trichoderma* spp. also, promote growth and induce resistance in plants (Harman, 2006). However, *Trichoderma* strains have a diverse specificity of action against different fungi, so if a commercial inoculant is going to be used, it should be tested first with the local *K. deusta* strains. Otherwise, it is recommended to isolate autochthonous *Trichoderma* spp.

Disposal

Removed trees or old stumps must be burned or deeply buried. The burning should be performed ideally in a closed waste incinerator. If it is not available, safety measures should be taken to avoid forest fires. For the deep burial, a suitable landfill site that authorizes the disposal of the infested wood and the associated fungus should be selected.

Alternatively, the material can be composted, but it must be assured that the compost pile will reach temperatures among 60 to 70°C for a period sufficient to kill the fungal spores.

Potential for climate change to affect the virulence and spreading of the pathogen

According to Schumacher et al. (2007), the optimum range of temperature for the growth of *K. deusta* is from 20 to 27°C. In the same way, high rain and relative humidity were reported as the main factors for active production of conidia and their germination, and infection of a host (Wilkins, 1939).

The climate of the Greater Vancouver region, British Columbia, is a moderate oceanic climate with local variations. The annual average temperature is 11°C, with a maximum of 22°C in the summer and minimal between 3 and 7°C in the winter. Historical data for Metro Vancouver shows that due to the climatic change average annual temperature has increased already by 1.4°C, and it is expected to rise 2.7°C by 2050. Average annual rainfall is also likely to rise by 12 % (Ministry of Environment BC, 2016).

A complete report about indicators of climate change for British Columbia can be found in the link below: https://www2.gov.bc.ca/assets/gov/environment/research-monitoring-and-reporting/reporting/envreportbc/archived-reports/climate-change/climatechangeindicators-13sept2016_final.pdf

Under these conditions, the growth rate and virulence of *K. deusta* may increase, as the temperature and humidity will approach the ideal range for this forest pathogen.

Forest paleoecology studies buried ancient sediments and pollen to analyze past landscapes and understand environmental changes.

K. deusta is also a fungus that has been used as indicator organism of severely damaged deciduous woodland in forest paleoecology studies. Several studies indicated that higher *K. deusta* occurrences may be associated with the decline of woodland by a process that increased the amount of injured or dying trees (Pals et al., 1980; Innes et al., 2006).

Latalowa et al. (2013) performed pollen and macrofossil analysis of mid-Holocene deposits from northern Poland. Data showed the impact of climate warming in the outbreak success of the pathogen *K. deusta* on *Tilia cordata* trees probably weakened by the environmental conditions. They detected high *T. cordata* pollen and *K. deusta* spore frequencies. They concluded that in a similar climate warming scenario there is an increased risk of *K. deusta* outbreaks.

The Holocene was a period of about 10 000 years ago, characterized by rapid climate change events. Some took place in just a few decades.

Because these events took place in similar conditions of today´s (increasing temperatures and carbon dioxide), scientists are looking into that data to gain a better understanding of a future global warming scenario.

Similar results were obtained in an analogous study previously performed by Innes et al. (2006) about the decline of *Ulmus* trees during the mid-Holocene in North Wales, United Kindom.

On the other hand, it is also expected that increases in insect pests that could potentially be associated with the transmission of the fungal infection could increase rates of infection. At the same time, drought followed by severe rain, and other abiotic stresses can make the trees more prone to disease development and increased mortality.

Summary

The forest fungal pathogen *K. deusta* is present in all the Regional Parks of the Metro Vancouver region, targeting maple trees. Prevention and management strategies should be followed to control the spread of the disease.

Diseased trees should be evaluated case to case for risk management. Trees located close to properties, parking lots, or trails should be removed as they represent a hazard. However, restricting the access to trails with affected trees (where it is possible to do so) would help to keep trees for a longer time, as very large old trees provide unique services to the forest ecosystem. When the affected tree is in an area of low risk, the recommendation is to maintain the tree as this will help to develop resistance in the others.

According to forest paleoecology studies performed with Mid-Holocene evidences, it is expected an increased risk of *K. deusta* outbreaks under a climatic change scenario. This conclusion is also supported by the biological and physiological characteristics of the fungus.

Recommendations

- More wide-spread surveys of brittle cinder fungus across BC forests.
- Evaluate the spreading of the disease by specific molecular techniques (PCR), sampling trees and forest soil for more accurate results.
- Evaluate the ability of commercial strains of *Trichoderma* spp. to be used as a biocontrol agent. Determine the interaction of *Trichoderma* spp. with *K. deusta* in vitro, in wood blocks, and in field.
- The use of autochthonous bacterial endophytes of maple trees should be also considered as a biocontrol agent alternative, to be used alone or in combinationwith *Trichoderma* spp..
- Study the biology and virulence of the fungus under climate change conditions (increased temperature and CO_2 levels).
- Identify possible transmission vectors (like beetles) as a possible way to help with the managing of the disease.

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