Assessing preference by white-footed mice (*Peromyscus leucopus*) for coarse woody debris

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Abstract

Research to expand current knowledge of habitat use by white-footed mice *(Peromyscus leucopus)* at fine spatial scales is needed given the species' widespread distribution in the United States and its prevalence as a reservoir for zoonotic pathogens like Lyme disease. Downed coarse woody debris, a structural component of forest floor habitat important for many small mammals, may be preferred by woodland dwelling *P. leucopus* because of its multiplicity of uses from cover to landmarks that aid in spatial memory for navigation. To assess the role that downed woody debris plays in facilitating habitat preference of *P. leucopus*, Sherman box traps were deployed for live trapping and tagging of *P. leucopus* and coarse woody debris was surveyed in grids across various types of forest at Brookhaven National Laboratory during the summer of 2017. A Pearson correlation analysis produced no significant correlation between abundance estimates of *P. leucopus* population size and total volumes of coarse woody debris. In order to inform wildlife and forest management practices of the importance of woody debris in facilitating *P. leucopus* populations, more long-term studies are needed that can account for the interacting effects of other habitat characteristics like patch size and understory vegetation density. Over the course of the study I became proficient and confident in handling and processing *P. leucopus*, a useful skill to have for future studies in wildlife ecology.

Introduction

Lyme Disease (LD) is a major public health issue in the United States with approximately 30,000 cases of LD being reported to the Center for Disease Control (CDC) every year, a number that has been increasing every year since 1995 (CDC 2015). Other research conducted in association with the CDC indicates that this number may actually be closer to 300,000 cases nationwide annually (Hinckley et al. 2014, Nelson et al. 2015). Because there is currently no vaccine for LD on the market and LD can cause debilitating acute and chronic symptoms and even be fatal, it poses a significant public health risk and is of the utmost importance for the scientific community to understand as much as possible about the underlying factors driving the disease.

The white-footed mouse (*Peromyscus leucopus*), an abundant generalist mammal species, is one of the most successful host reservoirs for LD and other zoonotic diseases like Babesiosis and Ehrlichiosis (LoGiudice et al. 2003, Shaw et al. 2003). *Borrelia burgdorferi*, the spirochete bacteria responsible for causing LD is benign to *P. leucopus*. However, once a blacklegged tick or “deer” tick (*Ixodes scapularis*) at the larval or nymph stage bites and consumes a blood meal to repletion (until it falls off) from an infected white-footed mouse, it has up to a 90% chance of becoming infected with the *B. burgdorferi* bacteria (Shaw et al. 2003) and is subsequently more likely to become a vector to transmit the bacteria to a human and cause LD than when feeding on other host species. *P. leucopus’* effectiveness as a host reservoir may stem from its habitat use; microhabitat segregation between *P.leucopus* and the eastern chipmunk (*Tamiasciurus hudsonicus*) shows that *P. leucopus* is more likely to use tick-infested habitat and attract questing larval ticks and have much higher tick burdens than *T. hudsonicus*, despite significant grooming by *P. leucopus* (Shaw et al. 2003).

Given that *P. leucopus* is abundant in the Northeastern United States where cases of LD are high, assessing the relationship between habitat characteristics that may be preferred by *P. leucopus*, and *P. leucopus* abundance could inform wildlife and/or forest management by providing a quantifiable basis for forest areas to be designated as high-risk for LD because of its suitability for *P. leucopus*.

Numerous factors facilitate *P. leucopus* populations, from forest productivity and mast production (Ostfeld et al. 1996, Elias et al. 2004), to habitat patch edge-to-interior ratio (Anderson et al. 2003), connectivity (Rizkalla and Swihart 2007), and vegetation density (Monamy and Fox 2000). Downed coarse woody debris (CWD), a significant structural component of forest habitat, may be an important determinant of *P. leucopus* populations (Graves et al. 1988, Barnum et al. 1992). CWD is heterogeneous across the landscape and variable from one forest patch to the next due to the random effects and varying magnitudes inherent to different disturbance types (Harmon et al. 1986). For example: fire, a less frequent but significant disturbance, has the capacity to exacerbate the role of CWD in providing habitat structure by not only felling trees directly but by making surviving trees more susceptible to wind and insect infestations as well as “re-setting” the succession of herbaceous understory cover.

Small mammals utilize CWD in different ways but generally use it for cover from predators (Zollner and Crane 2003, Fanson 2010), foraging space, and nesting (Bowman et al. 2000). Research has also highlighted the importance of downed wood for *P. leucopus* by using CWD as “highways” or landmarks that aid in spatial navigation (Graves et al. 1988, Barnum et al. 1992, McMillan and Kaufman 1995). This knowledge sets a precedent to investigate the preference of *P. leucopus* for habitat containing relatively larger amounts of CWD. I hypothesized that *P. leucopus* populations are positively correlated with volume of CWD.

Field Methods

To investigate the hypothesis that *P. leucopus* populations and volume of CWD are positively correlated, Sherman traps were deployed Monday- Thursday of each week between June 12th and August 4th 2017 to mark and recapture *P. leucopus* individuals and estimate their abundance at 16 different trapping sites around Brookhaven National Laboratory (BNL) in Upton, New York (Figure 1). All sites were adjacent to roads, but set-up at least a few meters into the forest to reduce edge effect. Sites 11-16 constituted mixed oak and pitch pine (*Pinus rigida*) stands with blueberry (*Vaccinium corymbosum*) dominating the understory and contained relatively few fallen trees, forests gaps, or larger CWD. These sites have not been burned by wildfire or prescribed fires in recent decades.

Sites 9 and 10, near the Long Island Solar Farm, were similar to 11-16 but differed with a more heterogeneous understory of herbaceous groundcover and open/somewhat grassy patches as well as more treefalls and a taller canopy. Sites 7 and 8, near the sewage treatment plant at BNL both constituted large areas of open grasses mixed with patches of blueberry with some large treefalls. Site 7 in particular was about 1/3rd open canopy and grass. Sites 3 and 5 were within quadrants of forest between dirt roads that were subject to prescribed fires before trapping occasions in the first trapping session. Both exhibited similar vegetation to Site 4, an unburned site between the two burned quadrants with homogenous blueberry and generally taller and thicker understory with more treefalls, gaps, and large CWD. These quadrants were previously burned unsuccessfully in 2015. Site 6 was across a dirt road from site 5 and was not burned this summer or in the past. It also contained homogenous blueberry understory with greater amounts of CWD. Site 1 had similar vegetation and canopy structure to sites 3-6 (pre-burn) and was burned by a wildfire in 2012.

Trap grids were $35m^2$ and included 64 traps spaced 5m apart for a total of 8192 trap nights over the course of the study. Traps contained a cotton square and a peanut butter and oat bait. Trapped P. leucopus were tagged and ticks were removed and put into ethanol when found. Each grid was surveyed completely for CWD pieces at least 16cm in diameter and 60cm in length. Volume of CWD pieces were calculated based on the volume of a cylinder ($V = \pi r2h$) and summed for a total volume of CWD for each grid.

Diameter was measured by eye-balling the middle of the CWD piece in an effort to reduce the error associated with the taper of downed pieces and calculating volume based on a uniform cylinder. When possible, multiple measurements were taken and recorded as separate pieces (for example, a downed tree where the main trunk splits into smaller branches) to further reduce this error. Pieces had to be at least half inside of the grid to be counted, and had to be resting at an angle less than 45^o to be considered downed.

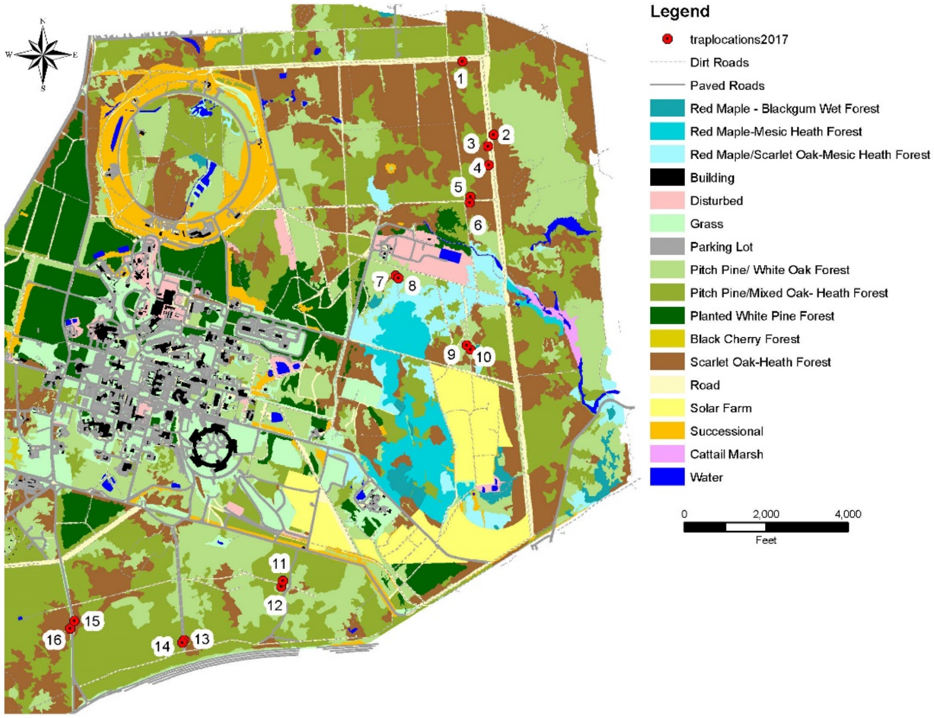

Figure 1. Map of Brookhaven National Laboratory including land cover types and the 16 trap sites for the study. Map courtesy of Leanna Thalmann.

Statistical Methods

Population abundance estimates and 95% confidence intervals were produced by running a Huggins p and c robust design model (a population estimate that combines the closed model of Lincoln-Peterson and the open model of Jolly-Seiber (Huggins 1991)) in program MARK ver 6.1.7601. A Pearson correlation analysis was run in R Studio ver 1.0.136 to produce a correlation coefficient for CWD as an x variable and *P. leucopus* abundance as a y variable.

Results

The correlation between *P. leucopus* abundance and total volume of CWD across all trapping sites was weakly positive ($r = 0.09$, 95% CI [-0.35, 1]) and not statistically significant ($p = 0.37$). A few sites with high abundance had high volumes of CWD while most others had low abundance and relatively high CWD or relatively high abundance and low CWD (Figure 2). Although Site 6, an unburned site, had the highest volume of CWD (1,920,791.74 cm^3) as well as the highest estimate of *P. leucopus* abundance (35.58, 95% CI [21, 47.2]), Wildfire site 1 ranked 4^{th} overall for abundance estimates (31.1, 95% CI [24.02, 32.99]) as well as having a high total volume of CWD (1,374,011.68 cm^3). The sites in the southern part of BNL (11-16) fell into the lower half of all sites for both abundance estimates and volumes of CWD. Both prescribed burn sites 3 and 5 exhibited low abundance estimates (3.35, 95% CI [2.44, 4.26], and 8.63, 95% CI [4.99, 10] respectively) but high volumes of CWD (1,463,817.24 cm^3 and 1,533,172.61 cm^3 respectively).

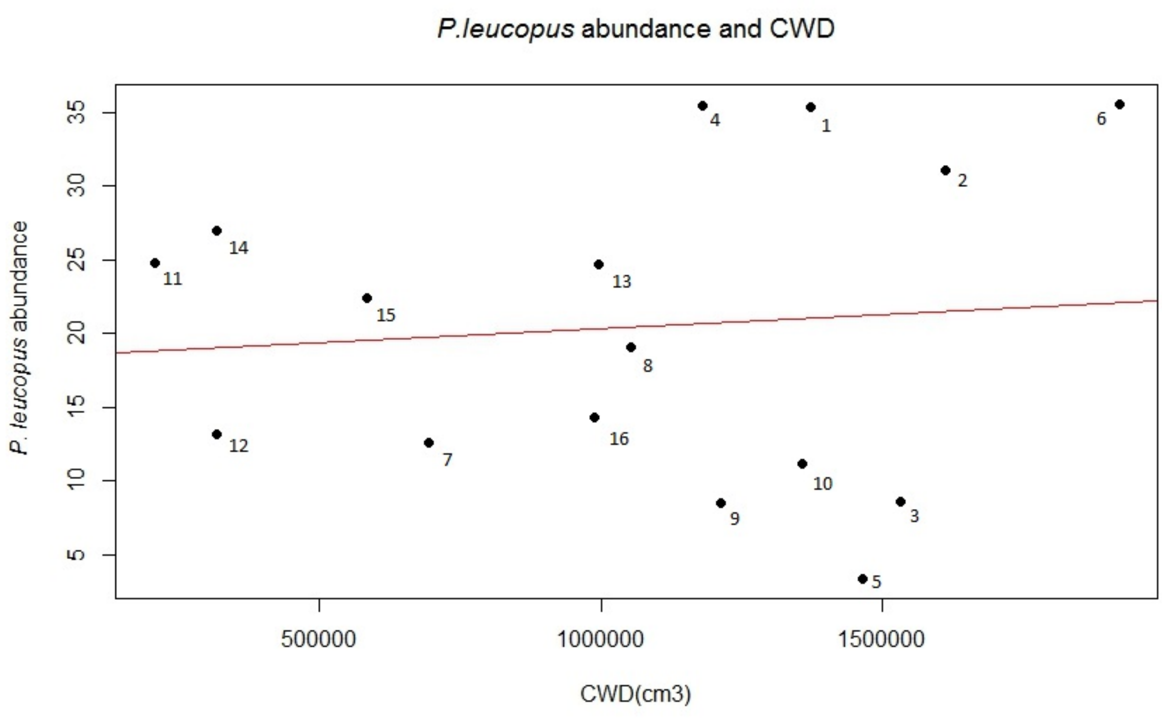

Figure 2. Correlation analysis of volume of CWD in cubic centimeters (x-axis) against *P. leucopus* abundance (y-axis). R coefficient = 0.09 (red line), p-value = 0.37. Black circles represent different trap sites and correspond to the trap numbers labeled in Figure 1.

Discussion

The structural and functional complexity of forest habitat makes focusing on one characteristic independent of all others difficult. Although CWD has been shown to be an important aspect of habitat for small mammals (Graves et al. 1988, Barnum et al. 1992, Bowman et al. 2000, Brannon 2005) the simultaneous and possibly interacting effects of other habitat components like understory vegetation density (Monamy and Fox 2000), habitat patch size and edge-to-interior ratio (Anderson et al. 2003), patch connectivity (Rizkalla and Swihart 2007), and mast production (Ostfeld et al. 1996, Elias et al. 2004) all work to influence small mammal abundance.

The low abundance estimates but high CWD volumes for both of the prescribed burn sites (3 and 5) most likely biased the results of the correlation analysis. Several of the downed trees surveyed in site 5 were cut by workers post-burn for safety reasons, and nearly half of all pieces surveyed in site 3 were also cut by workers post-burn which significantly influenced the total volumes calculated for both sites. Furthermore, although vegetation density and habitat structure have been shown to be better predictors of small mammal abundance post-disturbance (Monamy and Fox 2000) it is likely that adequate time had not passed since the prescribed burns to allow small mammal populations to fully re-colonization; other studies of how fire effects small mammal populations have sampled populations on the scale of months or years after fire (Vieira 1999), not within the same week/the weeks following the fire as was done here.

Abundance may not be the best parameter with which to study the preference of a small mammal species like *P. leucopus* for habitat structure like CWD. Spatially explicit models in tandem with habitat surveys that give accurate information about the distribution of a habitat component within a trapping area would be more likely to reveal a use preference by a species because of the aforementioned number of variables that can contribute to influencing small mammal abundance. Many studies use florescent powder to mark and track the movements of small mammals within a habitat (McMillan and Kaufman 1995), a technique that could be used in tandem with trapping to elucidate habitat use preferences at a finer spatial scale.

The time and resource restrictions of this study limited CWD surveying to larger pieces (≥ 16cm in diameter and ≥ 60cm in length) and excluding decay class from measurements of CWD pieces, another factor known to influence species specific preference for CWD (Bowman 2000, Brannon 2002). Furthermore, trapping occurred only twice at each site, limiting the accuracy with which local populations of *P. leucopus* could be estimated and stretching the assumptions of a robust design. Pollock (1982) states that at least 3 primary trapping sessions and 5 secondary trapping occasions for each primary session are required for using a robust design to estimate population size. Although our study incorporated a large number of secondary trapping occasions across different sites, there were only two primary trapping sessions because each site was only visited twice. This gave us a relatively large number of trap nights (8192), but between 2 sessions conducted over a relatively short period of time compared to other mark-recapture studies (Graves et al. 1988, Brannon 2005). This could have violated the assumption that individuals of the same species have the an equal chance of being captured, as condensed trapping occasions could have exacerbated behavioral responses by *P. leucopus* like being trap-happy or trap-shy.

Future studies using small mammal abundance as a parameter to correlate to volume of CWD must take place over longer spans of time to allow for more trapping sessions with longer intervals between sessions, as well as include surveys for multiple habitat characteristics that might influence *P. leucopus* abundance. If prescribed burns are going to be used to simulate disturbance and successional variables, adequate time must be given for small mammal populations to re-colonize before surveying an area after a burn. Running multivariate statistics to analyze the interacting effects between multiple habitat characteristics could better elucidate the role of CWD in facilitating populations of *P. leucopus* and by extension, forest areas at a higher risk of harboring *I. scapularis* infected with Lyme disease.

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Citations

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