

Aspen heart rot fungus (*Phellinus tremulae*)
distribution in aspen forests in relation to open
meadows: implications for red-naped sapsucker
(*Sphyrapicus nuchalis*) nesting habitat

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Abstract

Red-naped sapsuckers (*Sphyrapicus nuchalis*) are an integral part of the aspen (*Populus tremuloides*) ecosystem in the montane western U.S. They are a double keystone species, providing both shelter and nutrients to a variety of organisms within the system. Numerous studies have documented the importance of fungal infection in nest site selection by woodpecker species. Aspen heart rot fungus (*Phellinus tremulae*) is extremely important in nest site selection in red-naped sapsuckers. To gain an adequate understanding of the dynamics of the fungus and its influence on the cavity-nesting complex, this study aims to understand the relationship between fungal density and distance to open meadow. Stands of aspen within the vicinity of the Rocky Mountain Biological Laboratory, CO, USA were selected based on similar slopes and accessibility. Fifty transects ranging from 30m to 100m were run across elevational gradients from meadows into the interior of aspen stands. Number of trees, fungal presence, and sapsucker damage was recorded along each transect. Total fungal density and fungal density in trees >17cm DBH were negatively correlated with distance from edge ($\tau = -0.1296$, $p = 0.0073$; $\tau = -0.1264$, $p = 0.0095$, respectively), suggesting an effect of edge on the occurrence of fungus. Possible causes of increased fungal density at edges include increased wind dispersal mediated by complex three dimensional flows within stands, as well as increased pruning and therefore open wounds, due to high velocity and common occurrence of wind at stand edges. Further studies need to be done on the dispersal dynamics of the fungus in order to gain a full understanding of its complex effects on the aspen ecosystem.

Introduction

Red-naped sapsuckers (*Sphyrapicus nuchalis*) are an integral part of the aspen (*Populus tremuloides*) ecosystem in the montane western U.S. They are a double keystone species, providing both shelter and nutrients to a variety of organisms within the system (Daily et al 1993). As primary cavity nesters, red-naped sapsuckers excavate fresh cavities in aspen trees each year, opening up previous years nest sites for other primary and secondary cavity nesters. Trees chosen by sapsuckers as nest sites are consistently infected with aspen heart rot fungus (*Phellinus tremulae* formerly *Fomes ignarius* var. *populinus*) (Floyd, C.H., pers. comm.). This fungus rots the heartwood of the aspen while leaving the sapwood intact providing a healthy and well-protected yet easily excavated tree (Kilham 1971).

Numerous studies have documented the importance of fungus infection in nest site selection by woodpecker species (Jackson & Jackson 2004; Unno 2004; Daily 1993; Runde & Capen 1987; Conner et al 1976; Kilham 1971). Daily (1993) suggested that fungus distribution might influence sapsucker occurrence on local and micro-habitat levels. However, very little is known about the distribution or dispersal of *P. tremulae* despite its common occurrence. In addition to its importance in being a key variable in nest site selection, the fungus also has important forest management and timber production implications. Infected trees are of reduced value to timber companies and can cause complications in management methods (Ohman & Kessler 1964). Understanding the fungus and its importance to sapsucker abundance may lead to more effective management practices both ecologically and economically.

To gain an adequate understanding of the dynamics of the fungus and its influence on the cavity-nesting complex, studies are needed on the abundance and densities of fungal infected trees. This study aims to understand the relationship between fungal density and distance to open meadow. Previous studies have suggested that the primary mode of dispersal is through windborne movement of spores (Jackson & Jackson 2004), indicating that fungal distribution should be highest at forest edges. Invertebrates and vertebrates may also achieve some amount of transmission. In addition, Unno (2004) stated that *P. hartigii* which infects Sakhalin Fir (*Abies sachalinensis*) is assumed to disperse by wind blown spores.

Infection commonly occurs through open wounds on the trees surface (Jackson & Jackson 2004). These wounds consist mainly of branch scars caused by natural pruning events, which allow fungal invasion through exposed heartwood (Jackson & Jackson 2004). Infection potential may then increase with the size of the wound and, assuming airborne dispersal, amount of airflow (Jackson & Jackson 2004). While there are some suggestions that forested trees may undergo more extensive pruning than open area trees, aspens are very susceptible to blow downs and high winds are quite common in the montane western U.S. (Jackson & Jackson 2004; Geise & Cuthbert 2003). This allows for numerous pruning opportunities in open area trees thereby facilitating infection.

Greater stand and foliage density should decrease infection potential by limiting airflow. Therefore fungal abundance and density should be maximized at forest and meadow interfaces where increased airflow is a possibility. Support for increased density of fungus at forest interfaces comes from a number of studies showing preference for nest sites toward edges. Lawler and Edwards (2002) found that woodpeckers tended to nest

more frequently in less dense fragments adjacent to meadows. It was also determined that there was a lack of cavity nesters in aspen fragments surrounded by coniferous forest, suggesting that decreased airflow may occur in these areas and therefore decrease fungal prevalence (Lawler & Edwards 2002). While it has been suggested that nesting toward meadowed edges may reduce foraging commute time (Dobkin et al 1995) and shown that sapsucker nest sites are tied to willow proximity (Daily et al 1993), it is likely sapsuckers are choosing their nest sites based on the availability of suitable fungus infected trees as well as minimizing commute time. However, if fungal infected trees are absent within the vicinity of willows, they would not be able to nest there regardless of the presence of willows. Areas with large numbers of willows may be characterized by increased airflow in relation to aspen stands, as well as the possibility of fungal spores being dispersed by water, thereby leading to an increase in fungal abundance and suitable nest trees.

This study asks the question of whether fungal infection density is greater at forest edges than in the interior. My hypothesis is that fungal density should increase at forest edges due to increased airflow across available wounds.

Methods

Stands of aspen within the vicinity of the Rocky Mountain Biological Laboratory, Colorado, USA, were chosen based upon similar slopes and accessibility in three different areas. A randomized start point for the initial transect in each of the three areas was created at the stand-meadow interface using ArcGIS by randomly selecting a point within four points that encompassed the entirety of the area. Additional transect start points were then placed 100m from the previous point on the stand-meadow interface.

Meadows were considered those areas consisting mainly of grasses and shrubs that were no smaller than 1000m² in area. Transects varied in length from 30m to 100m.

Transect length was chosen based upon stand size and transects were separated by least 100m. In all cases, no point on the transect was closer to a meadow than from the point at which the transect originated (Figure 1). Therefore stand width was a limiting factor in transect selection. Fifty transects were run across elevational gradients into the stand to remove any effect of elevation. Every 10m a point on the transect was taken and 10m was run perpendicular from the transect starting on the right side and alternating every 10m thereby creating 100m² plots on either side of the transect (Figure 2). All trees within the 100m² plots were separated by DBH being in one of two categories: between 5cm and 17cm DBH and >17cm DBH. Number of trees, fungal presence, and sapsucker damage was recorded for each of these categories. Fungal occurrence was determined by the presence of a white fungal conk on branch scars which is characteristic of infection. Data was analyzed using Kendall's Tau.

Results

Total fungal density (all trees >5cm DBH was negatively correlated with distance from forest edge (Figure 3, $\tau=-0.1296$, $p=0.0073$). Density of fungus in trees >17cm DBH was also negatively correlated with distance from edge (Figure 4, $\tau=-0.1264$, $p=0.0095$). However, fungal density in trees between 5cm and 17cm DBH showed a trend of decreasing density from edge to interior but results were only marginally significant (Figure 5, $\tau=-0.0991$, $p=0.0509$).

Discussion

The extent of airflow within an aspen forest is mediated by a number of complex habitat factors, all of which are likely to influence fungal dispersal and infection potential. Our results show an effect of edge on fungus distribution, most likely due to decreased spore dispersal within the stand. Tree density increases friction and alters airflow patterns throughout the forest (Jackson & Jackson 2004). In addition, distribution of limbs and downed trees, as well as deflection from angled surfaces, creates complex three dimensional airflow patterns within a tree stand (Parker 1995). This has the potential to decrease the availability of fungal spores to open wounds within the forests interior.

While airflow still penetrates the forest interior through short-term penetrating eddies, the canopy acts as a filter for high frequency gusts, preventing constant intrusion of an air mass through the forest (Parker 1995). Therefore the majority of airflow experienced at a stand edge is likely to have dissipated when it reaches the interior. In addition the high winds on the outside of the stand allow for numerous pruning opportunities, which create the wounds necessary for fungal infection. Our results support this idea with an obvious trend toward decreased fungal infection on the interior of the stand (Figures 3,4).

Discrepancies in significance between fungal infection in the two size categories (5cm to 17 cm DBH and >17cm DBH) can be explained by differences in susceptibility of infection between younger and older trees. Older trees are more likely to become infected based upon the fact that they have incurred more damage than younger individuals (Floyd, C.H., pers. comm.). Our results demonstrate this trend, with smaller

trees (5cm to 17cm DBH) showing no significant correlation between fungal density and distance to forest edge and larger trees (>17 cm DBH) showing a negative correlation between fungal density and distance to forest edge. In addition, it is possible that older individuals are more susceptible to the infection regardless of the number of available wounds due to some unknown factor related to the health or resistance of the tree. However, to our knowledge no studies have determined any parameters for the susceptibility of infection. It is also possible that the genetics of different stands, or genets, may play a role in fungal infection.

Increased fungal density toward stand edges has important implications for sapsucker cavity location and therefore may affect community structure. As sapsuckers nest almost exclusively in fungal infected trees (Floyd, C.H., pers. comm.) fungal distribution may in turn control bird location. As the sapsucker is a double keystone species, its distribution may influence the distribution, or at least the abundance, of numerous other species which rely on its ecosystem services. Therefore, the fungus may be the basal keystone species in what Daily et al. (1993) called a keystone species complex. If this is the case the fungus significantly affects and supports a large portion of the animals in the montane aspen ecosystem.

To better understand the impact of the fungus on the aspen ecosystem a number of studies are required. Mapping fungal distribution is the first step in understanding its dispersal dynamics to an even greater extent than this study has attempted. Looking at distribution over the scale of entire stands, taking into consideration different environmental variables, will allow comprehension of fungal dispersal. Soil moisture and proximity to riparian areas may play a large role in determining the extent of fungal

infection within a stand and should be considered during future studies (Jackson & Jackson 2004).

Additionally, studies on other possible modes of dispersal such as avian and insect borne fungus should be done to determine whether wind is really the main driver of fungal infection. Simple methods such as using tanglefoot and mist nets to obtain organism near fungal infected trees may allow for a greater understanding of the fungus' dispersal dynamics. In conclusion, this study should be used a basis for future research to help to clarify the affects of fungus on community and ecosystem properties of the aspen forest system.

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Figures

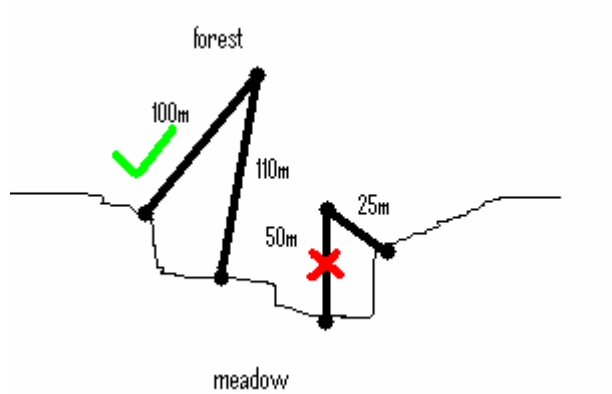


Figure 1. Transect selection method based on distance from original point and closest meadowed edge

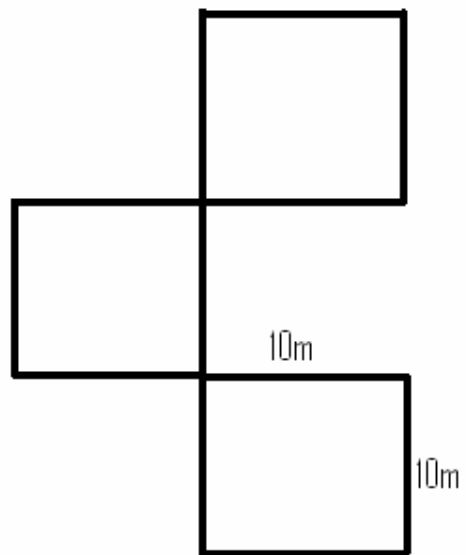


Figure 2. Transect and 100m² plot setup

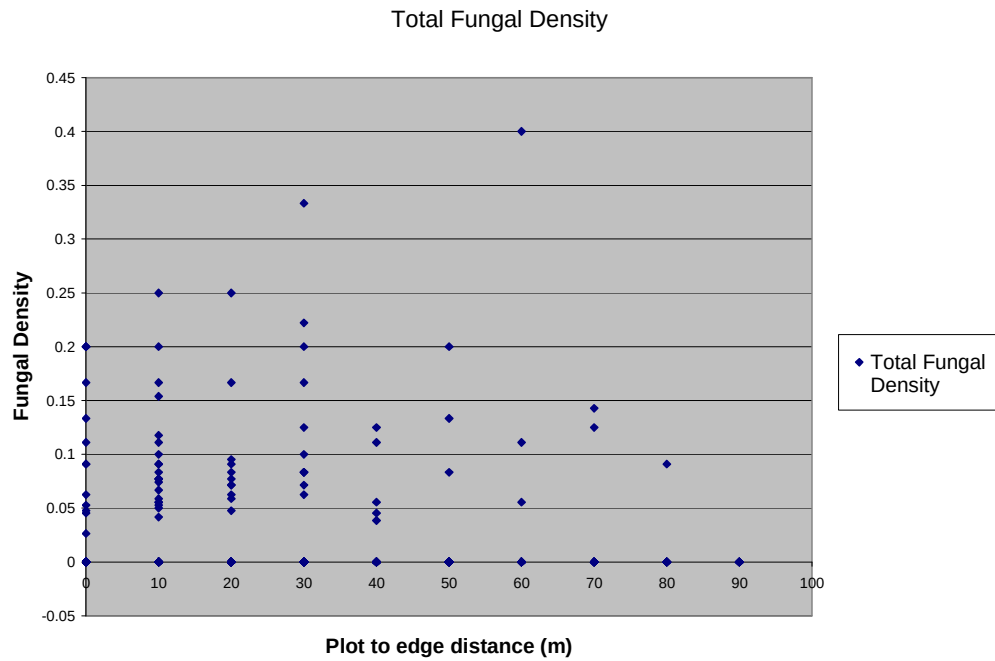


Figure 3. Fungal density of all trees >5cm DBH plotted against plot to edge distance (n=287).

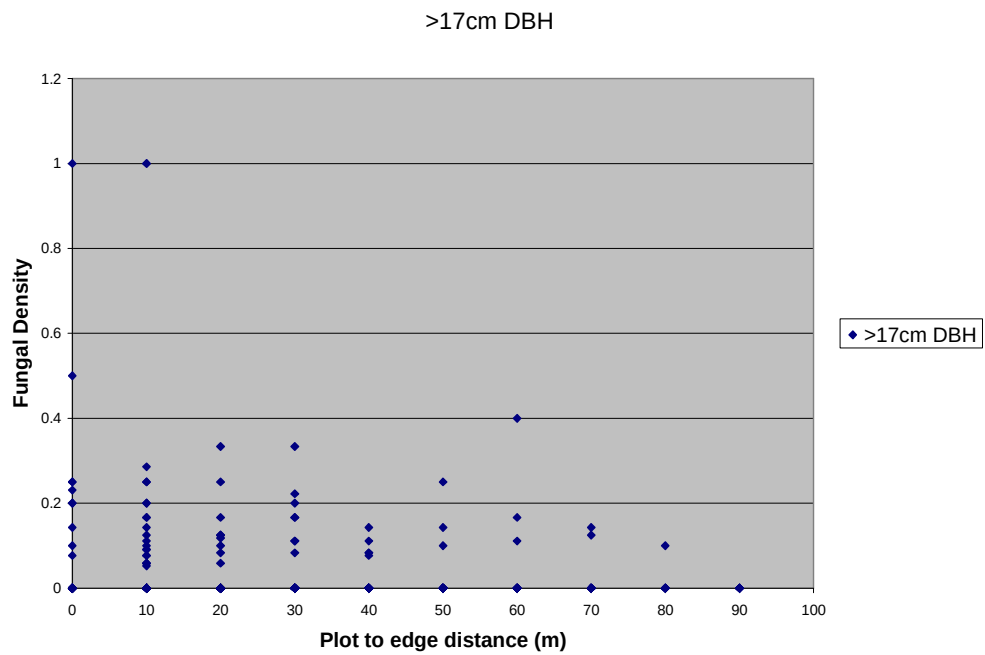


Figure 4. Fungal density of trees >17cm DBH plotted against plot to edge distance (n=287).

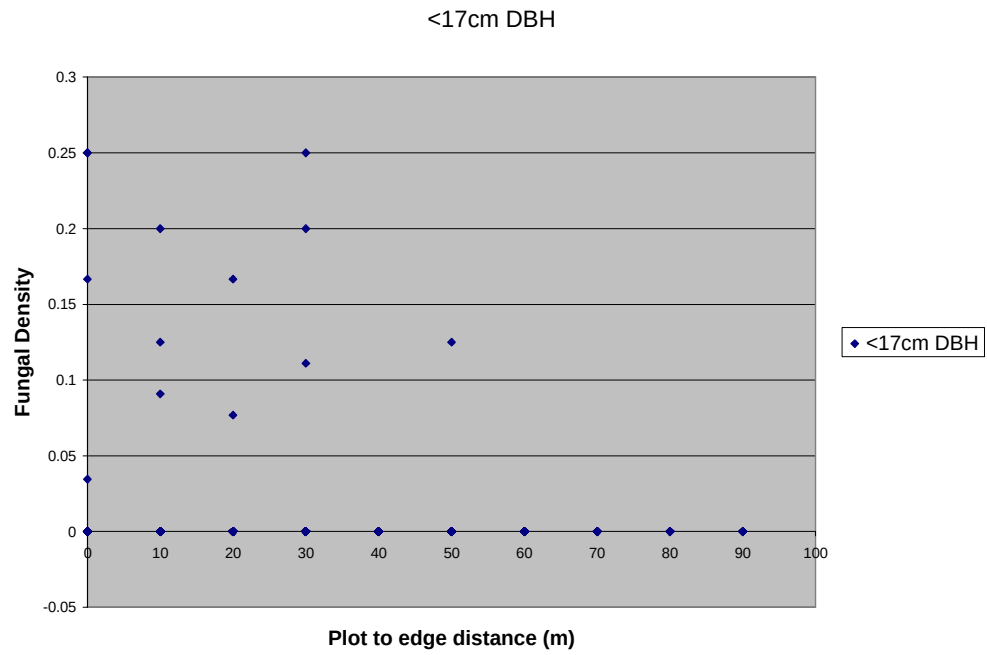


Figure 5. Fungal density of trees between 5cm and 17 cm DBH plotted against plot to edge distance (n=287).

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