INTRODUCTION

Quantitative descriptions of dispersal are essential to understanding the spatial and genetic structure of plant populations (Howe and Smallwood 1982; Levin et al. 2003; Ridley 1930). In particular, dispersal plays a crucial role in the survival of populations in systems, which are fragmented, either naturally or due to anthropogenic impacts. In recent years, dispersal ecology has become an active area of research as a result of current concerns about climate change, invasive species, and habitat fragmentation (Cousens et al. 2008). In plants, dispersal precedes colonization of new habitat patches; allows an escape from competition, either with the parent plant and/or with individuals of other species; and permits gene flow between established populations (Howe and Smallwood 1982; van der Pijl 1982). Given the widely differing reproductive strategies, diaspore types, and patchy distribution of bryophytes, these organisms offer a good model to address questions about plant dispersal.

Bryophyte dispersal occurs through the dissemination of sperm, spores, specialized asexual propagules, or gametophytic fragments. Spores are considered the primary agents of long-distance dispersal in bryophytes given their small size (8–200 μm); large production numbers (14–90 million/capsule); release above the boundary layer; and ability, in at least some species, to survive cold, drought, and UV-radiation (Longton 1997; van Zanten 1976, 1978; van Zanten and Pócs 1981). In contrast, sperm, specialized asexual propagules and gametophytic fragments are dispersed over much shorter distances (1.2 cm–2 m) (Andersson 2002; Brodie 1951; Cameron and Wyatt 1990; Kimmerer 1991). The delicate nature of sperm and their need for a water film is assumed to limit their mobility. In contrast, it is mass and lack of specialized release mechanisms that limit the movement of asexual propagules and fragments (Laaka-Lindberg et al. 2003). These asexual propagule types are considered important in local population maintenance, but they have received little attention with respect to their possible role in dispersal over longer distances (> 2 m). Recent work, however, has provided evidence to suggest that fragments and specialized asexual propagules may be equally important to dispersal beyond the immediate vicinity of a bryophyte patch (Heinken et al. 2001; Parsons et al. 2007; Pohjam et al. 2006; Robinson 2012; Rudolphi 2009).

Bryophytes are an integral component of forest ecosystems, forming extensive mats on logs, stumps, and rocks. They are important for soil formation, provide much needed moisture and shelter for invertebrates and small vertebrates, and serve as a seedbed for understory vegetation (Bates and Farmer 1992; Nilsson and Wardle 2005; Turetsky 2003). The effect of different dispersal strategies, however, on the distribution, diversity, abundance, and colonization rate of different species in northern forests has not been well studied. In order to investigate the dispersal to, and colonization of logs in

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northern hardwood/coniferous forests, a long-term study is being established at three properties maintained by the SUNY-Oneonta Biological Field Station (BFS). The objective of this study was to select appropriate sites and collect baseline data for the long-term study. Additionally, the bryophyte diversity data collected serve as the first of their kind for the properties on which sites were established.

METHODS

This study took place at the following SUNY-Oneonta properties: Greenwoods Conservancy, Thayer Farm, and Rum Hill. Three sites at each of these three locations (nine sites total) were selected based on an initial survey of bryophyte diversity and forest composition. This provided three replicates each at three sites with similar community structure. The GPS coordinates for each site were recorded using a Garmin GPSmap 76CSx GPS unit. After determining the location of all nine sites, two were chosen to be sampled for this initial study, one site at Thayer Farm and one site at Rum Hill.

At both locations, circular belt transects were established around a central point, marked with a stake, in ½-m increments to a total distance of 10 meters from the central point. To accomplish this, a 30-m length tape measure was extended from the stake, and flags or dowels were used to mark the inner and outer borders of each transect (Figure 1). Each ½-m transect was surveyed for the presence of moss and liverwort patches. When a patch was located, a sample was collected for later identification, and the following information was recorded: substrate type, transect number, compass bearing from central point, presence/absence of sporophytes, site name, date, and time. After identifying each sample collected, data associated with that specimen were organized by transect number, bearing, and site using Microsoft excel. Presence/absence of sporophytes was recorded for each specimen in order to estimate the amount of spore production for each species at each site. Nomenclature for hepatics followed Schuster (1953), and for mosses, Crum and Anderson (1981).
RESULTS

Combining material collected at both sites, a total of 572 bryophyte patches, representing 50 species (8 liverworts and 42 mosses) were found, sampled, and identified. Overall bryophyte abundance was higher at the Thayer farm site with 390 collections compared to the 182 collections made at Rum Hill. Species richness, however, was greater at Rum Hill. A total of 26 and 41 species were found at the Thayer farm and Rum hill sites, respectively (Figures 2 and 3). Eleven of the 26 species found at Thayer farm and 22 of the 41 species found at Rum Hill were unique to those sites. Of the ten most abundant species encountered at each site, four were the same. These included *Hypnum imponens*, *Hypnum pallescens*, *Lophocolea heterophylla*, and *Dicranum montanum* (Figures 2 and 3).

Bryophytes were found growing on seven and eleven substrate types at Rum Hill and Thayer farm, respectively (Figures 4 and 5). Logs at varying levels of decay were the dominant substrate type at Rum Hill, while DOM (Dead Organic Matter) was the dominant type at Thayer farm. Dead organic matter consisted of highly degraded organic material that could not be identified as any specific substrate type (i.e. branch, log, stump, etc.).

Overall sporophyte production was higher at Rum Hill (44% of material collected) compared to Thayer Farm (35% of material collected). Combining data from both sites, the most abundant species encountered also had the greatest sporophyte production (Figure 6). Consequently, a Pearson’s correlation found that sporophyte production was significantly correlated with species abundances (r = 0.93, p = 0.0000). Seven of the most abundant species, however, showed low to no sporophyte production. These included *Leucobryum glaucum*, *Dicranum montanum*, *Dicranella heteromalla*, *Leskea gracilescens*, *Leskeela nervosa*, *Dicranum viride*, and *Platygerium repens*. 
Figure 2. Total number of collections made (black bars), and number of collections with sporophytes present (gray bars) for each species encountered at the Rum Hill site.
Figure 3. Total number of collections made (black bars), and number of collections with sporophytes present (gray bars) for each species encountered at the Thayer Farm site.
Figure 4. Total number of collections found on each substrate type encountered at the Rum Hill Site.
Figure 5. Total number of collections found on each substrate type encountered at the Thayer Farm site.
Figure 6. The relationship between species abundances and sporophyte production in a linear regression based on all samples collected from the Thayer Farm and Rum Hill sites.
DISCUSSION

The results presented in this paper are meant to serve as baseline data for a long-term study that will be used to investigate bryophyte dispersal to, and subsequent spread on logs in northern hardwood/coniferous forests. A total of nine sites among three locations have been chosen for this study with the plan to establish two to three a year over the next three to four years. The two sites discussed in this paper are the first two, of the expected nine, to be established.

In terms of species richness and abundance, it is difficult to make comparisons given the uniqueness of this study and the current lack of replicate plots at each location. It is interesting to note, however, that a greater number of species were encountered at Rum Hill, even though the number of samples collected was less than half of that from Thayer farm. Additionally, Thayer farm had a greater number of substrate types. This result was most likely due to the greater diversity of tree species found at the Rum Hill site (data not shown). Gustafsson and Eriksson (1995) found a strong correlation between bark chemistry and epiphytic diversity (bryophytes and lichens), as well as soil chemistry. While there was a greater number of substrate types at Thayer Farm, given the homogeneity of the site, with respect to the vascular vegetation (hemlock forest), important variables such as pH and nutrient levels were likely very similar throughout the plot. A greater diversity in soil and bark chemistry at the Rum Hill site, consequently, could explain the greater species diversity. These variables need to be measured, however, before such conclusions can be made.

At both sites sampled, species abundance was strongly correlated with sporophyte production. This is an indication of greater dispersal ability and colonization rate of spore producing species compared to those that rely more on asexual means of reproduction and dispersal. This result is consistent with past work showing evidence of the local and long-distance dispersal ability of spores (During 1990; Longton 1997; van Zanten 1976, 1978; van Zanten and Pócs 1981). Seven of the most abundance species, however, showed little to no sporophyte production. Five of these seven species produce some sort of specialized asexual propagule. Such propagules were originally not thought to be important to dispersal beyond the immediate vicinity of a bryophyte patch. Recent work, however, has provided evidence to the contrary (Parsons et al. 2007; Pohjam et al. 2006; Rudolphi 2009). The results of this study appear to support these recent findings, showing that species relying more on asexual propagules are equally capable of dispersal, at least within a 314 m² area, as those that produce high numbers of spores.

ACKNOWLEDGMENTS

We would like to thank the Biological Field Station and its staff for providing all the necessary resources to complete this project. Field work conducted at Thayer Farm by Alexander Lawrence and Rebekah Obenauer was done during there time as Biological Field Station Interns during the summer of 2012. Thanks to Mathew Dami, Elli Edelstein, and Elizabeth Castle (SUNY-Oneonta graduate students) for their assistance with the identification of collected material.
REFERENCES

Andersson, K. 2002. Dispersal of spermatozoids from splash-cups of the moss 


Brodie, H. J. 1951. The splash-cup dispersal mechanism in plants. Canadian Journal of 

Cameron, R. G. and R. Wyatt. 1990. Spatial patterns and sex ratios in dioecious and 

Oxford University Press, New York.

University Press, New York.

Gustafsson, L. and I. Eriksson. 1995. Factors of importance for epiphytic vegetation of aspen 
*Populus termula* with special emphasis on bark chemistry and soil chemistry. Journal of 

Heinken, T., R. Lees, D. Raudnitschka and S. Runge. 2001. Epizoochorous dispersal of 
bryophyte stem fragments by roe deer (*Capreolus capreolus*) and wild boar (*Sus scrofa*). 


Kimmerer, R. W. 1991. Reproductive ecology of *Tetraphis pellucida* II differential success of 


Levin, S. A., H. C. Muller-Landau, R. Nathan, and J. Chave. 2003. The ecology and 
evolution of seed dispersal: A theoretical perspective. Annual Review of Ecology and 
Systematics 34: 575–604.

65–102.

Nilsson, M-C. and D. A. Wardle. 2005. Understory vegetation as a forest ecosystem driver: 
Evidence from the northern Swedish boreal forest. Frontiers in Ecology and the 


