ABSTRACT

Title of Thesis: AN ECOLOGICAL ANALYSIS OF THE POTENTIAL FOR MOSS-BASED GREEN ROOF DESIGN

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Green roofs are a maturing application of best management practices for controlling urban stormwater runoff. The majority of green roofs are planted with drought resistant, higher plant species, such as the genus Sedum. However, other plant varieties, such as mosses, may be equally applicable. Residential roofs and natural terrestrial communities were sampled in both Maryland and Tennessee to determine moss community structure and species water composition. This served as a natural analog for potential green roof moss communities. During sampling, 21 species of moss were identified throughout the 37 total sites. The average percent moss cover and water composition across all roof sites was 40.7% and 38.6%, respectively and across all natural sites, 76.7% and 47.7%, respectively. Additional maximum water holding capacity procedures were completed on sedum and 19 of the 21 sampled moss species to assess their individual potential for stormwater absorption. Sedum species on average held 166% of their biomass in water, while moss species held 732%. The results of this study are used as a basis to propose moss species that will improve green roof performance.

AN ECOLOGICAL ANALYSIS OF THE POTENTIAL FOR MOSS-BASED GREEN ROOF DESIGN

by

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CHAPTER I: Introduction

The incorporation of green elements into the latest architectural trends is a guiding force behind innovative urban development. This force, green infrastructure, is a maturing approach that dictates the relationship between anthropogenic structures and the natural world. Through mimicking natural processes, such as carbon sequestration, stormwater retention, and infiltration, green infrastructure softens the delineation between human and natural design. Integration of this concept into an operative society has the potential to remedy many human generated environmental disturbances (Tzoulas et al., 2007). However, mirroring ecosystem community structure, each project may rely upon a unique plant species palette; customizing this palette is generally based upon the surrounding climate, project form, or project intent (Todd et al., 1994).

Green roofs are a frequently implemented form of green infrastructure (Gill et al., 2007). Mainly focused upon reducing stormwater runoff volume, green roofs also provide pollution reductions, a remedy to the heat-island effect, and significant indoor heating and cooling benefits (Benedict and McMahon, 2006). In certain regions of the United States, architects design basic, empty roofs with the expectation of later installing a green roof on top (Furbish, 2016). Plant palettes may vary with different depths of green roof media, but all plant palettes provide stormwater retention, filtration, evapotranspiration, and aesthetic qualities (Monterusso et al., 2005). The standard green roof plant palette consists of a variety of sedum species—a genus of flowering succulents (Hideaki, 1977). Sedum species are recognized for desiccation, inundation, and irradiance tolerance, making them well suited for many green roofing applications (Monterusso et

al., 2005). However, the price of just the extensive green roof media and sedum, without government incentives, averages approximately $15 per square foot in the United States (Urban Design Tools Low Impact Development, 2016). Many architects and developers will quickly choose cheaper and easier to install asphalt singles when planning the roof of a structure. In addition, the average extensive green roof when fully saturated may weigh up to 146.5 kg/m^2 (30 lb/ft^2) (Garner, 2016). This weight will further limit green roofs to structures with adequate support. For green roofs to become more widely applicable, cost reductions through either policy or component changes, and weight reductions are needed.

Despite the somewhat variant, site-specific green roof plant palette choices, mosses are rarely viewed as a potential sedum substitute (Madre et al., 2013). The inclusion of mosses within the realm of green roofing may provide an inexpensive, lightweight, and efficient alternative to the broadly applied sedum genus.

Mosses, an essential component of numerous early stage successional communities, are nonvascular, non-woody, non-flowering bryophytes that tend towards clumping and forming mat-like surfaces (Lepp, 2012). Every species of moss is classified into one of three growth categories: acrocarpous, pleurocarpous, or sphagnum. Acrocarpous mosses grow upright, tightly packed, with generally unbranched stems (Spain, 2010). Pleurocarpous mosses branch horizontally in an unsystematic fashion and lay relatively flat against the underlying surface (Glime, 2007). Sphagnum mosses grow in tightly packed mats of porous, vertical stems. Atop each stem is a cluster of smaller branches that resembles a cotton ball (Glime, 2007).

These growth categories can be further broken down into unique water transport methods. The lack of vascular tissue is the main distinction between bryophytes and the other divisions of Plantae (Glime, 2007). Bryophytes have developed alternative water transport methods, lacking lignin, that can be separated into three categories: ectohydric, endohydric, and mixohydric (Chopra and Kumra, 1988).

Mosses can also be divided by water transport strategies (Purcell, 2014). There is a significant correlation between moss water transport system and habitat preference by species (Chopra and Kumra, 1988). Ectohydric bryophytes absorb water through capillary action. Tight, external, capillary channels formed between the leaves and the stem guide water to the interior of the plant (Chopra and Kumra, 1988). When the plant is desiccated, these channels close to retain water internally. Despite the non-waxy exterior of ectohydric bryophytes, they are extremely resistant to total desiccation; due to the minimal amount of water required by this category of plants, ectohydric bryophytes are rarely completely dry (Chopra and Kumra, 1988). Ectohydric mosses colonize "hard, impermeable, and often nutrient poor [substrates], notably rocky surfaces" (Chopra and Kumra, 1988). Endohydric bryophytes typically possess a waxy exterior, which limits water uptake through the leaves. Consequently, this category relies entirely upon internal water transport (Glime, 2015). Located near the rhizoids of the individual plant, the central strand transports water up the stem to the costa, the mid-rib of the leaf, where the water is expended (Glime, 2006). Endohydric mosses generally colonize moist, loose surfaces, such as "soil or humus" (Chopra and Kumra, 1988) due to this limitation. Mixohydric bryophytes use both ectohydric and endohydric transport methods. These

mosses, having developed both internal and external water transport structures, tend to colonize “loams or clays” (Glime, 2007).

The unique combinations of growth category and water transport category, to some extent, determine the habitat in which each species colonizes (Chopra and Kumra, 1988). Additional factors including sun, drought, and heavy metal tolerance also have a significant effect (Tuba, 2011). Understanding the habitat preferences dictated by growth and water transport category may aid architects in selecting the most effective moss species for different green infrastructure projects. For example, acrocarpous mosses tend to expand radially through asexual reproduction at slower rate than pleurocarpous mosses; this generalization is purely due to the prostrate habit displayed by pleurocarpous mosses. However, due to the stem density displayed in acrocarpous mosses, other plant species cannot establish within the boundaries of the moss colony. A lack of adequate sunlight and a foothold in the community prevents most external weedy seedlings from fully developing (Klinck, 2009). These species-specific growth category tradeoffs paired with a complementary water transport category may provide an extremely effective alternative green infrastructure plant palette.

This study aims to compare species composition and percent water composition of moss communities found on existing structure roofs and those found in natural terrestrial environments. To test the viability of moss incorporation into green infrastructure, a series of studies were completed during the summer and early fall of 2015. The goal was to identify all species that maximize percent cover while minimizing percent water composition relative to other moss species identified during the study. This combination of traits is ideal for a green roof environment; all percent coverage

guarantees made by project managers and variability in rainfall events command substantial consideration when selecting a project specific plant palette. A related, additional study was completed in early spring of 2016 to test the total maximum water holding capacity of moss and sedum species. This aimed to compare the water retention and weight of prospective moss based green roof profiles with current FLL (Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau or German Landscape Research, Development and Construction Society) sedum based green roof profiles.

The research approach is to compare moss cover and water composition between roof and natural terrestrial moss communities. The overall goal is to identify species differences between naturally colonized roofs and natural terrestrial communities. All moss species that disproportionately prefer roof sites are potential candidates for green roof design.

CHAPTER II: Methodology

Section II a: Site Selection and On-Site Procedure

Roof sites and natural terrestrial environments were visited in both Maryland and Tennessee (Appendix 1 and 2). These two states were chosen due to differences in average temperature and humidity. The average high and low annual temperatures in Knoxville, Tennessee are 70 °F and 49 °F, while in Maryland they are 65 °F and 45 °F (Current Results Weather and Science Facts, 2016). The average annual relative humidity in Knoxville, Tennessee is 69%, while in Maryland it is 64% (Current Results Weather and Science Facts, 2016). Despite the environmental differences, moss species along the Appalachian Mountains are fairly constant (McKnight et al., 2013). Therefore, having similar species experiencing different environmental factors may lead to comparable percent cover and percent water composition data.

Sites in Maryland include 12 roofs and 15 natural terrestrial environments. Sites in Tennessee include 5 roofs and 5 natural terrestrial environments. Natural terrestrial environments include: grass covered areas, bare soils, and forests in various successional states. The research was centered on the differences in moss communities between roof and natural terrestrial sites; therefore, as a prerequisite, each sampled site must have had detectable moss communities. The boundaries of the moss-covered roof determined where the site samples could be taken (Appendix 3). Determining the boundaries of natural sites was more subjective. By using the extents of the moss community, a rectangular sampling area was generated (Appendix 4). By creating these boundaries, natural sites and roof sites became more procedurally standardized. Insolation, pitch, and

aspect of each site were approximated; north facing sites, sites with less than approximately 70% insolation, or sites on a pitched surface greater than 12/12 (45°) were not sampled. These limitations eliminated the sampling of sun intolerant mosses. Percent shade was estimated in 10% increments. A combination of Google Earth and visual estimation was used to approximate the total shade at each site. Using the area of each site, a relative percent shade was generated. With greater insolation, lower pitch, and a non-north face, the sites will support mosses more applicable to green roofing plant palettes. These limitations also aided in forming a more consistent sampling procedure for comparing natural sites and roof sites. When addressing private property owners, an approximately 5-minute speech detailing the research intent was delivered and a liability waiver was signed. Roofs were accessed using a 7.6 m (25') extension ladder with the permission or supervision of the owner. Each site was visited within approximately 4-5 days after a rain event to minimize confounding percent water composition data (Appendix 5-11).

Ten random samples were taken at each site using a 400-cm^2 quadrat to sample percent surface cover by species. All moss species identified within the respective samples were collected using a thin knife to separate the moss from the substrate as effectively as possible. These samples were stored in sealed plastic bags for off-site percent water composition analysis. An approximately 25-cm^2 section of each species identified in each sample was taken; if any species represented a less than 25-cm^2 surface area, the entirety of the species was taken. In order to randomize initial quadrat placement, the quadrat was blindly tossed into the boundary area of each site. For the 9 subsequent samples, a pair of random numbers determined the position of the bottom left

corner of the quadrat relative to the previous location in centimeters. Depending upon the size of the site boundaries, the random numbers were scaled up or down by a single digit constant assigned to the site—this accommodated larger or smaller site boundaries.

Section II b: Percent Cover and Water Composition Analysis

A photograph of each quadrat sample was taken and stored in site-specific folders for off-site analysis. Using AutoCAD 2015 to calculate the percent cover by species (Figure 1) allowed for more precise measurements than an on-site estimate using a quadrat; the following procedure was used:

1. Insert Raster Image Reference and choose quadrat sample photograph.
2. Specify the photograph insertion point on screen and specify desired scale factor.
3. Using PLINE, outline the interior of the quadrat.
4. Calculate the area of the interior of the PLINE by selecting AREA and OBJECT and selecting the PLINE.
5. Select both the photograph and the PLINE and use SCALE to alter the size of both
6. Repeat steps 4 and 5 until the area of the interior of the PLINE is equal to 400 cm^2.
7. Using a PLINE, outline each species of moss and calculate the area of each by using AREA and OBJECT

This method eliminated the need for a consistent photograph angle and distance, which minimized the time spent on site. Percent cover of each moss species was calculated for each site using:

% Cover by species = (Sum of area in cm^2 for all occurrences of an individual moss species) / (400 cm^2 * 10 samples)

This equation accounts for the samples where no moss species were found and where moss species overlap occurred.

Post site visit, species samples were cleaned of all soil and gravel and individually weighed. Each species sample was then placed in a labeled brown paper bag, and stored in an oven set at 80° C for 24 hours to remove all moisture. Each sample was weighed again to calculate the percent water composition on a site and species-specific basis. Percent water composition was calculated using:

% Water by species = (Sum of % Water for all occurrences of an individual moss species) / (number of occurrences of individual moss species)

In anticipation for any additional testing, all samples were stored in sealed plastic bags in a dry, temperate location.

For each site, total moss biomass and total water weight were calculated using:

Moss Biomass (g) = (Site % moss cover) * (Average biomass of 25-cm^2 moss samples) * [(Area of site in cm^2) / 25 cm^2]

Water weight (g) = (Site % moss cover) * (Average wet weight of 25-cm^2 moss samples) * (Average % water composition of mosses from site) * [(Area of site in cm^2) / 25 cm^2]

Section III c: Supplementary Total Water Holding Capacity Tests

Supplementary tests to address the total maximum water holding capacity of the moss species collected were preformed in the early spring of 2016. To generate a realistic baseline for the study, sedum species were sampled from a single green roof in Baltimore, MD and collected in an identical fashion to the moss species. Identical percent

cover and percent water composition procedures were performed. All moss and sedum species were stored in an oven set at 80° C for 24 hours to remove all moisture. Sedum and moss samples were each separated by species and weighed to determine the total biomass collected by species. Each species was then stored in sealable, gallon plastic bags, which were filled completely with water. Each species was left to soak for 10 minutes before draining the water using a 0.15 mm sieve (US Standard Mesh Number 120). Samples were left to drain until the samples stopped draining for more than 30 seconds. Samples were weighed a second time to determine total maximum water holding capacity by species.

Section II d: Statistical Analysis

The means and variances of percent cover and percent water composition were calculated for each moss species and site categories (MD Roof, MD Natural, TN Roof, TN Natural). A two-factor ANOVA statistical test was completed to test for significance in percent cover and percent water composition between moss species and between site categories. A Fisher least significance difference post hoc test was applied to determine the specific differences. A two-sample t-test was performed on the percent cover and percent water composition of roofs and natural terrestrial sites to determine significant differences. A two-sample t-test was performed on both total biomass and total water between roof sites and natural terrestrial sites. This served as an additional distinguishing factor between the two site categories. A significance level of 0.05 was used to determine significant results in percent cover and percent water composition, and total biomass and total water.

A linear regression analysis of the total rainfall (kg/m^2) for two weeks prior to sampling and the moss water composition (kg/m^2) at each site was conducted. A two-week period was chosen to account for the rapid water composition changes found in different moss growth categories. An earlier study cites natural desiccation rates of 11 and 5 hours for ectohydric and endohydric moss clumps, respectively (Zúñiga-González, 2016). Full (100% water capacity) inundation rates for both growth categories were measured to be less than 6 minutes (Zúñiga-González, 2016). The rapid moisture exchange attributed to different moss species requires a longer time period of analysis due to the lack of site-specific, by minute, moisture data. This additional analysis served to analyze relationships between the site rainfall and the moss water composition data. If the slope of the regression line differs significantly from 0, there is a relationship between rainfall events and water composition in the sampled mosses. A significance level of $p<0.05$ was used to determine if the slope varied significantly from zero.

CHAPTER III: Results

Section III a: Overall Species Comparisons

Throughout Maryland and Tennessee, 37 study sites were located and sampled; of these sites, 27 were in Maryland and 10 were in Tennessee. In Maryland, 12 roof sites and 15 natural terrestrial sites were sampled and in Tennessee, 5 roof sites and 5 natural terrestrial sites were sampled. Between all 37 sites, 21 species of moss were found and these species occurred 553 times at varying site locations (Table 1 and Figure 2). All growth categories—acrocarpous, pleurocarpous, and sphagnum—were represented by at least one species of moss. However, only endohydric and ectohydric mosses were found (Appendix 12). The average percent moss cover across all sites was 60.2±0.8% and the average percent water composition at all sites was 45.6±0.7%.

Section III b: Site Category Comparisons

Across all roof sites in both Maryland and Tennessee, 9 species of moss were found. Across all natural terrestrial sites in both Maryland and Tennessee, 17 species of moss were found. An overlap of 5 species—*Brachythecium salebrosum, Ceratodon purpureus, Entodon seductrix, Plagiomnium cuspidatum*, and *Thuidium delicatulum*—was recorded (Figure 3). Percent cover and percent water composition of mosses on roof sites were both significantly lower than mosses on natural terrestrial sites (Table 2). The average percent cover and water composition found on roof sites was 40.7±2.1% and 38.6±1.3%, respectively. The average percent cover and water composition found on natural terrestrial sites was 76.8±1.3% and 47.7±0.9%, respectively.

A total of 20 moss species were identified in all Maryland sites (Tables 3 and 4). In all Maryland natural terrestrial sites, 16 species of moss were identified. In all Maryland roof sites, 7 species of moss were identified. An overlap of 3 species—*B. salebrosum, E. seductrix,* and *T. delicatulum*—was recorded (Figure 4). Mosses found in natural sites had a significantly lower average percent water composition and a significantly higher average percent cover when compared to roof sites. *E. seductrix*, uniquely, had a significantly higher percent cover on roof sites than on natural sites and a significantly lower percent water composition on roof sites than on natural sites (Tables 5 and 6). *T. delicatulum* had a significantly higher percent water composition on roof sites than on natural sites.

A total of 9 moss species were identified in Tennessee sites (Tables 7 and 8). In all Tennessee natural terrestrial sites, 6 species of moss were identified. In all Tennessee roof sites, 6 species of moss were identified. An overlap of 3 species—*B. salebrosum, C. purpureus,* and *T. delicatulum*—was recorded (Figure 5). Similarly to Maryland, Tennessee natural sites had a significantly higher percent cover when compared to Tennessee roof sites; however, Tennessee natural sites had a significantly higher percent water composition than Tennessee roof sites. *B. salebrosum* sampled from natural sites had significantly higher percent cover and percent water composition than *B. salebrosum* sampled from roof sites (Tables 9 and 10). While *C. purpureus* and *T. delicatulum* had no significant differences in percent cover between the natural and roof sites, *C. purpureus* natural samples had significantly less percent water composition than samples from roof sites and vice versa for *T. delicatulum*.

When comparing Maryland roof sites and Tennessee roof sites, an overlap of 4 moss species—*Anomodon attenuatus*, *B. salebrosum*, *Bryum argenteum*, and *T. delicatulum*—was noted (Figure 6). *A. attenuatus* identified in Maryland roof sites had a significantly lower percent cover than *A. attenuatus* identified in Tennessee roof locations (Tables 11 and 12). *B. salebrosum* and *T. delicatulum* both had a higher percent water composition in Maryland roof sites than in Tennessee roof sites. Expanding the focus to the 9 total moss species identified in all roof sites—*A. attenuatus, Brachythecium rivulare, B. salebrosum, B. argenteum, C. purpureus, E. seductrix, Plagiomnium cuspidatum, Schistidium apocarpum,* and *T. delicatulum*—displays differences in percent water composition and percent cover between the species (Tables 13 and 14). Most notably, *E. seductrix* showed higher percent cover than all other species found excluding *A. attenuatus*. In addition, *E. seductrix* showed lower percent water composition than 3 other species.

When comparing Maryland and Tennessee natural sites, an overlap of 5 moss species—*B. salebrosum*, *Dicranum scoparium*, *Fissidens adianthoides*, *Polytrichum commune*, and *T. delicatulum*—was noted (Figure 7). *P. commune* and *T. delicatulum* both had significantly lower percent cover in Tennessee natural sites than in Maryland natural sites (Table 15). *B. salebrosum* and *T. delicatulum* identified in Maryland natural sites showed significantly lower percent water composition than *B. salebrosum* and *T. delicatulum* identified in Tennessee sites (Table 16). Of the 17 species identified in all natural sites—*Atrichum altecristatum, B. salebrosum*, *C. purpureus*, *Climacium dendroides*, *D. scoparium*, *E. seductrix*, *F. adianthoides*, *Hypnum lindbergii*, *Hypnum pallescens*, *Leucobryum glaucum*, *P. cuspidatum*, *Platylomella lescurii*, *P. commune*,

Schwetschkeopisis fabronia, *Sphagnum wulfianum*, *T. delicatulum*, *Ulota crispa*—many species differed in both percent water composition and percent cover (Tables 17 and 18). However, *B. salebrosum* contained significantly more water than 5 other species and has a higher average percent cover than all other species.

Section III c: Total Biomass and Total Water by Site

Both the total biomass and total water found on roof sites was significantly less than natural terrestrial sites. The site with the lowest total biomass and total water per unit area was Roof site 7, having 0.97 g/m^2 and 0.5 g/m^2, respectively (Table 19). The site with the highest total biomass and total water per unit area was Natural site 5, having 1.7 kg/m^2m and 5.1 kg/m^2, respectively. Roof sites had a significantly lower biomass and water per unit area than natural sites.

Section III d: Rainfall and Water Composition Linear Regression

The linear regression between total rainfall for two weeks prior to sampling and the average moss water composition found at each site did not yield significant results. The slope of the regression line y=0.045-0.0006x had a p-value greater than 0.05 (0.38), which indicates no relationship between the variables. Excluding the outlier, Natural terrestrial site 7, the slope of the regression line y=0.032-0.00035x had a p-value greater than 0.05 (0.33), which again indicates no relationship between the variables. The residual plots indicate a normal linear distribution as an adequate representation (Appendices 13 and 14).

Section III e: Sedum and Moss Water Capacity

The percent cover of the mature green roof was 100% while the percent water composition of all 10 sedum samples averaged 48% (Table 20). The average percent water of all moss species did not different significantly from sedum. Using:

Water Capacity = (Inundated weight of each species) / (Biomass weight of each species)

Sedum, on average, can hold 166% of its biomass in water, while mosses, on average, can hold 732% of their biomass in water (Table 21). The lowest water holding capacity of any moss species was *Bryum argenteum* at 364%, and the highest water holding capacity was *Sphagnum wulfianum* at 1,234%. Using the approximately 25-cm^2 samples, the average weight (g/m^2) for both sedums and mosses were calculated at 100% surface coverage in order to standardize the percentages.

Dry Weight (g/m^2) = (Average dry weight of species) / (0.0025 m^2)

Wet Weight (g/m^2) = (Dry Weight (g/m^2)) * (Water holding capacity %)

Water Weight (g/m^2) = (Wet Weight (g/m^2)) – (Dry Weight (g/m^2))

On average, mosses can hold 32% more water (g/m^2) than sedums at equivalent percent cover. In addition, at full water capacity, mosses weigh 39% less than sedums at full capacity.

CHAPTER IV: Discussion

Section IV a: Species Coverage and Water Composition Analysis

The purpose of this research aimed to define community diversity and water composition of mosses found in natural terrestrial environments and in grey, roof environments. Using the results of this study to inform potential green infrastructure plant palette communities is a supplementary goal. Habitat quality differences such as substrate type and heavy metal presence between the two categories (roof and natural terrestrial sites) may led to the significantly higher percent cover and percent water in natural sites than in roof sites. However, Maryland and Tennessee roof sites shared a lower number of species in common than the respective natural terrestrial sites. This shows high habitat specificity in select moss species. For example, *Anomodon attenuatus* and *Bryum argenteum* were found only to colonize roof sites. Excluding moss species found in all 4 site categories (MD roof, MD Natural, TN roof, and TN Natural) only three moss species, *Ceratodon purpureus*, *Entodon seductrix,* and *Plagiomnium cuspidatum*, were found on a roof site and a natural site. Therefore, almost all species of moss were found on either only roof sites or only natural sites. All other mosses were found on either only roof sites or only natural sites. This indicates a preference by moss species to colonize either roof sites or natural sites. In addition, no species of moss was found to colonize exactly 3 site categories—all species colonized 1, 2, or 4 site categories.

Pleurocarpous and ectohydric moss species dominated roof colonization. On Maryland Roofs, 5 pleurocarpous mosses and 2 acrocarpous mosses were found; all 7 of which were ectohydric species. On Tennessee roofs, 5 pleurocarpous and 1 acrocarpous

mosses were found; 5 of which being ectohydric and 1 being endohydric (Appendices 15 and 16). This pattern shows a higher ability for ectohydric, pleurocarpous moss species to colonize roof environments. This is supported by water availability preferences displayed individually by both ectohydric mosses and pleurocarpous mosses. Moss species that fall into either category tend to colonize dry surfaces (Govndapyari et al., 2014). This is only amplified when a moss species falls into both categories. Another explanation for the differential in growth and water transport category representation may be due to specific metal resistance displayed by pleurocarpous mosses. When *Pseudoscleropodium purum*, a pleurocarpous moss, and *Ceratodon purpureus*, an acrocarpous moss, were exposed to 18 elements over the course of 6 months, *P. purum* accumulated Al, Cu, Zn, and Fe, significantly more efficiently than *C. purpureus* (Fabure et al., 2010). These four elements are commonly found in high concentrations in roof environments (Sainte et al., 2009), most specifically, in zinc strips installed under the shingles to prevent moss growth. This tolerance may aid in explaining the almost exclusive colonization of pleurocarpous mosses on roof sites and the more balance colonization of pleurocarpous and acrocarpous mosses in natural sites (Sidhu and Brown, 1996).

Entodon seductrix, a pleurocarpous, ectohydric moss species, displayed unusual percent cover and percent water composition between Maryland roof and Maryland natural sites. *E. seductrix* had a significantly higher percent cover in Maryland roof sites than in Maryland natural sites despite having significantly less percent water composition. This relationship may show a preference towards roof environments. However, this relationship may also point towards an inferior ability to outcompete other potential colonizing plants. The harsh environmental conditions associated with roof sites

severely limit potential plant species composition. A higher tolerance, rather than a preference, for these conditions, points towards *E. seductrix* having lower interspecies competition ability. This relationship may help explain the significantly lower percent cover by *E. seductrix* in natural sites; with more species able to colonize the area, *E. seductrix* is outcompeted for resources. However, because of the high ratio of percent cover to percent water composition, *E. seductrix* is still a valuable species to informing green infrastructure. Able to survive at a low percent water composition, *E. seductrix* leaves a high potential for additional water capacity.

Anomodon attenuatus is another intriguing prospective species. Similar to *E. seductrix*, *A. attenuatus* is a pleurocarpous, ectohydric moss. However, throughout the course of the study, the species occurred only on roof sites and occurred the most frequently out of all other moss species. Accounting for approximately 12% of Maryland roof site moss cover and approximately 58% of Tennessee roof site moss cover, *A. attenuatus* displays a similar preference for roof site environments. The species was not identified in any natural terrestrial site samples and the percent water composition was significantly different between Tennessee and Maryland roof sites. Displaying a similar high percent cover and low percent water relationship to *E. seductrix* in Tennessee sites, *A. attenuatus* may be an ideal species for southern United States green roofs.

Section IV b: Green Roofing Implications

The importance of high water storage in green roofing projects plays a significant role in the industry. Balancing total water capacity and overall system weight is site specific and paramount. A high ratio of water capacity to weight is ideal. The traditional, standard plant palette, sedum varieties, offer little water holding capacity (Farrell et al.,

2012)—the majority of the water retention comes from the green roof media. Introducing high maximum water composition moss species to a green roofing project will provide additional water retention. For this reason, the water holding capacity results of the study demonstrate the potential for moss-based green roofing. The moss water holding capacities found in this study are confirmed by other studies that show moss species holding 8-10 times their own biomass in water and approximately 30% more water than sedum (Anderson et al., 2010). In order to examine the effectiveness of a moss-based green roof system, the average weights of two common green roofing substrates were provided by Furbish, a green roofing company in Baltimore, Maryland (Table 22). A standard green roof substrate commonly paired with sedum is FLL media, which holds approximately 11.42 kg/m^2 of water per centimeter of media (Garner, 2016). An additional green roof component is 0.635 cm (¼") thick, 0.82 kg/m^2 (18 oz.) capillary fabric, which holds approximately 3.6 kg/m^2 of water (Garner, 2016). This component may only be paired with mosses due to how deep sedum roots penetrate the substrate when compared to moss rhizoids. On identical substrates, mosses, as proven previously, can hold more water at less weight (Table 23 and Figures 8 and 9). However, a green roof comprised of 5.1 cm (2") deep FLL standard green roof media and sedum holds 87% more than a green roof comprised of mosses and 0.636 cm (¼"), 0.82 kg/m^2 capillary fabric (Figure 10). This high percentage is expected due to the efficiency at which FLL substrate retains water. But, as previously mentioned, the important factor for all green roof projects is the water retention to weight ratio. A fully saturated, 0.635 cm (¼"), 0.82 kg/m^2 capillary fabric moss green roof weighs 98% less than a 5.1 cm (2") FLL sedum green roof (Table 24). The most effective comparison is a 0.635 cm (¼") FLL sedum

green roof and a 0.635 cm (¼"), 0.82 kg/m^2 capillary fabric moss green roof. This comparison is hardly realistic, in that sedum would most likely not survive in media that shallow. At equivalent depths, the moss green roof can hold 75% as much water as a sedum green roof; however, with both fully saturated, the moss system weighs 85% less than the sedum system (Table 25). At 8.7 kg/m^2 (1.8 lbs./ft^2), a completely inundated moss green roof that is 86% water weight is a very effective stormwater retention method. Residential roofs that were designed without the intention of a green roof installation, on average, can hold approximately 96.7- 120.9 kg/m^2 (20-25 lbs./ft^2) before they become stressed (Insurance Institute for Business & Home Safety, 2016). At lower than 10% of the critical weight, a moss capillary fabric green roof can provide stormwater retention at a previously unoccupied location. In the United States, this green roof system is considered pervious surface and will lower the required stormwater tax associated with the location of the residence (Plant Connection Inc., 2016). A moss capillary fabric green roof system is a lightweight and efficient answer to stormwater issues presented to residential homes.

Many factors contribute to the successful application of a moss green roofing system. Despite the misconception, a low irradiance roof, when compared to a high irradiance roof, may not have a significantly different moss species composition. Due to the variety of environmental conditions roofs may undergo within even a 3-hour period of time, colonized mosses must have equally high tolerances to extreme inundation, desiccation, and irradiance (Studlar and Peck, 2009). Unless the roof is at a constant extreme, this suggests that despite location specific environmental ranges, mosses with the highest frequency of occurrence across all sampled roofs would be the most

applicable at every location. For this study, *Anomodon attenuatus* (93), *Entodon seductrix* (53), and *Thuidium delicatulum* (31), show the highest potential for green roof plant palette application—all are ectohydric, pleurocarpous mosses. Despite occurring most frequently out of all moss species in the study, *A. attenuatus*' significant difference in percent cover on MD Roofs and TN Roofs exclude the species from general recommendations. In addition, roof pitch may be a higher contributing factor than previously acknowledged. Roofs with a larger pitch angle supported higher frequencies of xerophytic species of moss in earlier studies (Studlar and Peck, 2009); the higher pitch angle prevents water from pooling. This implies drought tolerance as the most important factor to consider when choosing a potential moss species.

Additional studies suggest beneficial groupings of mosses and herbaceous forbs in green roof plant palettes. A species of grass, *Festuca rubra*, commonly know as red fescue, performed significantly better in test green roof plots with mosses than when mosses were absent (Heim et al., 2014). This suggested facilitative effect could be due to additional resource availability for the forb generated by the mosses (Heim et al., 2014). The thick layer of moss prevented weed growth and allowed the forbs more access to nutrients (Heim et al., 2014). In addition, the forb provided shade for the moss species (Heim et al., 2014). Reduced nutrient availability for self-colonizing weed species would postpone any supplemental green roof maintenance. The facilitative nature of the relationship between forbs and mosses may further expand the potential acceptable mixed plant palettes for green roofs.

CHAPTER V: Conclusions

- Sixteen of twenty-one mosses displayed a preference for either roof or natural terrestrial habitats. The high number of pleurocarpous, ectohydric mosses found to colonize roof sites may show a relationship between habitat preference, growth category, and water transport category.
- The pleurocarpous, ectohydric, *E. seductrix* was found to have a significantly higher percent cover and a significantly lower percent water composition in roof sites than in natural sites; this differed from all other moss species identified. Having high maximum water holding capacity and a high tolerance for water scarcity, *E. seductrix* may be an ideal species for green roof implementation.
- There was no relationship between rainfall and moss water composition when samples were taken at least 4 days after a rain event.
- Total moss biomass and total water found at natural terrestrial sites were significantly higher than roof sites. Natural terrestrial sites show a higher ability to promote moss communities than roof sites.
- Due to the greater maximum water holding capacity displayed in mosses, at equivalent coverage and on identical media, mosses retain more stormwater than sedums. Stormwater retention is a primary goal in the green roofing market; choosing the appropriate moss species to replace sedums will yield higher results.
- The substrate that shows the greatest potential for a moss green roof plant palette is 0.635 cm, 0.82 kg/m^2 capillary fabric. At equivalent thicknesses, a moss capillary fabric green roof weighs 85% less than a sedum FLL green roof and

holds only 25% less water. Weighing only 8.7 kg/m^2 fully saturated, a moss capillary fabric green roof can be widely applied to residential homes. Due to low water and nutrient input needed to propagate mosses, the cost of maintaining a moss farm may be lower than a sedum farm.

- A mixed green roof plant palette, containing both mosses and sedums, may have a higher success rate than a green roof with either plant type individually. Sedums would provide shade and additional water availability for mosses, while mosses would provide higher water holding capacity at a lower weight than sedums.

Table 1: Occurrences of Each Moss Species Identified at Each Site Category. Percentages were calculated using the occurrence of each moss species in the respective number of samples for each site category.

Species	MD Natural	MD Roof	TN Natural	TN Roof
Anomodon attenuatus	0%	53.3%	0%	58%
Atrichum altecristatum	9.3%	0%	0%	0%
Brachythecium rivulare	0%	0.8%	0%	0%
Brachythecium salebrosum	18.7%	1.7%	76%	36%
Bryum argenteum	0%	1.7%	0%	4%
Ceratodon purpureus	0%	0%	20%	12%
Climacium dendroides	6.7%	0%	0%	0%
Dicranum scoparium	11.3%	0%	4%	0%
Entodon seductrix	5.3%	43.3%	0%	0%
Fissidens adianthoides	1.3%	0%	10%	0%
Hypnum lindbergii	2.7%	0%	0%	0%
Hypnum pallescens	28%	0%	0%	0%
Leucobryum glaucum	25.3%	0%	0%	0%
Plagiomnium cuspidatum	14%	0%	0%	8%
Platylomella lescurii	3.3%	0%	0%	0%
Polytrichum commune	14%	0%	10%	0%
Schistidium apocarpum	0%	17.5%	0%	0%
Schwetschkeopsis fabronia	1.3%	0%	0%	0%
Sphagnum wulfianum	12.0%	0%	0%	0%
Thuidium delicatulum	16.7%	13.3%	10%	30%
Ulota crispa	0.7%	0%	0%	0%

Table 2: Percent Cover and Water Composition of all Mosses Found on Roof Sites and Natural Terrestrial Sites. Shows significant differences in percent cover and percent water composition between locations. Standard Error is shown.

Location	% Cover	% Water
Natural	76.8±1.3%[a]	47.7±0.9%[a]
Roof	40.7±2.1%[b]	38.6±1.3%[b]

a: significantly higher at $p < 0.05$
b: significantly lower at $p < 0.05$

Table 3: Total Percent Cover of All Moss Species Identified at Either Maryland Natural Terrestrial Sites or Maryland Roof Sites. Shows significant differences in total percent cover between site categories. Standard Error is shown.

Moss Species	MD Natural	MD Roof
Hypnum pallescens	14.6±2.8%	
Brachythecium salebrosum	13.1±2.6%	0.02%
Thuidium delicatulum	8.8±3.1%	4.5±3.11%
Plagiomnium cuspidatum	7.6±2.5%	
Leucobryum glaucum	6.9±2.3%	
Polytrichum commune	6.6±2.7%	
Sphagnum wulfianum	5.6±2.5%	
Climacium dendroides	4.5±2.5%	
Anomodon attenuatus		4.3±0.84%
Atrichum altecristatum	3.6±3.2%	
Dicranum scoparium	2.4±1.5%	
Platylomella lescurii	1.5±2.7%	
Entodon seductrix	1.5±2.3%	23.8±2.9%
Schistidium apocarpum		1.1±0.74%
Schwetschkeopisis fabronia	0.7±2.6%	
Hypnum lindbergii	0.6±2.4%	
Fissidens adianthoides	0.09±0.5%	
Ulota crispa	0.50%	
Bryum argenteum		0.009±0.04%
Brachythecium rivulare		0.00%
20 Species	78.8±1.1%[a]	33.7±3.2%[b]

a: significantly higher at $p < 0.05$
b: significantly lower at $p < 0.05$

Table 4: Average Percent Water Composition of All Moss Species Identified at Either Maryland Natural Terrestrial Sites or Maryland Roof Sites. Calculated averages do not include 0% where moss species were not found. Shows significant differences in average percent water composition between site categories. Standard Error is shown.

Moss Species	MD Natural	MD Roof
Fissidens adianthoides	55±0.7%	
Schistidium apocarpum		55±5.1%
Atrichum altecristatum	53±5.3%	
Leucobryum glaucum	52±3.5%	
Plagiomnium cuspidatum	51±2.9%	
Bryum argenteum		50%
Polytrichum commune	49±2.9%	
Entodon seductrix	49±11.4%	32±2.4%
Hypnum lindbergii	48±4.5%	
Climacium dendroides	48±2.1%	
Hypnum pallescens	47±2.5%	
Brachythecium salebrosum	45±1.8%	63±3.3%
Thuidium delicatulum	44±4%	60±4%
Ulota crispa	43%	
Anomodon attenuatus		40±2.3%
Schwetschkeopisis fabronia	39±6.7%	
Platylomella lescurii	35±7.4%	
Dicranum scoparium	33±2.9%	
Sphagnum wulfianum	29±1.8%	
Brachythecium rivulare		0%
20 Species	45±1%[b]	50±1.3%[a]

a: significantly higher at $p < 0.05$
b: significantly lower at $p < 0.05$

Table 5: Total Percent Cover of Moss Species Identified at Both Maryland Natural Terrestrial Sites and Maryland Roof Sites. Shows significant differences in percent cover between site categories in individual species. Standard Error is shown.

Moss Species	MD Natural	MD Roof	Average
Brachythecium salebrosum	13.1±2.6%	0.019%	7.2±2.1%
Thuidium delicatulum	8.8±3.1%	4.5±3.11%	6.9±2.2%
Entodon seductrix	1.5±2.3%[b]	23.8±2.9%[a]	11.5±1.9%
3 Species	23.4%[a]	28.4%[b]	25.6%

a: significantly higher at $p < 0.05$
b: significantly lower at $p < 0.05$

Table 6: Average Percent Water Composition of Moss Species Identified at Both Maryland Natural Terrestrial Sites and Maryland Roof Sites Shows significant differences in percent water composition between site categories in individual species. Standard Error is shown.

Moss Species	MD Natural	MD Roof	Average
Entodon seductrix	49±11.4%[a]	32±2.4%[b]	41%
Brachythecium salebrosum	45±1.8%	63±3.3%	54%
Thuidium delicatulum	44±4%[b]	60±4%[a]	52%
3 Species	46%[b]	52%[a]	49%

a: significantly higher at $p < 0.05$
b: significantly lower at $p < 0.05$

Table 7: Total Percent Cover of All Moss Species Identified at Either Tennessee Natural Terrestrial Sites or Tennessee Roof Sites. Shows significant differences in total percent cover between site categories. Standard Error is shown.

Moss Species	TN Natural	TN Roof
Brachythecium salebrosum	58.4±4.1%	12.7±4.3%
Anomodon attenuatus		33.6±5.5%
Fissidens adianthoides	4.5±4.8%	
Ceratodon purpureus	3.8±2.1%	1.7±1.1%
Thuidium delicatulum	2.2±3.1%	7.4±2.7%
Polytrichum commune	1.6±2.5%	
Plagiomnium cuspidatum		1.4±2.9%
Dicranum scoparium	0.03±0.1%	
Bryum argenteum		0.6±1.1%
9 Species	70.5±9.3%[a]	57.5±5.1%[b]

a: significantly higher at $p < 0.05$
b: significantly lower at $p < 0.05$

Table 8: Average Percent Water Composition of All Moss Species Identified at Either Tennessee Natural Terrestrial Sites or Tennessee Roof Sites. Calculated averages do not include 0% where moss species were not found. Shows significant differences in average percent water composition between site categories. Standard Error is shown.

Moss Species	TN Natural	TN Roof
Thuidium delicatulum	75±6.2%	43±6.1%
Brachythecium salebrosum	61±1.9%	36±2.9%
Dicranum scoparium	58±8.3%	
Plagiomnium cuspidatum		51±7.3%
Fissidens adianthoides	51±4.5%	
Polytrichum commune	43±3.3%	
Bryum argenteum		34±0.4%
Ceratodon purpureus	33±3%	57±7%
Anomodon attenuatus		29±2.6%
9 Species	54±1.9%[a]	42±2.1%[b]

a: significantly higher at $p < 0.05$
b: significantly lower at $p < 0.05$

Table 9: Total Percent Cover of Moss Species Identified at Both Tennessee Natural Terrestrial Sites and Tennessee Roof Sites. Shows significant differences in total percent cover between site categories in individual species. Standard Error is shown.

Moss Species	TN Natural	TN Roof	Average
Brachythecium salebrosum	58.4±4.1%[a]	12.7±4.3%[b]	35.6±3.5%
Ceratodon purpureus	3.8±2.1%	1.7±1.1%	2.7±1.2%
Thuidium delicatulum	2.2±3.1%	7.4±2.7%	4.8±1.9%
3 Species	64.4%[a]	21.8%[b]	43.1%

a: significantly higher at $p < 0.05$
b: significantly lower at $p < 0.05$

Table 10: Average Percent Water Composition of Moss Species Identified at Both Tennessee Natural Terrestrial Sites and Tennessee Roof Sites. Shows significant differences in percent water composition between site categories in individual species. Standard Error is shown.

Moss Species	n	TN Natural	TN Roof	Average
Thuidium delicatulum	20	75±6.2%[a]	43±6.1%[b]	59%
Brachythecium salebrosum	56	61±1.9%[a]	36±2.9%[b]	49%
Ceratodon purpureus	16	33±3%[b]	57±7%[a]	45%
3 Species	92	56%[a]	45%[b]	51%

a: significantly higher at $p < 0.05$
b: significantly lower at $p < 0.05$

Table 11: Total Percent Cover of Moss Species Identified at Both Maryland Roof Sites and Tennessee Roof Sites. Shows significant differences in total percent cover between site categories in individual species. Standard Error is shown.

Moss Species	MD Roof	TN Roof	Average
Thuidium delicatulum	4.5±3.11%	7.4±2.7%	5.4±2.1%
Anomodon attenuatus	4.3±0.84%[b]	33.6±5.5%[a]	12.9±2.4%
Brachythecium salebrosum	0.02%	12.7±4.3%	3.8±2.3%
Bryum argenteum	0.009±0.04%	0.6±1.1%	0.2±0.7%
4 Species	8.9%[b]	54.3%[a]	22.3%

a: significantly higher at $p < 0.05$
b: significantly lower at $p < 0.05$

Table 12: Average Percent Water Composition of Moss Species Identified at Both Maryland Roof Sites and Tennessee Roof Sites. Shows significant differences in percent water composition between site categories in individual species. Standard Error is shown.

Moss Species	MD Roof	TN Roof	Average
Brachythecium salebrosum	63±3.3%[a]	36±2.9%[b]	50%
Thuidium delicatulum	60±4%[a]	43±6.1%[b]	52%
Bryum argenteum	50%	34±0.4%	42%
Anomodon attenuatus	40±2.3%	29±2.6%	35%
4 Species	53%[a]	36%[b]	44%

a: significantly higher at $p < 0.05$
b: significantly lower at $p < 0.05$

Table 13: Total Percent Cover of Moss Species Identified at Either Maryland Roof Sites or Tennessee Roof Sites. Shows significant differences in total percent cover between site categories. Standard Error is shown.

Species	MD Roof	TN Roof
Entodon seductrix	23.8±2.9%	
Thuidium delicatulum	4.5±3.11%	7.4±2.7%
Anomodon attenuatus	4.3±0.84%	33.6±5.5%
Ceratodon purpureus		1.7±1.1%
Plagiomnium cuspidatum		1.4±2.9%
Schistidium apocarpum	1.1±0.74%	
Brachythecium salebrosum	0.02%	12.7±4.3%
Bryum argenteum	0.009±0.04%	0.6±1.1%
Brachythecium rivulare	0.00%	
9 Species	33.7±3.2%[b]	57.5±5.1%[a]

a: significantly higher at $p < 0.05$
b: significantly lower at $p < 0.05$

Table 14: Average Percent Water Composition of Moss Species Identified at Either Maryland Roof Sites or Tennessee Roof Sites. Calculated averages do not include 0% where moss species were not found. Shows significant differences in average percent water composition between site categories. Standard Error is shown.

Species	MD Roof	TN Roof
Brachythecium salebrosum	63±3.3%	36±2.9%
Thuidium delicatulum	60±4%	43±6.1%
Ceratodon purpureus		57±7%
Schistidium apocarpum	55±5.1%	
Plagiomnium cuspidatum		51±7.3%
Bryum argenteum	50%	34±0.4%
Anomodon attenuatus	40±2.3%	29±2.6%
Entodon seductrix	32±2.4%	
Brachythecium rivulare	0%	
9 Species	50±1.3%[a]	41.6±2.1%[b]

a: significantly higher at $p < 0.05$
b: significantly lower at $p < 0.05$

Table 15: Total Percent Cover of Moss Species Identified at Both Maryland Natural Terrestrial Sites and Tennessee Natural Terrestrial Sites. Shows significant differences in total percent cover between site categories in individual species. Standard Error is shown.

Moss Species	MD Natural	TN Natural	Average
Brachythecium salebrosum	13.1±2.6%	58.4±4.1%	24.4±2.1%
Thuidium delicatulum	8.8±3.1%[a]	2.2±3.1%[b]	7.1±2.6%
Polytrichum commune	6.6±2.7%[a]	1.6±2.5%[b]	5.3±2.3%
Dicranum scoparium	2.4±1.5%	0.03±0.1%	1.8±1.3%
Fissidens adianthoides	0.09±0.5%	4.5±4.8%	1.2±2.3%
5 Species	31%[b]	66.7%[a]	39.8%

a: significantly higher at $p < 0.05$
b: significantly lower at $p < 0.05$

Table 16: Average Percent Water Composition of Moss Species Identified at Both Maryland Natural Terrestrial Sites and Tennessee Natural Terrestrial Sites. Shows significant differences in percent water composition between site categories in individual species. Standard Error is shown.

Moss Species	MD Natural	TN Natural	Average
Fissidens adianthoides	55±0.7%	51±4.5%	53%
Polytrichum commune	49±2.9%	43±3.3%	46%
Brachythecium salebrosum	45±1.8%[b]	61±1.9%[a]	53%
Thuidium delicatulum	44±4%[b]	75±6.2%[a]	60%
Dicranum scoparium	33±2.9%	58±8.3%	46%
5 Species	45%[b]	58%[a]	51%

a: significantly higher at $p < 0.05$
b: significantly lower at $p < 0.05$

Table 17: Total Percent Cover of Moss Species Identified at Either Maryland Natural Terrestrial Sites or Tennessee Natural Terrestrial Sites. Shows significant differences in total percent cover between site categories. Standard Error is shown.

Species	MD Natural	TN Natural
Hypnum pallescens	14.6±2.8%	
Brachythecium salebrosum	13.1±2.6%	58.4±4.1%
Thuidium delicatulum	8.8±3.1%	2.2±3.1%
Plagiomnium cuspidatum	7.6±2.5%	
Leucobryum glaucum	6.9±2.3%	
Polytrichum commune	6.6±2.7%	1.6±2.5%
Sphagnum wulfianum	5.6±2.5%	
Climacium dendroides	4.5±2.5%	
Ceratodon purpureus		3.8±2.1%
Atrichum altecristatum	3.6±3.2%	
Dicranum scoparium	2.4±1.5%	0.03±0.1%
Platylomella lescurii	1.5±2.7%	
Entodon seductrix	1.5±2.3%	
Schwetschkeopisis fabronia	0.7±2.6%	
Hypnum lindbergii	0.6±2.4%	
Ulota crispa	0.50%	
Fissidens adianthoides	0.09±0.5%	4.5±4.8%
17 Species	78.8±1.1%	70.5±9.3%

a: significantly higher at $p < 0.05$
b: significantly lower at $p < 0.05$

Table 18: Average Percent Water Composition of Moss Species Identified at Either Maryland Natural Terrestrial or Tennessee Natural Terrestrial Sites. Calculated averages do not include 0% where moss species were not found. Shows significant differences in average percent water composition between site categories. Standard Error is shown.

Species	MD Natural	TN Natural
Fissidens adianthoides	55±0.7%	51±4.5%
Atrichum altecristatum	53±5.3%	
Leucobryum glaucum	52±3.5%	
Plagiomnium cuspidatum	51±2.9%	
Entodon seductrix	49±11.4%	
Polytrichum commune	49±2.9%	43±3.3%
Hypnum lindbergii	48±4.5%	
Climacium dendroides	48±2.1%	
Hypnum pallescens	47±2.5%	
Brachythecium salebrosum	45±1.8%	61±1.9%
Thuidium delicatulum	44±4%	75±6.2%
Ulota crispa	43%	
Schwetschkeopisis fabronia	39±6.7%	
Platylomella lescurii	35±7.4%	
Ceratodon purpureus		33±3%
Dicranum scoparium	33±2.9%	58±8.3%
Sphagnum wulfianum	29±1.8%	
17 Species	45±1%[b]	53.5±1.9%[a]

a: significantly higher at $p < 0.05$
b: significantly lower at $p < 0.05$

Table 19: Total Moss Biomass and Total Water at Each Sampled Site. Calculated using equations found in methodology.

Site	Area (m^2)	Total Biomass (g/m^2)	Total Water (g/m^2)
R1	18.6	315.96	113.16
R2	46.4	129.66	60.85
R3	33.4	124.73	64.00
R4	34.8	44.99	41.29
R5	33.4	89.71	194.57
R6	18.1	5.64	2.89
R7	69.6	0.97	0.50
R8	55.7	17.23	10.18
R9	50.2	165.75	89.46
R10	34.8	50.12	26.56
R11	34.8	8.18	9.72
R12	69.6	732.59	213.81
R13	46.4	151.71	185.61
R14	58.1	68.54	29.55
R15	13.9	60.20	17.40
R16	41.8	788.67	412.38
R17	44.6	622.10	304.51
N1	34.8	401.26	449.51
N2	27.8	305.37	317.70
N3	33.4	215.41	112.49
N4	55.7	987.77	1068.09
N5	57.2	1213.23	1632.34
N6	16.7	1243.65	1603.67
N7	33.4	1796.35	5064.07
N8	23.4	1109.50	1261.37
N9	14.5	1158.45	1115.46
N10	40.8	783.77	430.11
N11	18.1	411.03	300.07
N12	23.7	355.37	199.54
N13	24.2	1543.02	1409.82
N14	12.1	722.03	253.27
N15	30.6	814.88	395.88
N16	16.7	364.79	670.72
N17	26.6	317.29	328.80
N18	20.9	602.49	429.13
N19	81.7	72.46	62.47
N20	25.1	286.56	287.29

Table 20: Average Percent Cover, Sampled Percent Water Composition, and Maximum Water Holding Capacity of All Sedum Species Sampled. Sedum species were sampled from 1 location in Baltimore, Maryland (MD). Samples were taken in the early spring of 2016.

Genus	% Coverage	% Water in Samples	Maximum % Water Capacity
Sedum	100%	61.9%	128.2%
Sedum	100%	47.3%	191.9%
Sedum	100%	52.7%	175%
Sedum	100%	50.9%	181%
Sedum	100%	39.2%	148.7%
Sedum	100%	40.8%	177.5%
Sedum	100%	42.9%	160.6%
Sedum	100%	45.9%	158.8%
Sedum	100%	42.8%	161.6%
Sedum	100%	57.6%	176.9%
Average	100%	48.2±2.3%	166.1±5.8%

Table 21: Average Percent Cover, Sampled Percent Water Composition, and Maximum Water Holding Capacity of All Moss Species Identified at All Sites. Moss species were identified at 37 total locations comprising of both roof and natural terrestrial sites in both Maryland (MD) and Tennessee (TN). Samples were taken in the summer and early fall of 2015. Standard Error is shown.

Moss Species	% Coverage	% Water in Samples	Maximum % Water Capacity
Sphagnum wulfianum	2.3±1.5%	29±1.8%	1234.9%
Schistidium apocarpum	0.35±0.42%	55±5.1%	979.4%
Hypnum pallescens	5.9±1.7%	47±2.5%	947.3%
Platylomella lescurii	0.64±1.7%	35±7.4%	929.2%
Climacium dendroides	1.8±1.6%	48±2.1%	896.7%
Anomodon attenuatus	5.9±1.6%	34.5±1.9%	859.6%
Leucobryum glaucum	2.8±1.5%	52±3.5%	851.1%
Entodon seductrix	8.4±1.6%	40.5±2.2%	850.6%
Brachythecium salebrosum	14.9±1.7%	51.25±1.6%	775.1%
Schwetschkeopisis fabronia	0.31±1.6%	39±6.7%	712.2%
Fissidens adianthoides	0.65±1.7%	53±3.2%	678.9%
Thuidium delicatulum	6.3±1.7%	55.5±2.8%	662.2%
Hypnum lindbergii	0.25±1.5%	48±4.5%	605.7%
Ceratodon purpureus	0.73±0.6%	45±4.1%	602.1%
Plagiomnium cuspidatum	3.3±1.6%	51±2.7%	581.7%
Atrichum altecristatum	1.5±2%	53±5.7%	484.7%
Dicranum scoparium	0.96±0.96%	45.5±3.2%	475.4%
Polytrichum commune	2.9±1.7%	46±2.4%	431.9%
Bryum argenteum	0.08±0.4%	42±4.6%	364.7%
Brachythecium rivulare	0%	0%	N/A
Ulota crispa	0.22%	43%	N/A
21 Species	60.2±0.8%	45.6±0.7%	732.8±50.9%

Table 22: Desiccated and Re-Inundated Green Roof Vegetation and Substrates. The average dry and wet weights of all moss samples, sedum samples, and two common green roofing components. Moss samples were taken in the summer and early fall of 2015. Sedum samples were taken in the early spring of 2016. All calculations are based on 100% coverage by the material.

Material	Dry Weight (g/m^2)	Wet Weight (g/m^2)	Water Weight (g/m^2)
Moss	680	4977.6	4297.6
Sedum	4928	8180.48	3252.4
5.1 cm (2") FLL Media	351400.1	409966.7	58566.6
0.635 cm (¼") Cap Fabric	606.7	4245.7	3639.1

FLL: Green Roofing Standard determined by the German Landscape Research, Development and Construction Society
Cap Fabric: 0.82 kg/m^2 capillary fabric

Table 23: Moss and Sedum Green Roof Configurations Based on Average Dry, Wet, and Water Weights. Realistic green roof configurations based on 100% coverage by all materials. Moss samples were taken in the summer and early fall of 2015. Sedum samples were taken in the early spring of 2016. All calculations are based on 100% coverage by the material.

Green Roof Configuration	Dry Weight (g/m^2)	Wet Weight (g/m^2)	Water Weight (g/m^2)
Sedum 5.1 cm (2") FLL Media	356328.1	418147.2	61819.1
Sedum 0.635 cm (¼") Cap Fabric	N/A	N/A	N/A
Moss 5.1 cm (2") FLL Media	352080.1	414944.3	62864.3
Moss 0.635 cm (¼") Cap Fabric	1286.7	9223.3	7936.6

FLL: Green Roofing Standard determined by the German Landscape Research, Development and Construction Society
Cap Fabric: 0.82 kg/m^2 capillary fabric

Table 24: Applicable Moss and Sedum Green Roof Configurations Based on Average Dry, Wet, and Total Water Weights. Realistic green roof configurations based on 100% coverage by all materials. Moss samples were taken in the summer and early fall of 2015. Sedum samples were taken in the early spring of 2016. All calculations are based on 100% coverage by the material.

Green Roof Configuration	Dry Weight (g/m^2)	Wet Weight (g/m^2)	Water Weight (g/m^2)
Sedum 5.1 cm (2") FLL Media	356328.1	418147.3	61819.1
Moss 0.635 cm (¼") Cap Fabric	1286.7	9223.3	7936.7
% Difference	0.36%	2.21%	12.84%

FLL: Green Roofing Standard determined by the German Landscape Research, Development and Construction Society
Cap Fabric: 0.82 kg/m^2 capillary fabric

Table 25: Applicable Moss and Sedum Green Roof Configurations Based on Average Dry, Wet, and Total Water Weights at Equivalent Depths. Realistic green roof configurations based on 100% coverage by all materials. Moss samples were taken in the summer and early fall of 2015. Sedum samples were taken in the early spring of 2016. All calculations are based on 100% coverage by the material.

Green Roof Configuration	Dry Weight (g/m^2)	Wet Weight (g/m^2)	Water Weight (g/m^2)
Sedum 0.635 cm (¼") FLL Media	48853.0	59426.3	10573.3
Moss 0.635 cm (¼") Cap Fabric	1286.7	9223.3	7936.7
% Difference	2.63%	15.52%	75.06%

FLL: Green Roofing Standard determined by the German Landscape Research, Development and Construction Society
Cap Fabric: 0.82 kg/m^2 capillary fabric

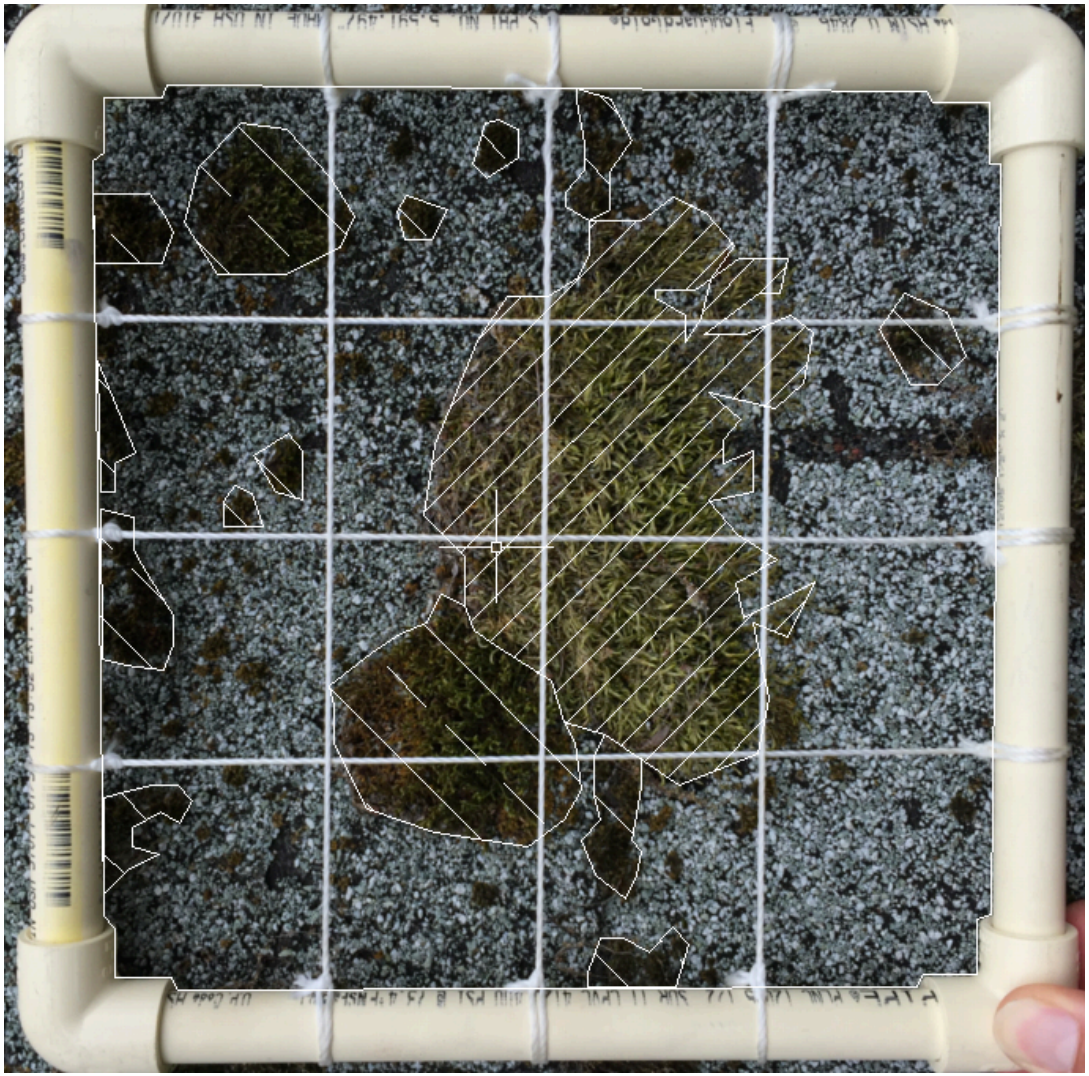


Figure 1: Example of quadrat with species percent area calculated using AutoCAD

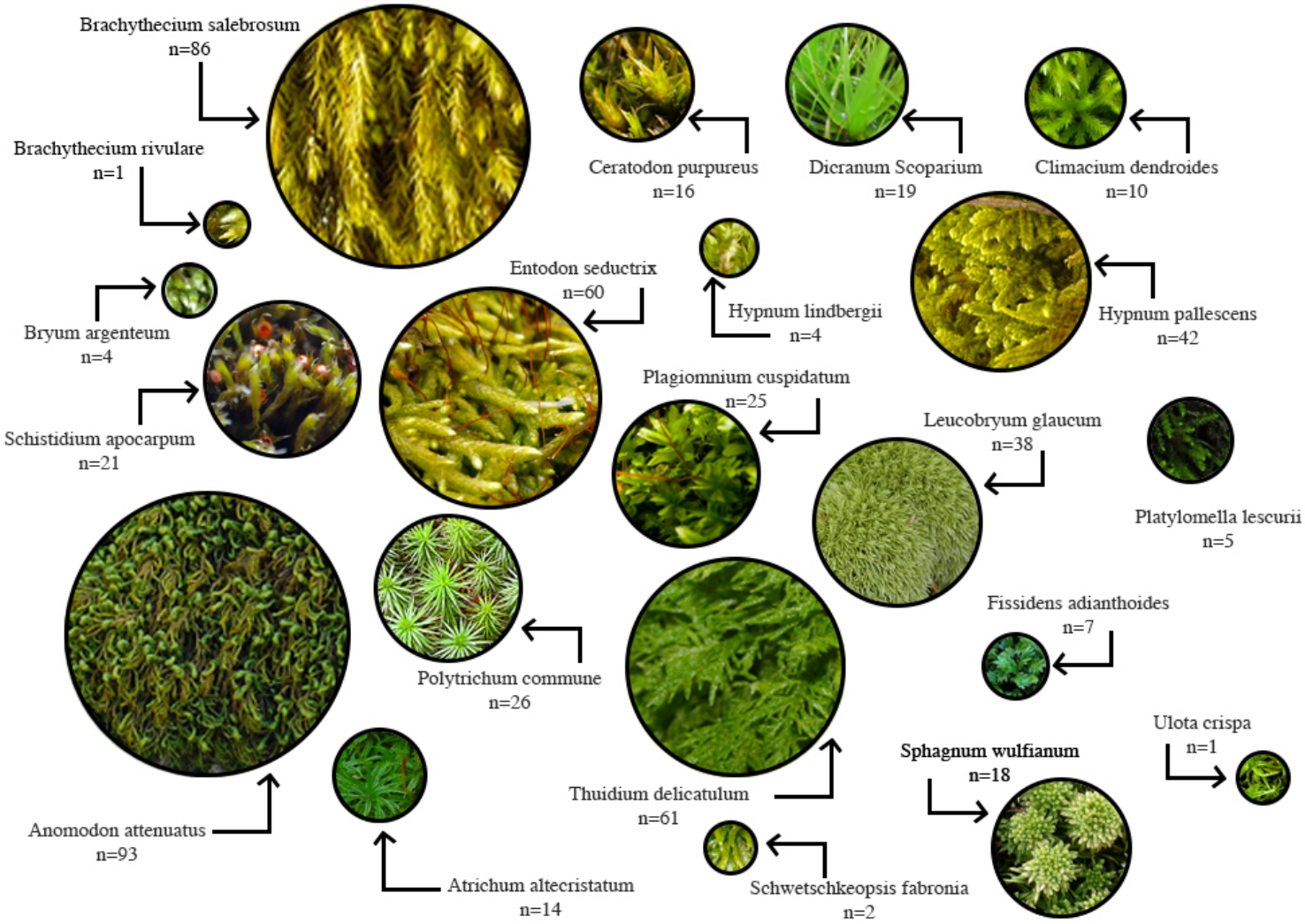


Figure 2: The relative size of each circle is directly related to the occurrences of each moss species found at all site categories. Photographs of mosses are cited in the References section.

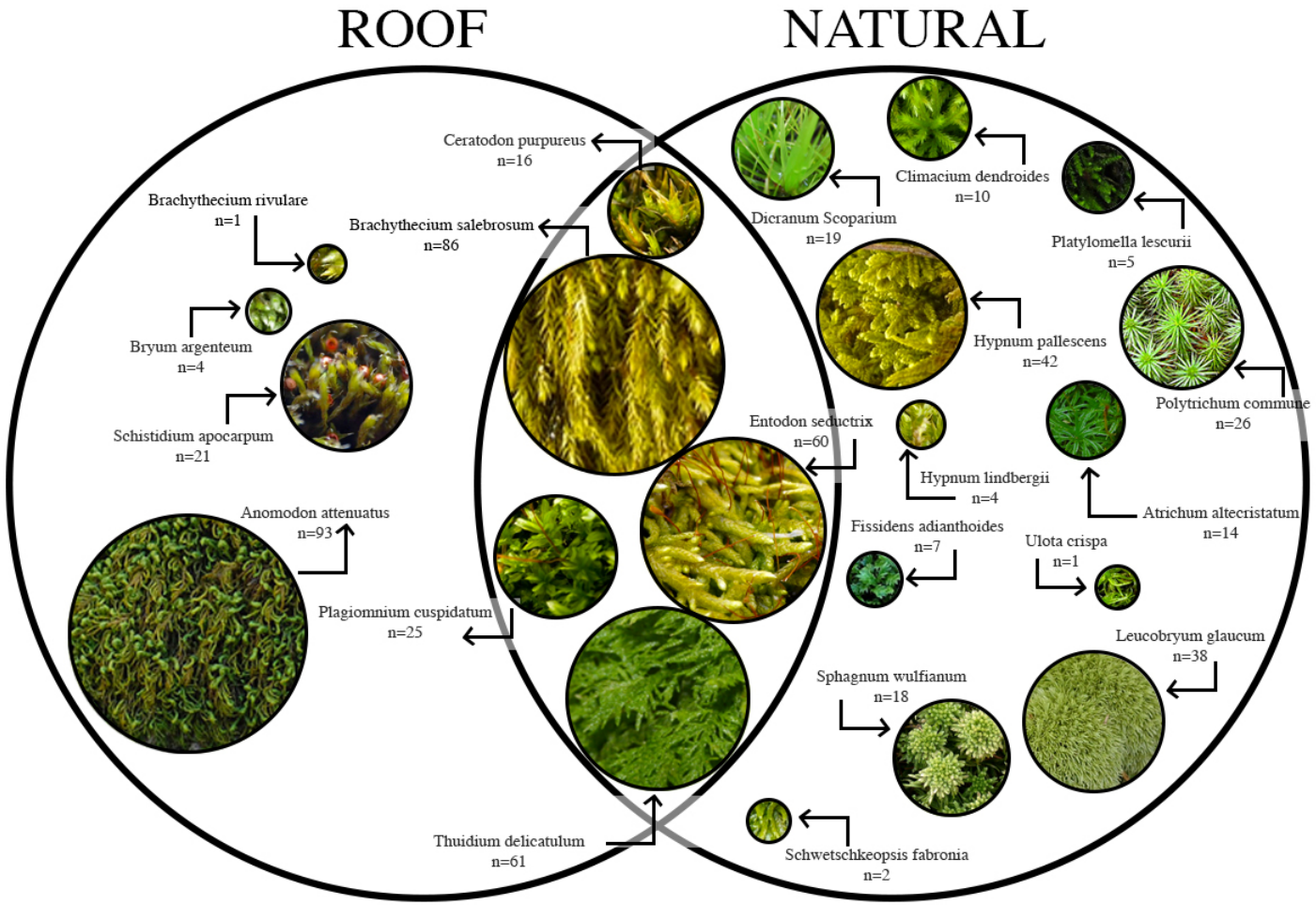


Figure 3: The relative size of each circle is directly related to the quantity of each moss species found at all site categories. Photographs of mosses are cited in the References section.

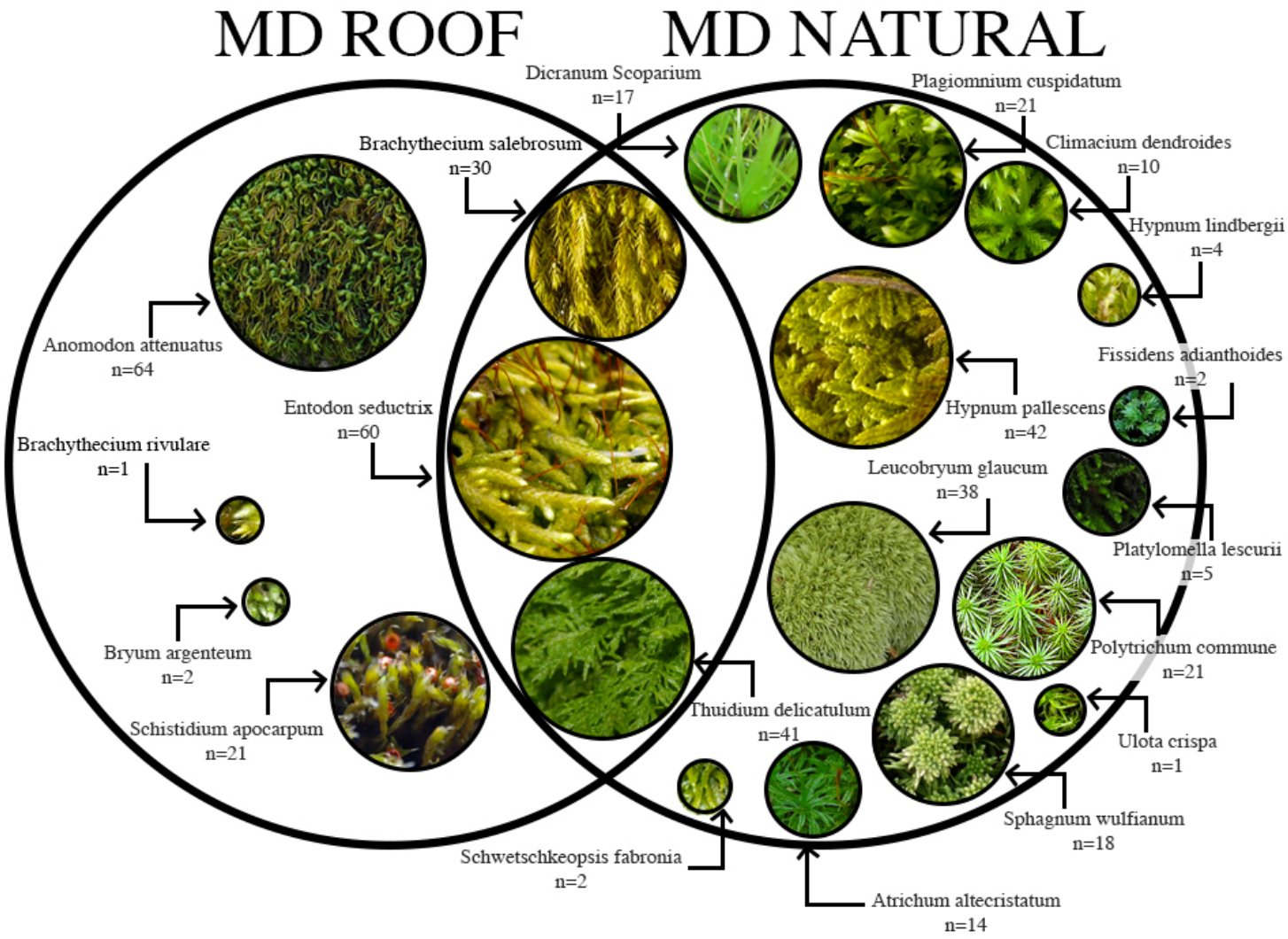


Figure 4: The relative size of each circle is directly related to the quantity of each moss species found at either site category. Mosses were sampled from natural terrestrial and roof sites in Maryland. Photographs of mosses are cited in the References section.

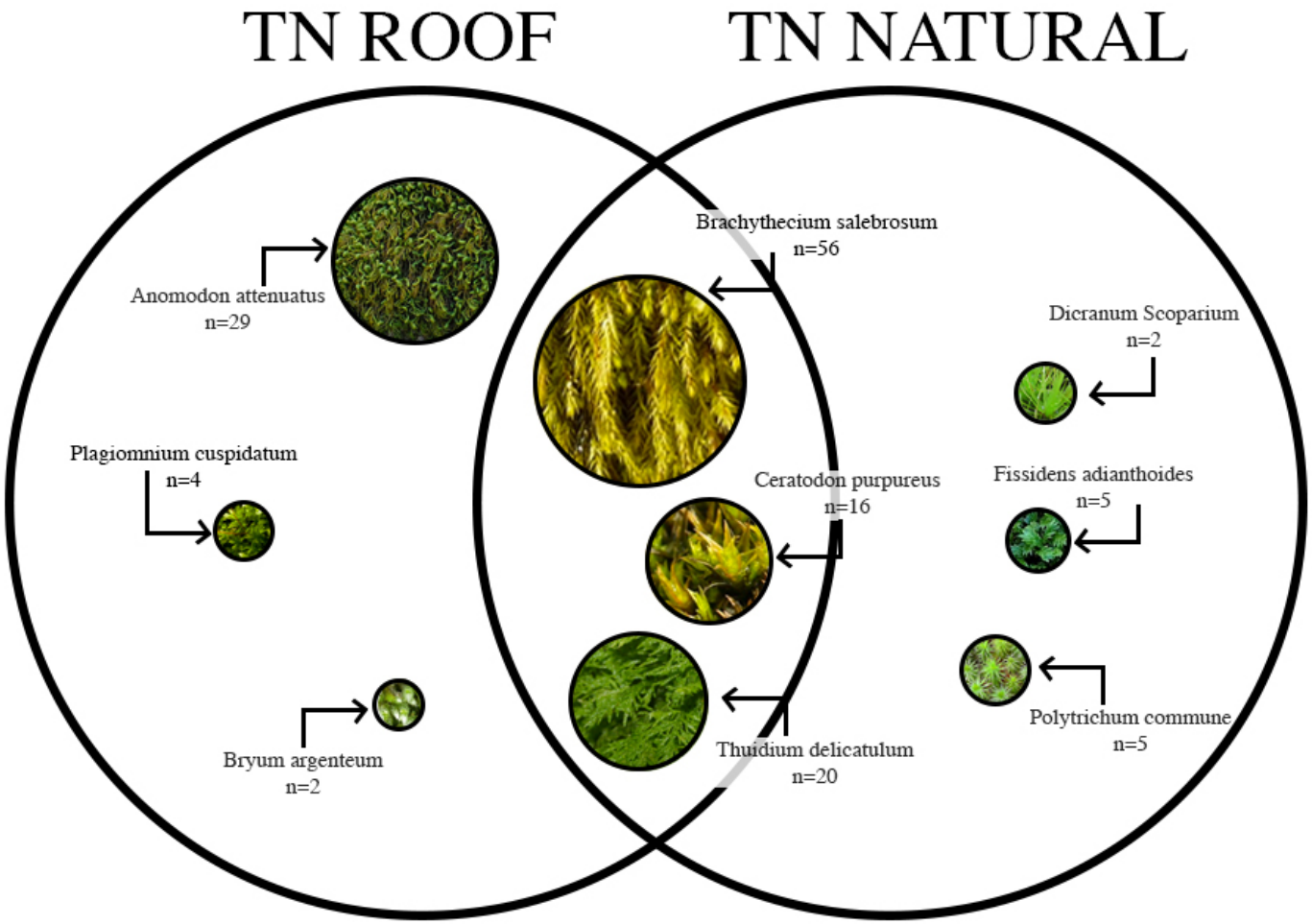


Figure 5: The relative size of each circle is directly related to the quantity of each moss species found at either site category. Mosses were sampled from natural terrestrial and roof sites in Tennessee. Photographs of mosses are cited in the References section.

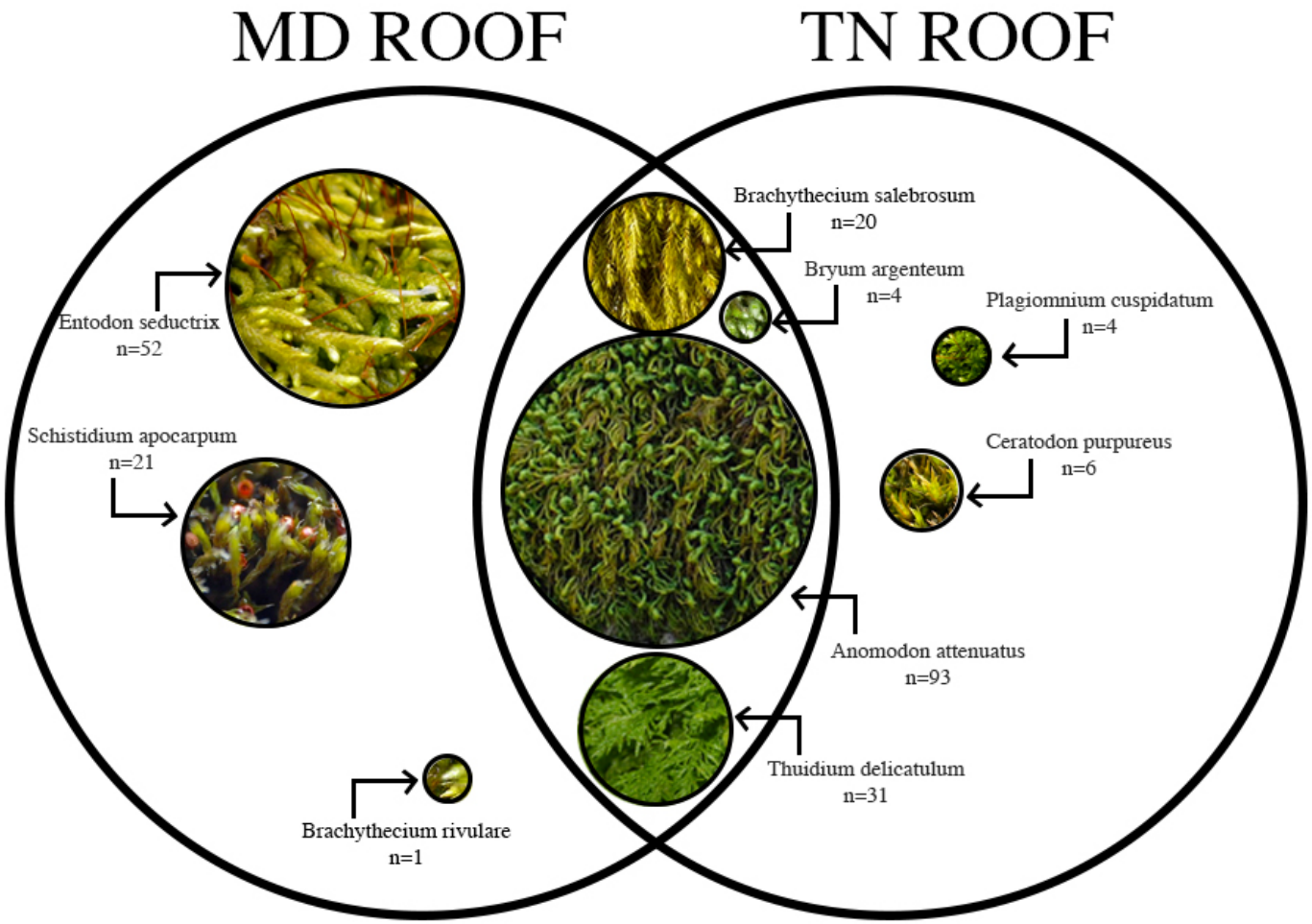


Figure 6: The relative size of each circle is directly related to the quantity of each moss species found at either site category. Mosses were sampled from roof sites in Maryland and Tennessee. Photographs of mosses are cited in the References section.

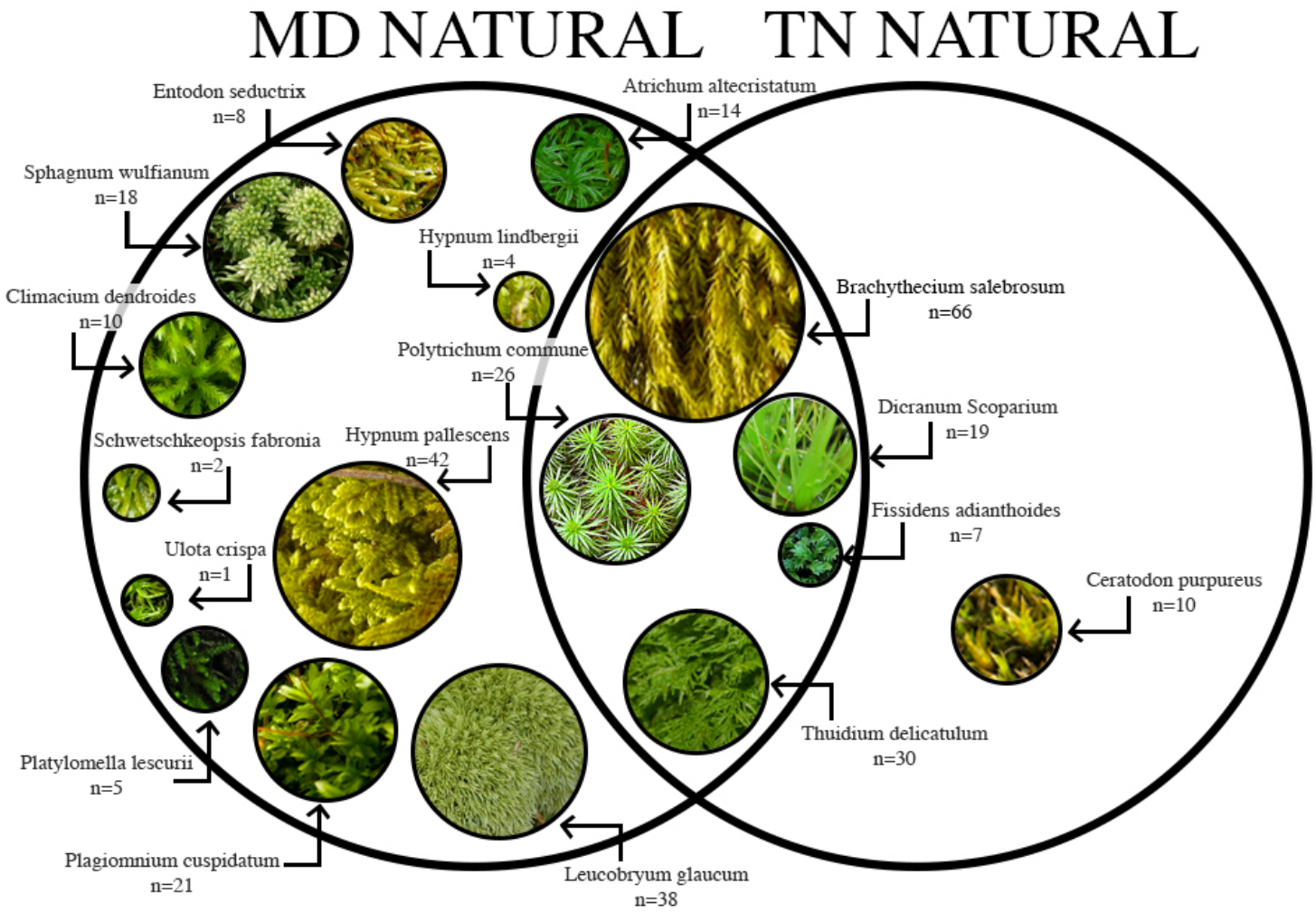


Figure 7: The relative size of each circle is directly related to the quantity of each moss species found at either site category. Mosses were sampled from natural terrestrial sites in Maryland and Tennessee. Photographs of mosses are cited in the References section.

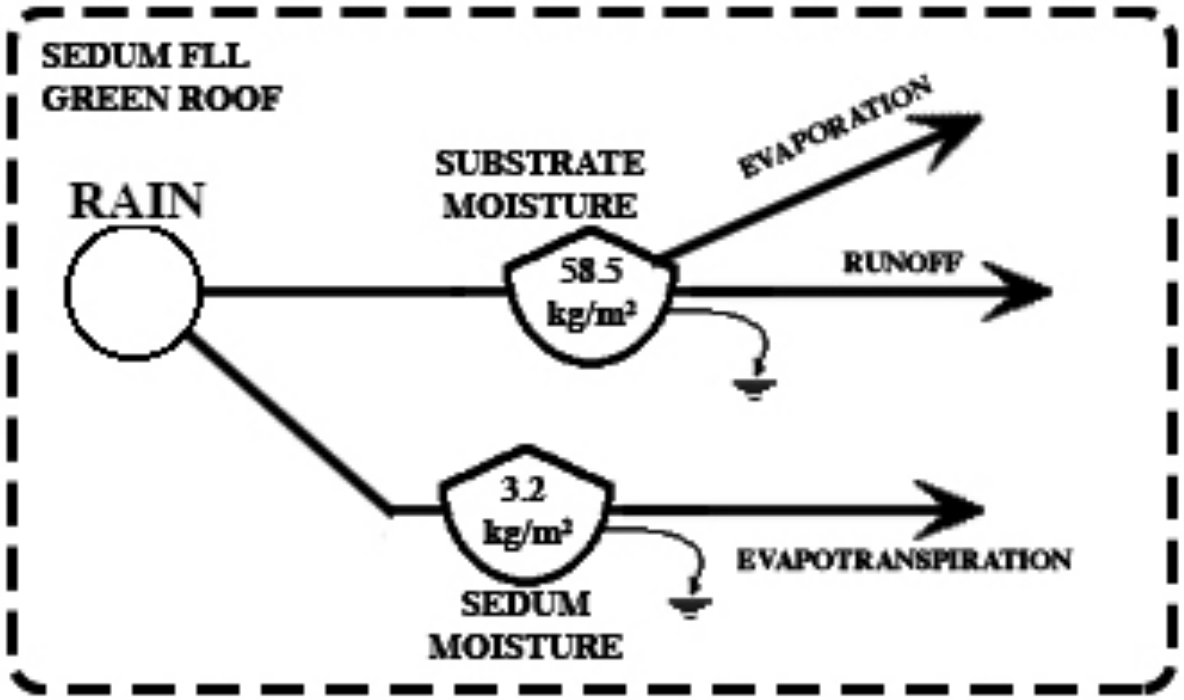


Figure 8: Energy diagram of a 5.1 cm (2") sedum FLL green roof. Values represent total maximum water capacity at 100% cover.

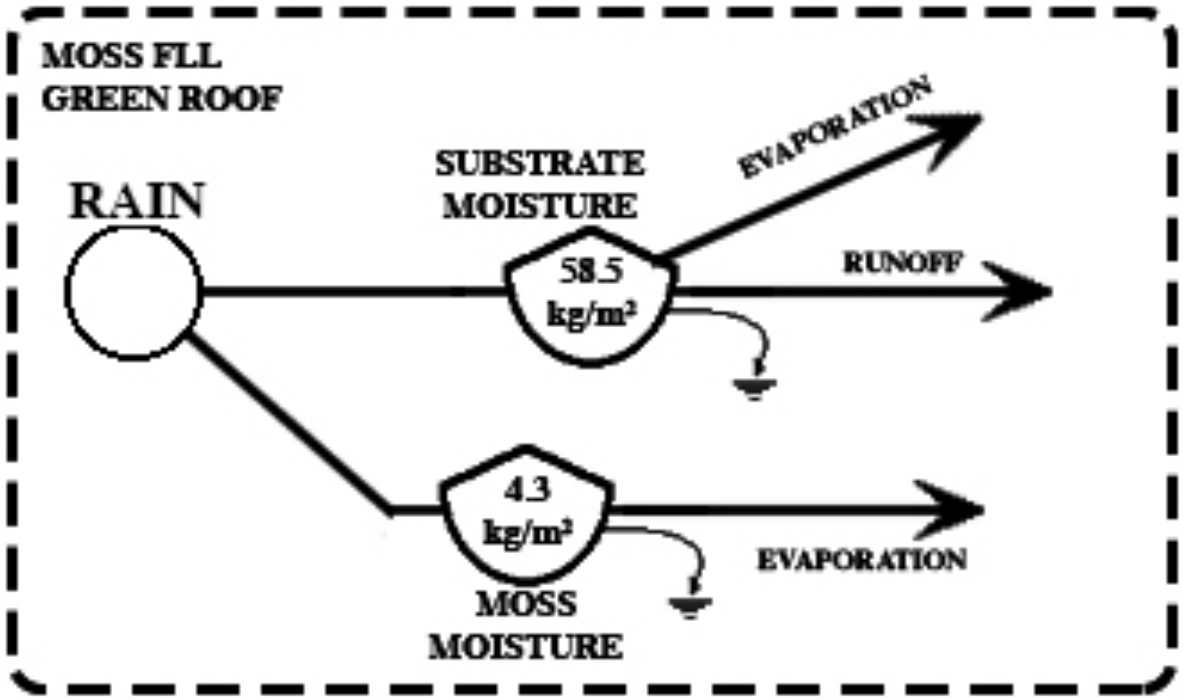


Figure 9: Energy diagram of a 5.1 (2") moss FLL green roof. Values represent total maximum water capacity at 100% cover.

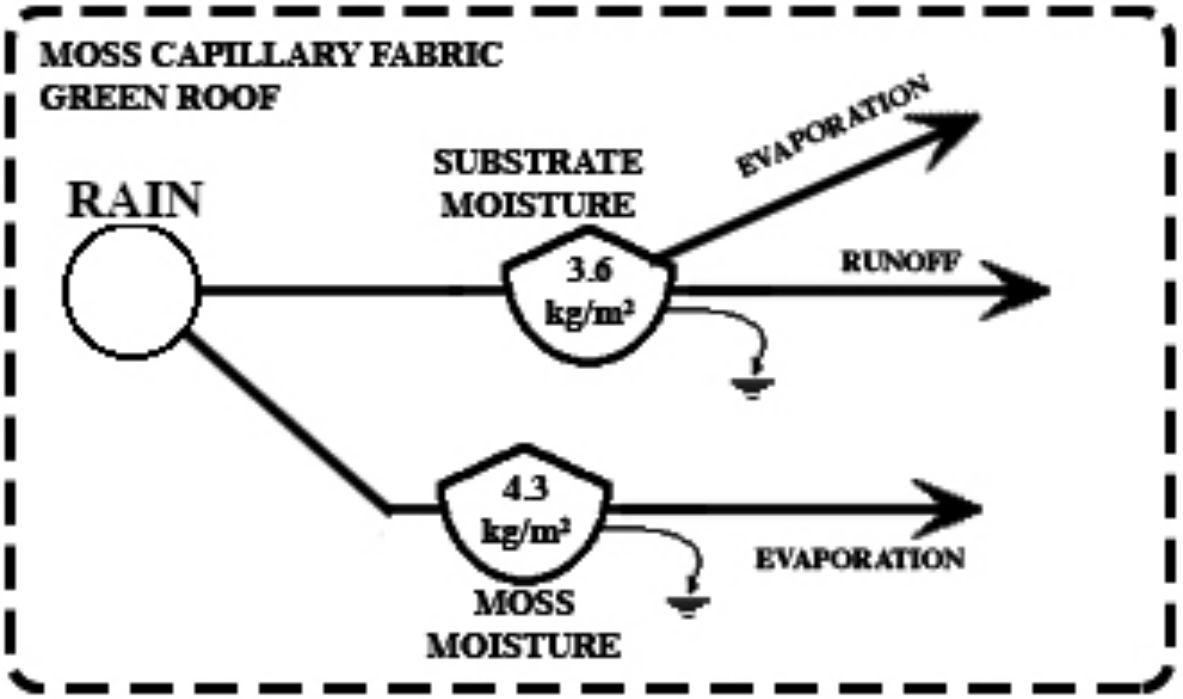


Figure 10: Energy diagram of a 0.635 cm (¼") moss capillary fabric green roof. Values represent total maximum water capacity at 100% cover.

Appendix

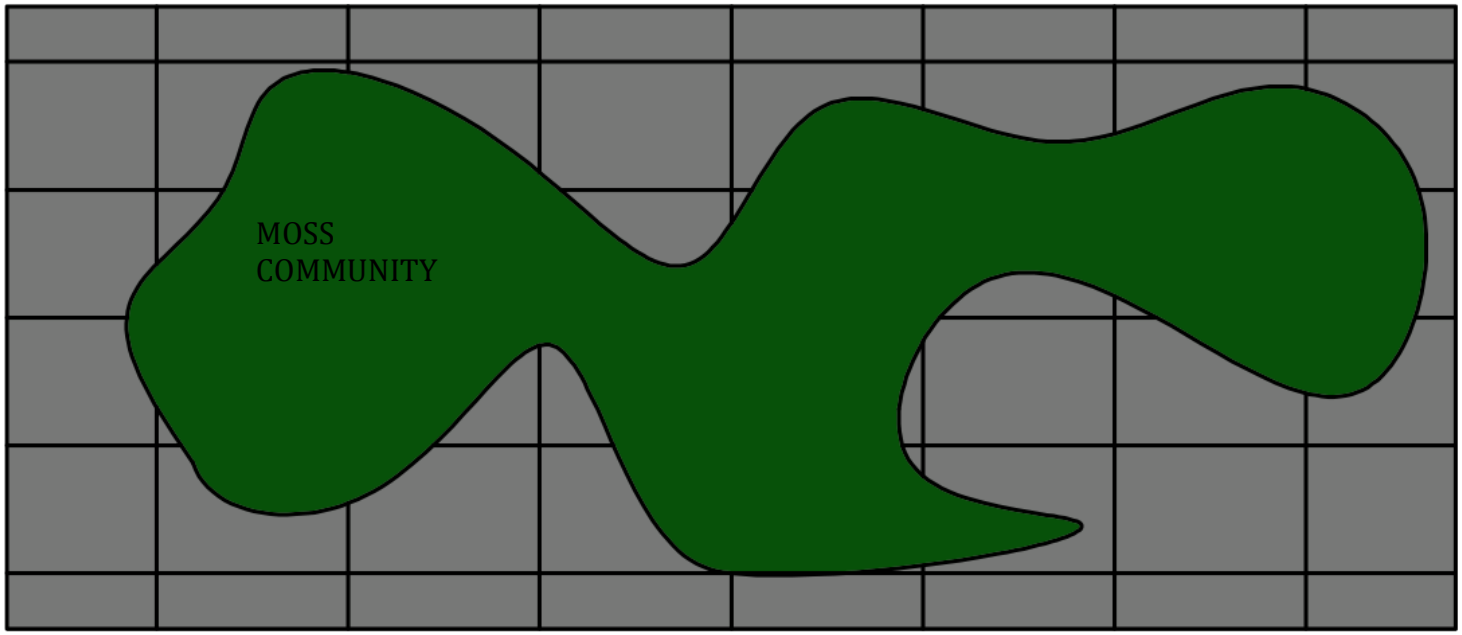
1. List of all roofs and respective characteristics sampled during study

Site	Address	City, State	Substrate	Area (m^2)	Approx Aspect	Approx Pitch	% Shade	% Cover	% Water	Total Biomass (g)	Total Water (g)
R1	6902 Oakridge Rd	University Park, MD	Asphalt	18.6	W	12/12	30%	79.9%	26.0%	5876.77	2104.82
R2	6904 Pineway Rd	University Park, MD	Asphalt	46.4	E	12/12	0%	37.2%	35.0%	6016.25	2823.41
R3	4308 Clagett Rd	University Park, MD	Asphalt	33.4	NW	12/5	0%	51.1%	35.0%	4165.99	2137.52
R4	4217 Woodberry St	University Park, MD	Slate	34.8	E	12/7	10%	14.2%	50.0%	1565.76	1436.77
R5	4316 Clagett Rd	University Park, MD	Asphalt	33.4	NW	12/3	30%	54.6%	67.0%	2996.18	6498.58
R6	8722 Valleyfield Rd	Timonium, MD	Asphalt	18.1	S	12/3	10%	4.0%	35.0%	102.08	52.31
R7	11911 Jenifer Rd A	Timonium, MD	Asphalt	69.6	NW	12/9	0%	1.4%	35.0%	67.35	34.45
R8	11911 Jenifer Rd B	Timonium, MD	Asphalt	55.7	S	12/3	20%	7.4%	39.0%	959.56	566.97
R9	350 Ridge Rd House	Pasadena, MD	Asphalt	50.2	S	12/4	30%	38.8%	59.0%	8320.84	4490.92
R10	350 Ridge Rd Shed	Pasadena, MD	Asphalt	34.8	SW	12/3	20%	16.5%	36.0%	1744.06	924.37
R11	207 Brookfield Rd	Pasadena, MD	Asphalt	34.8	W	12/6	30%	6.6%	51.0%	284.58	338.41
R12	4953 Mountain Rd	Pasadena, MD	Asphalt	69.6	SW	12/8	10%	93.8%	23.0%	50988.17	14881.50
R13	2742 Kingston Pike	Knoxville, TN	Cedar	46.4	S	12/7	0%	37.1%	58.0%	7039.33	8612.21
R14	1230 Cherokee Blvd	Knoxville, TN	Cedar	58.1	NE	12/5	10%	25.2%	29.0%	3981.94	1717.05
R15	1100 Ave C	Knoxville, TN	Asphalt	13.9	E	12/1	30%	12.3%	23.0%	836.80	241.83
R16	4310 Edington Rd	Knoxville, TN	Asphalt	41.8	S	12/1	20%	107.1%	34.0%	32966.41	17237.55
R17	4105 Candora Rd	Knoxville, TN	Asphalt	44.6	W	12/5	30%	105.8%	34.0%	27745.69	13581.12

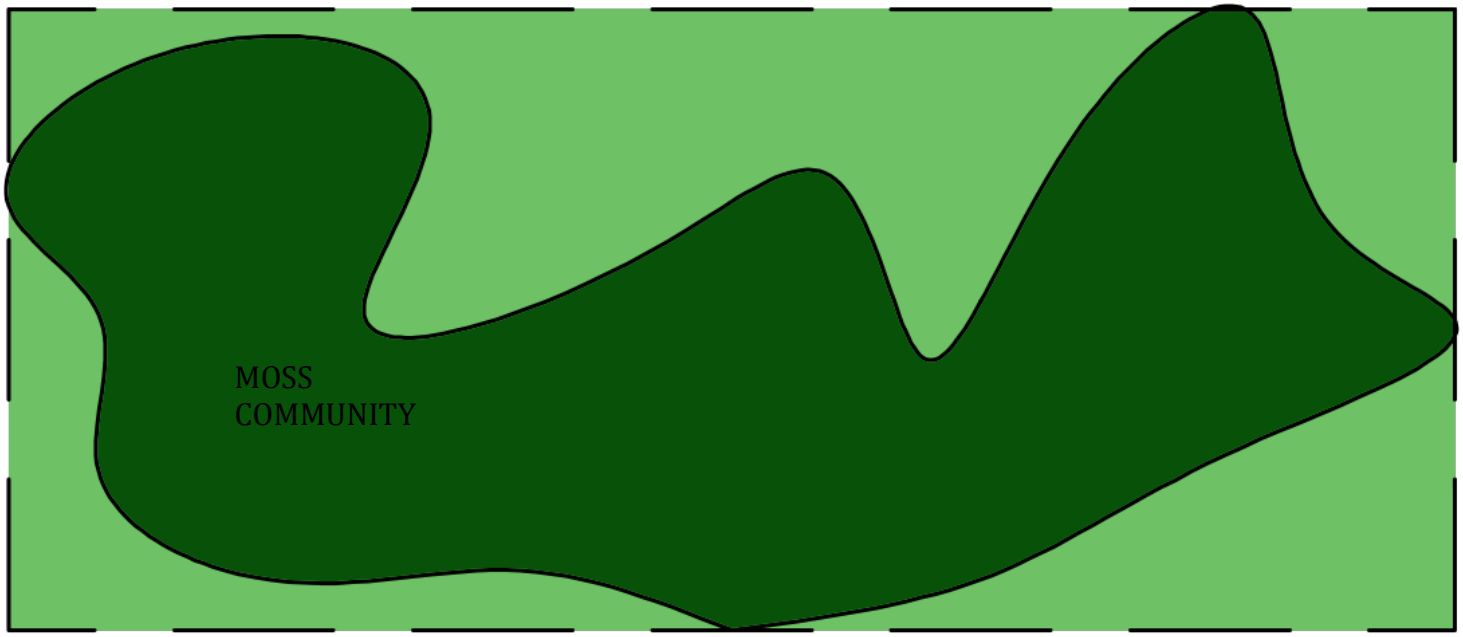
2. List of all natural sites and respective characteristics sampled during study

Site	Latitude	Longitude	City, State	Substrate	Area (m^2)	Approx Aspect	Approx Pitch	% Shade	% Cover	% Water	Total Biomass (g)	Total Water (g)
N1	39°25'47" N	76°38'38" W	Timonium, MD	Soil	34.8	NE	12/1	30%	55.9%	53.0%	13963.91	15642.80
N2	39°25'46" N	76°38'39" W	Timonium, MD	Soil	27.8	S	12/0.5	20%	85.5%	49.0%	8489.30	8831.95
N3	35°56'14" N	83°55'38" W	Knoxville, TN	Soil	33.4	E	12/0.5	20%	19.2%	35.0%	7194.84	3757.24
N4	35°56'15" N	83°55'36" W	Knoxville, TN	Soil	55.7	W	12/2	20%	50.5%	52.0%	55018.76	59492.60
N5	35°56'08" N	83°54'54" W	Knoxville, TN	Soil	57.2	N/A	12/0	0%	86.9%	56.0%	69397.00	93369.64
N6	35°56'11" N	83°55'51" W	Knoxville, TN	Soil	16.7	SW	12/5	10%	88.7%	56.0%	20768.98	26781.35
N7	35°56'13" N	83°54'55" W	Knoxville, TN	Soil	33.4	S	12/0.5	10%	107.3%	75.0%	59998.15	169140.1
N8	39°06'18" N	76°26'38" W	Pasadena, MD	Soil	23.4	N/A	12/0	30%	111.8%	52.0%	25962.40	29516.14
N9	39°06'20" N	76°26'36" W	Pasadena, MD	Soil	14.5	N/A	12/0	0%	84.9%	48.0%	16797.59	16174.17
N10	39°06'25" N	76°26'32" W	Pasadena, MD	Soil	40.8	E	12/1	30%	81.1%	37.0%	31977.76	17548.54
N11	39°06'27" N	76°26'39" W	Pasadena, MD	Soil	18.1	N/A	12/0	20%	86.3%	43.0%	7439.71	5431.24
N12	39°06'32" N	76°26'20" W	Pasadena, MD	Soil	23.7	NW	12/3	20%	59.6%	39.0%	8422.22	4729.00
N13	39°06'48" N	76°32'26" W	Pasadena, MD	Soil	24.2	W	12/1	0%	95.6%	46.0%	37341.02	34117.67
N14	39°06'44" N	76°32'28" W	Pasadena, MD	Soil	12.1	W	12/1	10%	90.9%	26.0%	8736.60	3064.55
N15	39°06'52" N	76°30'37" W	Pasadena, MD	Soil	30.6	NE	12/2	10%	89.6%	32.0%	24935.40	12114.02
N16	39°27'03" N	76°39'43" W	Timonium, MD	Soil	16.7	N/A	12/0	10%	88.4%	63.0%	6092.03	11200.95
N17	39°27'02" N	76°39'44" W	Timonium, MD	Soil	26.6	N/A	12/0	30%	69.6%	53.0%	8440.03	8746.20
N18	39°27'05" N	76°39'45" W	Timonium, MD	Soil	20.9	NE	12/4	0%	81.8%	42.0%	12592.02	8968.86
N19	39°27'01" N	76°39'50" W	Timonium, MD	Soil	81.7	W	12/0.5	10%	65.4%	49.0%	5919.90	5103.81
N20	39°25'55" N	76°38'10" W	Timonium, MD	Soil	25.1	N/A	12/0	10%	36.2%	50.0%	7192.62	7211.06

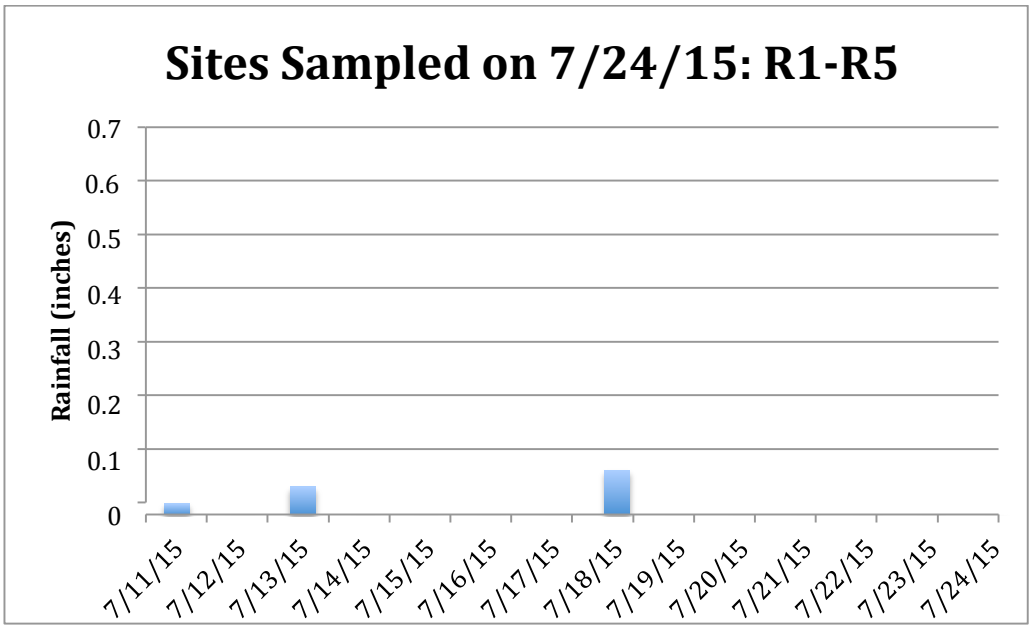
3. Example of Roof Site Sampling Boundaries



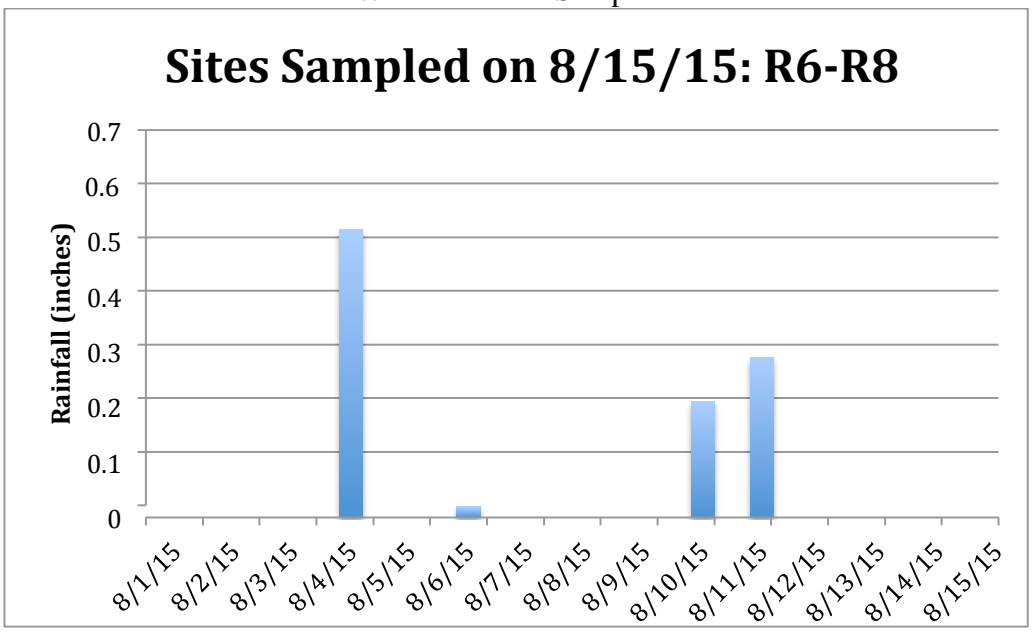
4. Example of Natural Site Sampling Boundaries



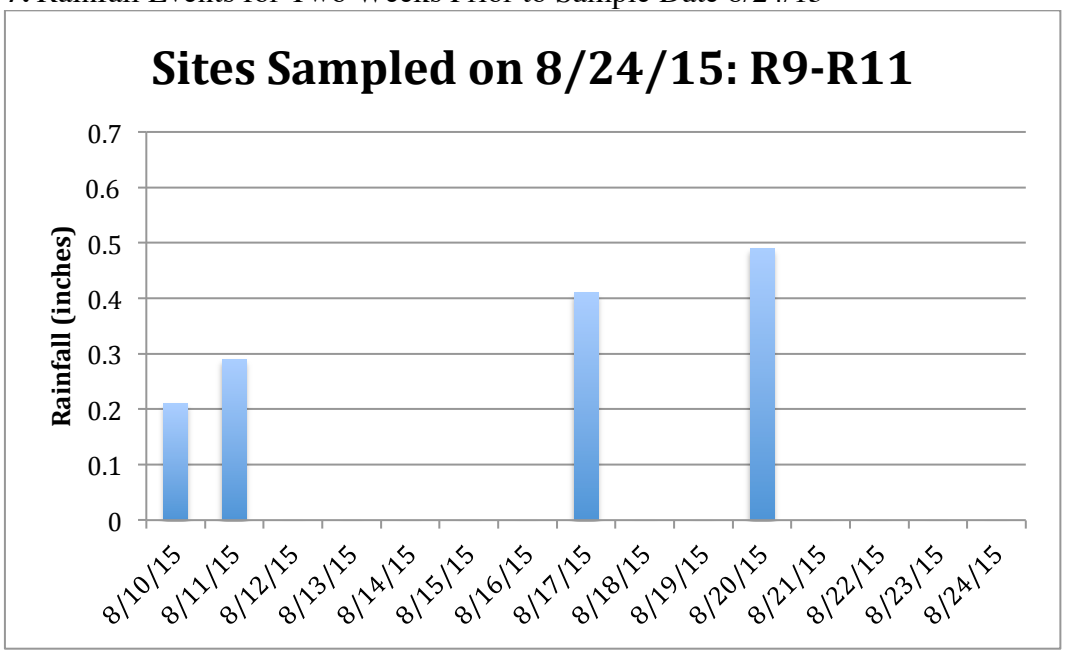
5. Rainfall Events for Two Weeks Prior to Sample Date 7/24/15



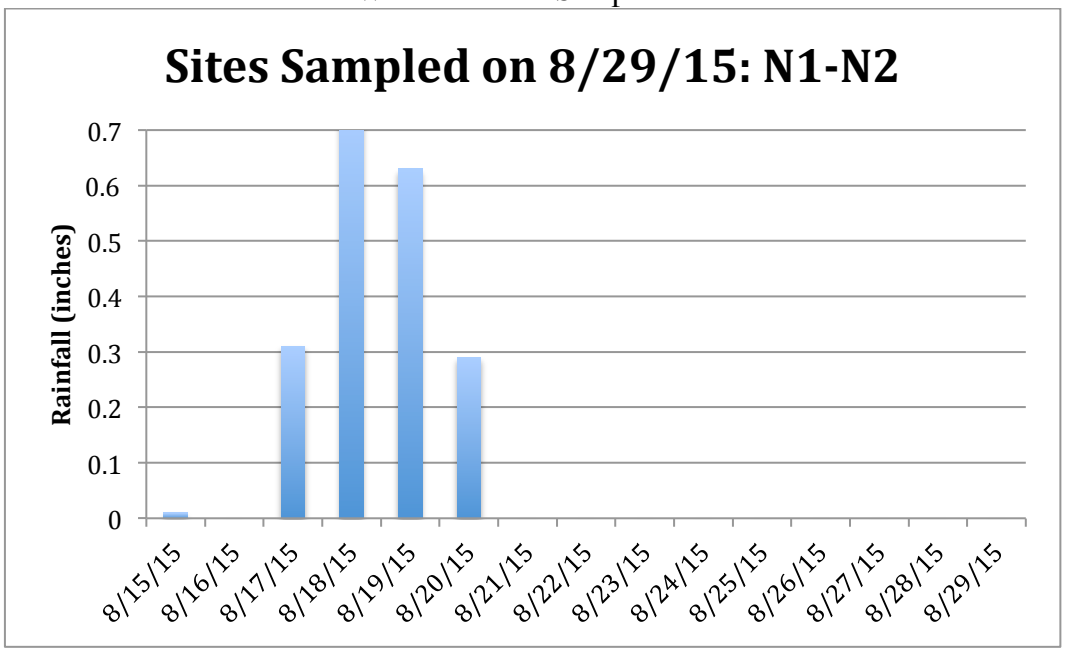
6. Rainfall Events for Two Weeks Prior to Sample Date 8/15/15



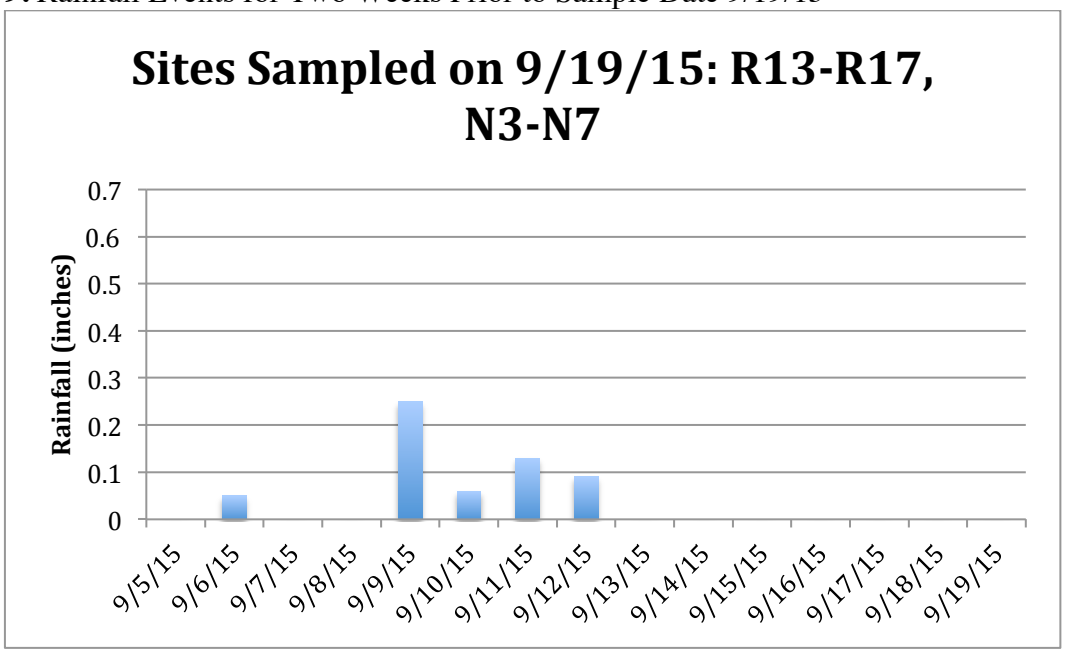
7. Rainfall Events for Two Weeks Prior to Sample Date 8/24/15



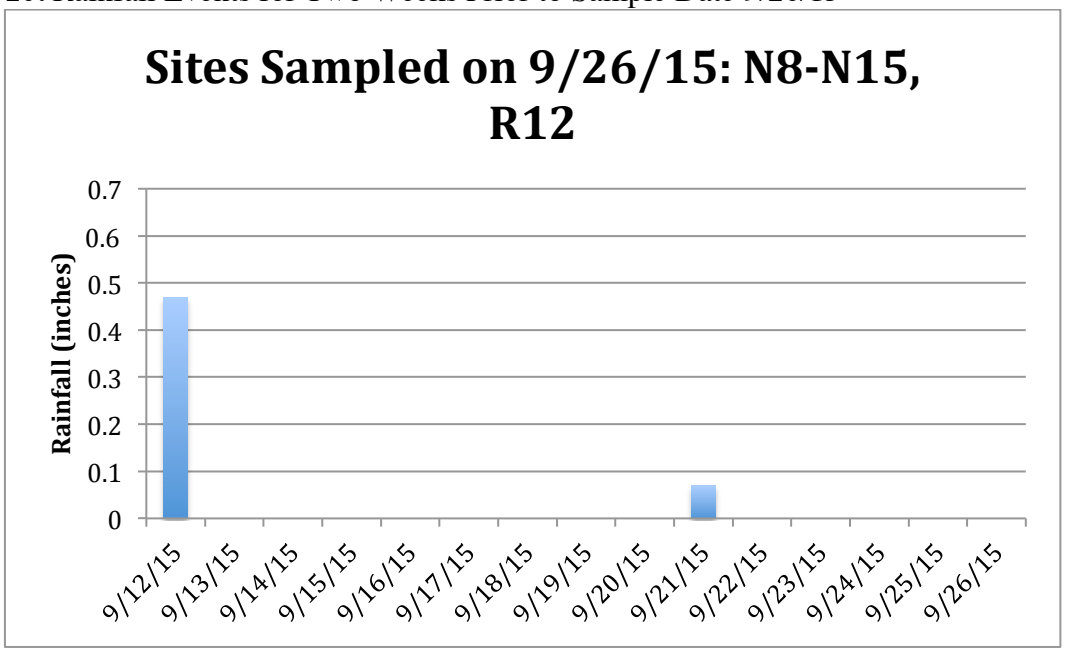
8. Rainfall Events for Two Weeks Prior to Sample Date 8/29/15



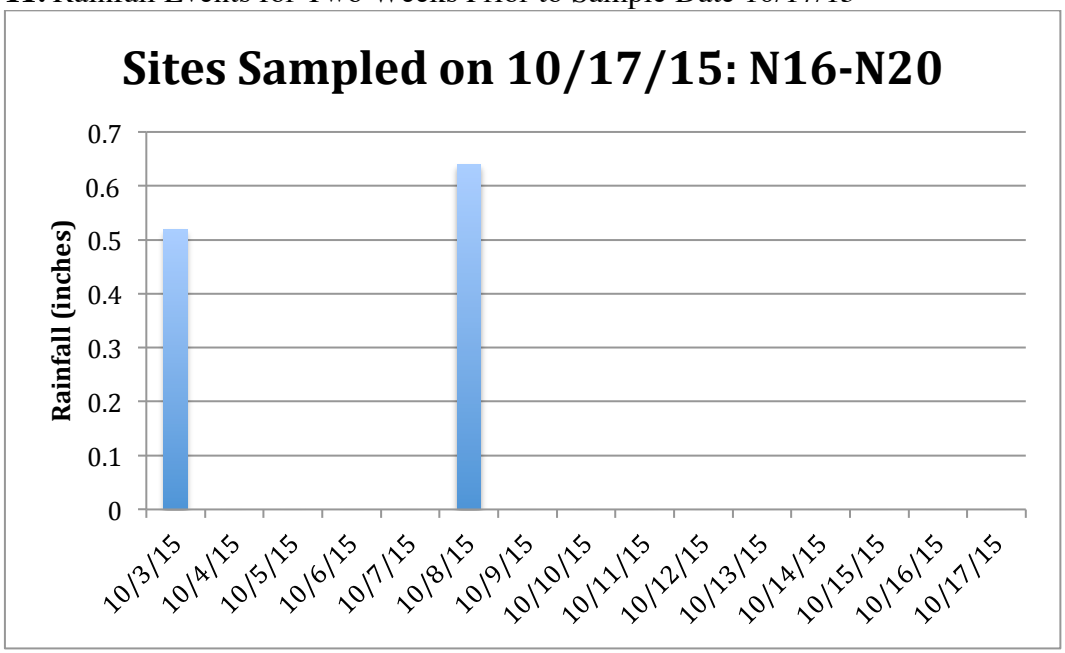
9. Rainfall Events for Two Weeks Prior to Sample Date 9/19/15



10. Rainfall Events for Two Weeks Prior to Sample Date 9/26/15



11. Rainfall Events for Two Weeks Prior to Sample Date 10/17/15



12. Growth category and water transport category matrix of all moss species sampled during study

	Ectohydric	Endohydric	Mixohydric
Acrocarpous	*Bryum argenteum* *Ceratodon purpureus* *Dicranum scoparium* *Fissidens adianthoides* *Leucobryum glaucum* *Schistidium apocarpum* *Ulota crispa*	*Atrichum altecristatum* *Plagiomnium cuspidatum* *Polytrichum commune*	
Pleurocarpous	*Anomodon attenuatus* *Brachythecium rivulare* *Brachythecium salebrosum* *Entodon seductrix* *Hypnum lindbergii* *Hypnum pallescens* *Platylomella lescurii* *Schwetschkeopsis fabronia* *Thuidium delicatulum*	*Climacium dendroides*	
Sphagnum	*Sphagnum wulfianum*		

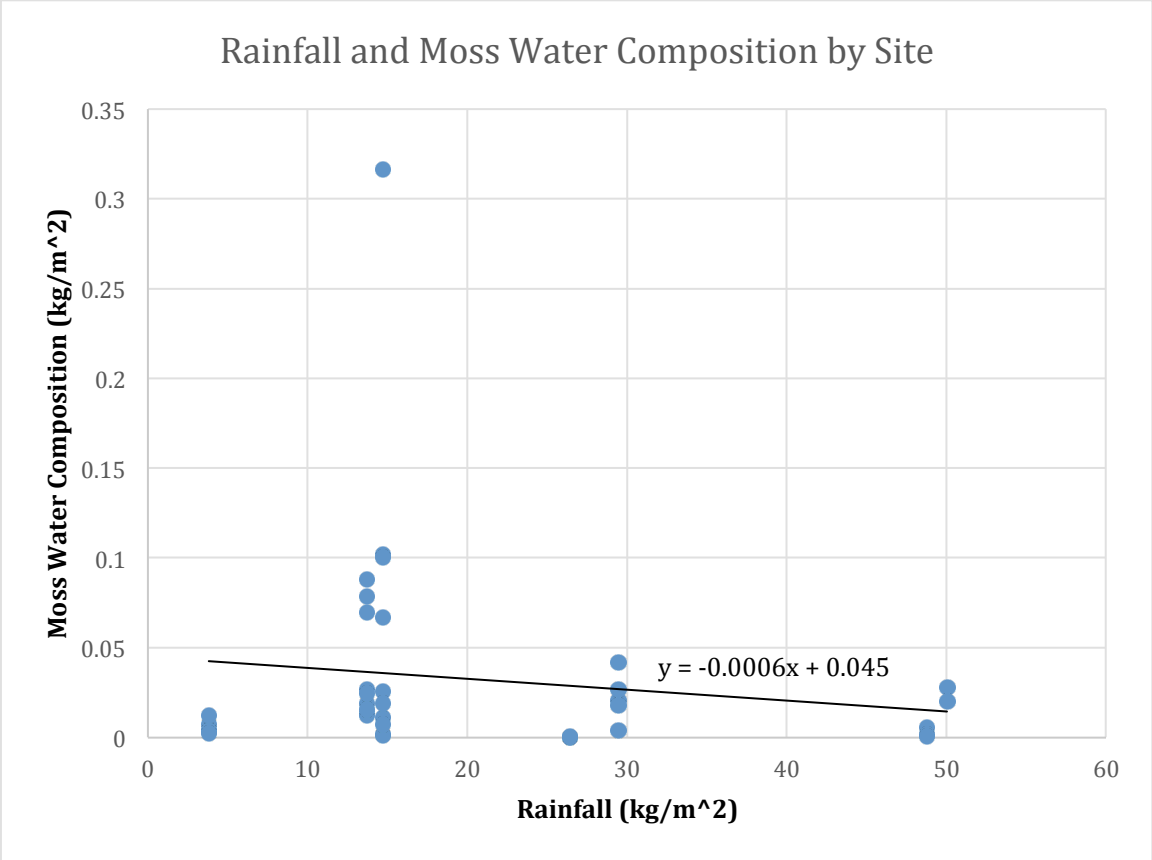
13. Occurrences of Moss Growth Category by Site Category

Site	Pleurocarpous	Acrocarpous	Sphagnum	Sum
MD Natural	8	7	1	16
MD Roof	5	2	0	7
TN Natural	2	4	0	6
TN Roof	4	2	0	6
Sum	19	15	1	35

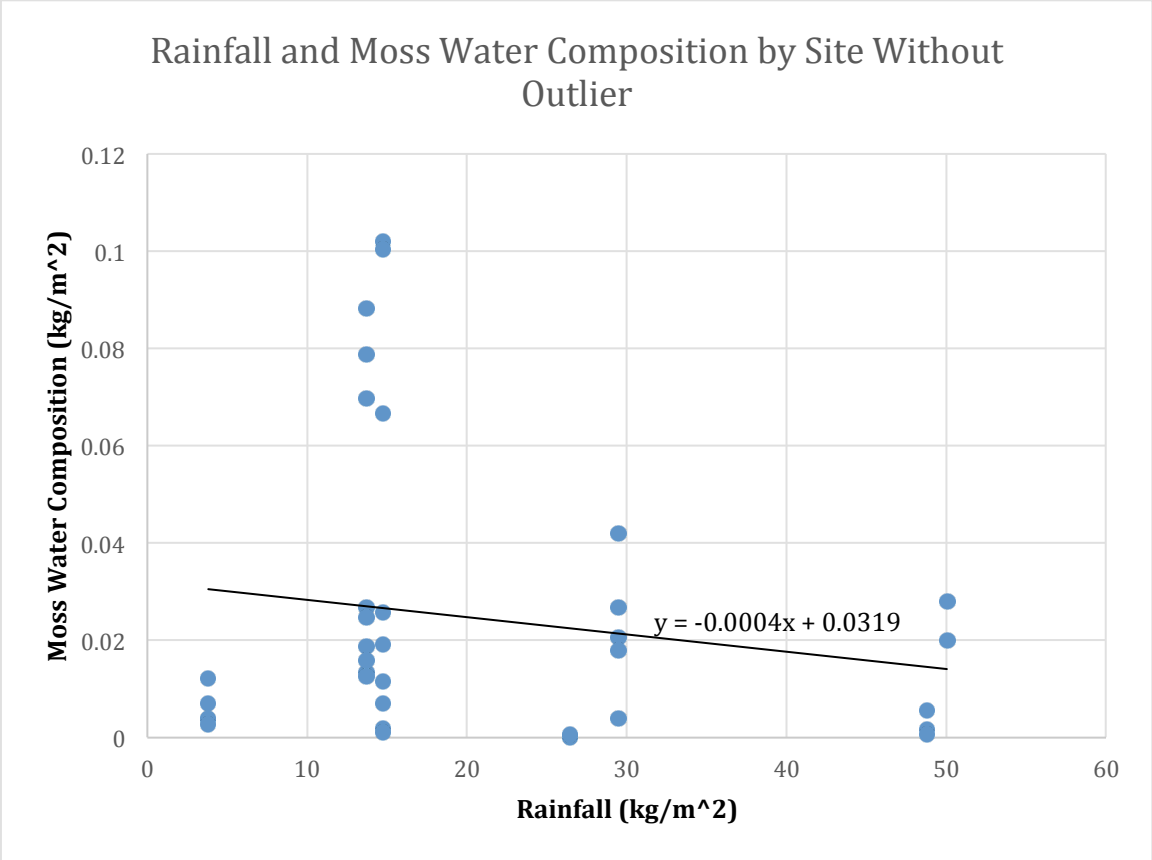
14. Occurrences of Water Transport Category by Site Category

Site	Ectohydric	Endohydric	Mixohydric	Sum
MD Natural	12	4	0	16
MD Roof	7	0	0	7
TN Natural	5	1	0	6
TN Roof	5	1	0	6
Sum	29	6	0	35

15. Regression Analysis of Site Rainfall in kg/m^2 and Moss Water Composition by Site in kg/m^2



16. Regression Analysis of Site Rainfall in kg/m^2 and Moss Water Composition by Site in kg/m^2 Excluding the Outlier



17. Raw Site Cover and Water Data

R1 Residential, Deciduous trees

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Entodon seductrix	332	8.30%	2.4	1.9	20.8%
2	Entodon seductrix	346.1	8.65%	1.2	1.0	16.7%
3	Entodon seductrix	295.5	7.39%	1.6	1.1	31.3%
4	Entodon seductrix	322.4	8.06%	0.6	0.5	16.7%
5	Entodon seductrix	343.6	8.59%	0.8	0.5	37.5%
6	Entodon seductrix	357.1	8.93%	2.3	1.7	26.1%
7	Entodon seductrix	244.6	6.12%	1.1	0.8	27.3%
8	Entodon seductrix	333.1	8.33%	1.2	0.8	33.3%
9	Entodon seductrix	299.1	7.48%	1.2	0.9	25.0%
10	Entodon seductrix	321.3	8.03%	1.0	0.7	30.0%

R2 Residential, Deciduous trees

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Entodon seductrix	270.5	6.76%	1.0	0.6	40.0%
2	Entodon seductrix	119.9	3.00%	1.6	1.3	18.8%
3	Entodon seductrix	177.2	4.43%	1.8	1.2	33.3%
4	Entodon seductrix	157.1	3.93%	1.1	0.8	27.3%
5	Entodon seductrix	11.2	0.28%	0.5	0.4	20.0%
6	Entodon seductrix	357.1	8.93%	1.3	1.1	15.4%
7	Entodon seductrix	11.7	0.29%	0.1	0.0	100.0%
	Bryum argenteum	3.3	0.08%	0.2	0.1	50.0%
8	Entodon seductrix	180.5	4.51%	1.7	1.5	11.8%
9	Entodon seductrix	40.5	1.01%	1.2	0.8	33.3%
10	Entodon seductrix	159.7	3.99%	1.3	0.9	30.8%

R3 Residential, Deciduous trees

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Entodon seductrix	218.3	5.46%	2.0	1.4	30.0%
2	Entodon seductrix	217.1	5.43%	0.5	0.2	60.0%
3	Entodon seductrix	149.9	3.75%	0.6	0.4	33.3%
4	Entodon seductrix	165.8	4.15%	0.5	0.3	40.0%
5	Entodon seductrix	196.8	4.92%	0.9	0.6	33.3%
6	Entodon seductrix	111.7	2.79%	0.6	0.2	66.7%
7	Entodon seductrix	243.1	6.08%	1.0	0.8	20.0%
8	Entodon seductrix	294	7.35%	1.0	0.9	10.0%
9	Entodon seductrix	233.4	5.84%	0.6	0.4	33.3%
10	Entodon seductrix	211.9	5.30%	1.2	0.9	25.0%

R4 Residential, Deciduous trees

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Entodon seductrix	126.3	3.16%	2.3	1.6	30.4%
2	Anomodon attenuatus	17.6	0.44%	0.6	0.3	50.0%
	Thuidium delicatulum	29.6	0.74%	0.6	0.4	33.3%
3	Anomodon attenuatus	39.4	0.99%	1.8	0.9	50.0%
	Thuidium delicatulum	32.1	0.80%	1.4	0.9	35.7%
4	Anomodon attenuatus	5.9	0.15%	0.6	0.3	50.0%
	Thuidium delicatulum	1.7	0.04%	0.5	0.2	60.0%
5	Anomodon attenuatus	5.5	0.14%	0.2	0.1	50.0%
	Thuidium delicatulum	17.1	0.43%	0.3	0.1	66.7%
6	Anomodon attenuatus	109.4	2.74%	1.5	0.8	46.7%
7	Entodon seductrix	54.3	1.36%	0.7	0.3	57.1%
	Thuidium delicatulum	43.5	1.09%	0.7	0.4	42.9%
8	Anomodon attenuatus	29.2	0.73%	0.6	0.4	33.3%
	Entodon seductrix	10.5	0.26%	0.2	0.1	50.0%
	Thuidium delicatulum	6.3	0.16%	0.2	0.1	50.0%
9	Anomodon attenuatus	7	0.18%	0.2	0.0	100.0%
	Thuidium delicatulum	1.2	0.03%	0.2	0.1	50.0%
10	Anomodon attenuatus	32.3	0.81%	1.8	0.9	50.0%

R5 Residential, Deciduous trees

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Entodon seductrix	133.7	3.34%	0.8	0.4	50.0%
	Thuidium delicatulum	148.2	3.71%	0.5	0.2	60.0%
2	Thuidium delicatulum	284.3	7.11%	4.2	1.1	73.8%
3	Thuidium delicatulum	278.5	6.96%	2.4	0.6	75.0%
4	Thuidium delicatulum	133.5	3.34%	0.5	0.2	60.0%
5	Thuidium delicatulum	381.6	9.54%	2.0	0.7	65.0%
6	Thuidium delicatulum	359.2	8.98%	1.1	0.3	72.7%
7	Thuidium delicatulum	199.6	4.99%	0.7	0.4	42.9%
8	N/A	0	0.00%	0.0	0.0	0.0%
9	Thuidium delicatulum	240.4	6.01%	0.3	0.1	66.7%
10	Entodon seductrix	2.4	0.06%	0.4	0.1	75.0%
	Thuidium delicatulum	23.6	0.59%	0.3	0.0	100.0%

R6 Residential, Deciduous trees

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Anomodon attenuatus	33.1	0.83%	0.5	0.3	40.0%
2	Anomodon attenuatus	13.2	0.33%	0.7	0.5	28.6%
3	Anomodon attenuatus	15.2	0.38%	0.5	0.3	40.0%
4	Anomodon attenuatus	20.4	0.51%	0.6	0.4	33.3%
5	Anomodon attenuatus	36.3	0.91%	1.3	1.0	23.1%
6	Anomodon attenuatus	8.2	0.21%	0.3	0.2	33.3%
7	Anomodon attenuatus	9.3	0.23%	0.3	0.2	33.3%
8	Anomodon attenuatus	10.2	0.26%	0.5	0.4	20.0%
9	Anomodon attenuatus	4.6	0.12%	0.2	0.1	50.0%
10	Anomodon attenuatus	10.5	0.26%	0.2	0.1	50.0%

R7 Residential, Deciduous trees

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Anomodon attenuatus	13.1	0.33%	0.5	0.4	20.0%
2	Anomodon attenuatus	1.4	0.04%	0.1	0.1	0.0%
3	Bryum argenteum	0.9	0.02%	0.2	0.1	50.0%
4	Anomodon attenuatus	20.1	0.50%	1.0	0.7	30.0%
5	Anomodon attenuatus	2.4	0.06%	0.1	0.1	0.0%
6	Anomodon attenuatus	0	0.00%	0.0	0.0	0.0%
7	Anomodon attenuatus	13.6	0.34%	0.3	0.2	33.3%
8	Anomodon attenuatus	0.4	0.01%	0.2	0.1	50.0%
9	Anomodon attenuatus	1	0.03%	0.1	0.1	0.0%
10	Anomodon attenuatus	0.8	0.02%	0.1	0.0	100.0%

R8 Residential, Deciduous trees

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Anomodon attenuatus	6.7	0.17%	0.7	0.4	42.9%
2	Anomodon attenuatus	17.6	0.44%	0.5	0.4	20.0%
3	Anomodon attenuatus	30.1	0.75%	0.6	0.3	50.0%
4	Brachythecium salebrosum	9.3	0.23%	0.3	0.1	66.7%
5	Anomodon attenuatus	42.2	1.06%	1.6	1.2	25.0%
6	Anomodon attenuatus	21.9	0.55%	0.5	0.3	40.0%
7	Anomodon attenuatus	69.8	1.75%	2.0	1.4	30.0%
8	Anomodon attenuatus	10	0.25%	0.7	0.4	42.9%
9	Anomodon attenuatus	39.8	1.00%	1.1	0.6	45.5%
10	Anomodon attenuatus	49.4	1.24%	0.9	0.7	22.2%

R9 Residential, Deciduous trees

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Anomodon attenuatus	192.3	4.81%	0.7	0.5	28.6%
2	Anomodon attenuatus	132.3	3.31%	0.6	0.4	33.3%
3	Entodon seductrix	131.1	3.28%	1.1	0.8	27.3%
4	Anomodon attenuatus	54.5	1.36%	0.7	0.4	42.9%
	Entodon seductrix	71.2	1.78%	1.5	1.3	13.3%
5	Anomodon attenuatus	154.6	3.87%	0.8	0.4	50.0%
6	Entodon seductrix	69.8	1.75%	1.1	0.7	36.4%
	Schistidium apocarpum	101.2	2.53%	0.4	0.3	25.0%
7	Anomodon attenuatus	68	1.70%	1.4	1.1	21.4%
	Schistidium apocarpum	73.4	1.84%	0.3	0.2	33.3%
8	Anomodon attenuatus	2.4	0.06%	0.7	0.4	42.9%
	Entodon seductrix	200.5	5.01%	2.0	1.6	20.0%
	Schistidium apocarpum	9.8	0.25%	0.1	0.0	100.0%
9	Anomodon attenuatus	15.9	0.40%	0.7	0.4	42.9%
	Entodon seductrix	102.1	2.55%	1.4	1.1	21.4%
	Schistidium apocarpum	40.5	1.01%	0.4	0.2	50.0%
10	Anomodon attenuatus	34.3	0.86%	1.1	0.7	36.4%
	Schistidium apocarpum	96.2	2.41%	0.4	0.2	50.0%

R10 Residential, Deciduous trees

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Anomodon attenuatus	48.5	1.21%	0.9	0.6	33.3%
	Schistidium apocarpum	57.9	1.45%	0.6	0.3	50.0%
2	Anomodon attenuatus	37.1	0.93%	0.7	0.5	28.6%
	Schistidium apocarpum	28.7	0.72%	0.6	0.2	66.7%
3	Anomodon attenuatus	86.1	2.15%	2.0	1.6	20.0%
4	Anomodon attenuatus	23.8	0.60%	0.8	0.5	37.5%
5	Anomodon attenuatus	36.9	0.92%	0.7	0.6	14.3%
	Schistidium apocarpum	10.3	0.26%	0.6	0.6	0.0%
6	Anomodon attenuatus	11.2	0.28%	0.4	0.2	50.0%
	Entodon seductrix	57.5	1.44%	0.7	0.4	42.9%
	Schistidium apocarpum	1.8	0.05%	0.1	0.1	0.0%
7	Anomodon attenuatus	27.2	0.68%	0.9	0.7	22.2%
8	Anomodon attenuatus	84.8	2.12%	1.1	0.8	27.3%
	Schistidium apocarpum	26.3	0.66%	0.8	0.8	0.0%
9	Anomodon attenuatus	16.1	0.40%	0.4	0.4	0.0%
10	Anomodon attenuatus	61.2	1.53%	0.9	0.6	33.3%
	Schistidium apocarpum	43.3	1.08%	0.2	0.1	50.0%

R11 Residential, Deciduous trees

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Anomodon attenuatus	8	0.20%	0.1	0.0	100.0%
	Schistidium apocarpum	0.7	0.02%	0.1	0.0	100.0%
2	Anomodon attenuatus	11.2	0.28%	0.2	0.1	50.0%
	Schistidium apocarpum	0.9	0.02%	0.0	0.0	0.0%
3	Anomodon attenuatus	33.9	0.85%	0.2	0.1	50.0%
	Schistidium apocarpum	1.1	0.03%	0.1	0.0	100.0%
4	Anomodon attenuatus	29	0.73%	0.4	0.2	50.0%
	Schistidium apocarpum	0.5	0.01%	0.2	0.1	50.0%
5	Anomodon attenuatus	29.6	0.74%	0.2	0.1	50.0%
	Schistidium apocarpum	2	0.05%	0.2	0.1	50.0%
6	Anomodon attenuatus	11.2	0.28%	0.3	0.1	66.7%
	Schistidium apocarpum	4	0.10%	0.2	0.1	50.0%
7	Anomodon attenuatus	25.9	0.65%	0.2	0.1	50.0%
	Schistidium apocarpum	2.5	0.06%	0.2	0.1	50.0%
8	Anomodon attenuatus	22.4	0.56%	0.2	0.1	50.0%
	Schistidium apocarpum	3.5	0.09%	0.5	0.3	40.0%
	Brachythecium rivulare	0.3	0.01%	0.0	0.0	0.0%
9	Anomodon attenuatus	29.4	0.74%	0.3	0.2	33.3%
	Schistidium apocarpum	4.3	0.11%	0.4	0.2	50.0%
10	Anomodon attenuatus	28.5	0.71%	0.6	0.4	33.3%
	Entodon seductrix	5.8	0.15%	1.6	0.5	68.8%
	Schistidium apocarpum	8.8	0.22%	0.4	0.3	25.0%

R12 Residential, Deciduous trees

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Entodon seductrix	336.7	8.42%	1.5	1.1	26.7%
2	Entodon seductrix	341.5	8.54%	2.3	1.8	21.7%
3	Entodon seductrix	400	10.00%	1.8	1.2	33.3%
4	Entodon seductrix	400	10.00%	2.9	2.3	20.7%
5	Entodon seductrix	400	10.00%	1.9	1.6	15.8%
6	Entodon seductrix	351.9	8.80%	1.5	1.2	20.0%
7	Entodon seductrix	366.1	9.15%	4.2	3.4	19.0%
8	Entodon seductrix	356.5	8.91%	5.4	4.5	16.7%
9	Entodon seductrix	400	10.00%	1.8	1.4	22.2%
10	Entodon seductrix	400	10.00%	1.5	1.0	33.3%

R13 Residential, Deciduous trees

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Ceratodon purpureous	45.6	1.14%	1.1	0.6	45.5%
	Thuidium delicatulum	10.1	0.25%	0.3	0.1	66.7%
2	Ceratodon purpureous	45	1.13%	0.7	0.3	57.1%
3	Ceratodon purpureous	73.5	1.84%	3.6	2.2	38.9%
	Thuidium delicatulum	93.4	2.34%	2.3	1.3	43.5%
4	Ceratodon purpureous	105.3	2.63%	2.0	0.9	55.0%
	Thuidium delicatulum	70	1.75%	2.0	1.1	45.0%
	Plagiomnium cuspidatum	55.4	1.39%	0.7	0.2	71.4%
5	Ceratodon purpureous	7.8	0.20%	0.5	0.1	80.0%
	Plagiomnium cuspidatum	191.4	4.79%	1.7	0.9	47.1%
6	Ceratodon purpureous	58.1	1.45%	0.9	0.3	66.7%
7	Thuidium delicatulum	136.1	3.40%	0.9	0.3	66.7%
8	Thuidium delicatulum	68.1	1.70%	1.0	0.4	60.0%
9	Thuidium delicatulum	213	5.33%	1.8	0.6	66.7%
	Plagiomnium cuspidatum	14.9	0.37%	0.2	0.1	50.0%
10	Thuidium delicatulum	298	7.45%	2.0	0.8	60.0%

R14 Residential, Deciduous trees

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Thuidium delicatulum	98.5	2.46%	0.5	0.4	20.0%
2	Thuidium delicatulum	55.5	1.39%	0.5	0.5	0.0%
3	Bryum argenteum	35.2	0.88%	3.8	2.5	34.2%
4	Bryum argenteum	78.7	1.97%	1.2	0.8	33.3%
5	Thuidium delicatulum	120.3	3.01%	0.6	0.4	33.3%
6	Thuidium delicatulum	103.6	2.59%	0.4	0.1	75.0%
7	Thuidium delicatulum	24.9	0.62%	0.5	0.3	40.0%
8	Thuidium delicatulum	137.3	3.43%	0.2	0.2	0.0%
9	Brachythecium salebrosum	82.3	2.06%	0.9	0.6	33.3%
	Anomodon attenuatus	177.8	4.45%	0.5	0.4	20.0%
10	Brachythecium salebrosum	94.4	2.36%	0.9	0.6	33.3%

R15 Residential, Deciduous trees

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Anomodon attenuatus	38.6	0.97%	2.3	1.9	17.4%
2	Anomodon attenuatus	56.9	1.42%	1.9	1.5	21.1%
3	Anomodon attenuatus	62.5	1.56%	1.6	1.4	12.5%
4	Anomodon attenuatus	19.2	0.48%	2.2	2.0	9.1%
5	Anomodon attenuatus	94.5	2.36%	0.9	0.4	55.6%
6	Anomodon attenuatus	64.6	1.62%	1.6	1.1	31.3%
7	Anomodon attenuatus	49.5	1.24%	1.1	0.9	18.2%
8	Anomodon attenuatus	28.4	0.71%	1.5	1.3	13.3%
9	Anomodon attenuatus	30	0.75%	0.6	0.4	33.3%
10	Anomodon attenuatus	48	1.20%	1.6	1.3	18.8%

R16 Residential, Deciduous trees

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Brachythecium salebrosum	71	1.78%	0.6	0.5	16.7%
	Anomodon attenuatus	393.8	9.85%	1.6	1.3	18.8%
2	Anomodon attenuatus	379.3	9.48%	1.0	0.8	20.0%
3	Brachythecium salebrosum	291.4	7.29%	0.6	0.4	33.3%
	Anomodon attenuatus	396.1	9.90%	0.9	0.6	33.3%
4	Brachythecium salebrosum	156.4	3.91%	0.8	0.6	25.0%
	Anomodon attenuatus	400	10.00%	1.3	0.9	30.8%
5	Brachythecium salebrosum	67.3	1.68%	0.3	0.1	66.7%
	Anomodon attenuatus	390	9.75%	1.7	1.4	17.6%
6	Brachythecium salebrosum	20.1	0.50%	0.2	0.1	50.0%
	Anomodon attenuatus	311.2	7.78%	1.3	1.1	15.4%
7	Brachythecium salebrosum	259.8	6.50%	1.9	1.2	36.8%
	Anomodon attenuatus	64	1.60%	1.5	0.7	53.3%
8	Brachythecium salebrosum	25.5	0.64%	1.1	0.6	45.5%
	Anomodon attenuatus	271.3	6.78%	1.7	1.0	41.2%
	Plagiomnium cuspidatum	17.4	0.44%	4.4	2.8	36.4%
9	Anomodon attenuatus	398.3	9.96%	2.0	1.3	35.0%
10	Brachythecium salebrosum	70	1.75%	2.1	1.3	38.1%
	Anomodon attenuatus	302.7	7.57%	2.9	1.7	41.4%

R17 Residential, Deciduous trees

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Brachythecium salebrosum	375.3	9.38%	0.6	0.4	33.3%
2	Brachythecium salebrosum	119.1	2.98%	0.8	0.6	25.0%
	Anomodon attenuatus	395.3	9.88%	1.0	0.8	20.0%
3	Brachythecium salebrosum	387.9	9.70%	0.7	0.5	28.6%
4	Brachythecium salebrosum	71.3	1.78%	0.5	0.3	40.0%
	Anomodon attenuatus	288.7	7.22%	0.4	0.3	25.0%
5	Brachythecium salebrosum	282.4	7.06%	0.8	0.6	25.0%
	Anomodon attenuatus	349	8.73%	3.1	2.4	22.6%
6	Brachythecium salebrosum	15.3	0.38%	0.6	0.3	50.0%
	Anomodon attenuatus	400	10.00%	3.4	2.5	26.5%
7	Brachythecium salebrosum	61.5	1.54%	0.2	0.1	50.0%
	Anomodon attenuatus	390.4	9.76%	1.9	1.2	36.8%
8	Anomodon attenuatus	376.4	9.41%	4.2	3.0	28.6%
9	Brachythecium salebrosum	103.3	2.58%	1.2	0.9	25.0%
	Thuidium delicatulum	18.8	0.47%	0.3	0.2	33.3%
	Anomodon attenuatus	177.9	4.45%	0.3	0.1	66.7%
10	Anomodon attenuatus	373.9	9.35%	0.6	0.3	50.0%
	Thuidium delicatulum	46.1	1.15%	0.3	0.2	33.3%

N1 Residential, Grassland

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Plagiomnium cuspidatum	256.5	6.41%	3.7	1.7	54.1%
2	Plagiomnium cuspidatum	377.1	9.43%	3.0	1.1	63.3%
3	Plagiomnium cuspidatum	394.2	9.86%	2.1	0.5	76.2%
	Entodon seductrix	2.8	0.07%	0.4	0.2	50.0%
4	Entodon seductrix	34.5	0.86%	3.9	1.9	51.3%
	Plagiomnium cuspidatum	209.1	5.23%	0.4	0.3	25.0%
5	Plagiomnium cuspidatum	206.2	5.16%	1.3	0.5	61.5%
	Brachythecium salebrosum	10.1	0.25%	1.6	0.7	56.3%
6	Plagiomnium cuspidatum	321.1	8.03%	2.9	1.1	62.1%
7	Brachythecium salebrosum	97.2	2.43%	6.4	3.6	43.8%
8	Brachythecium salebrosum	174.2	4.36%	1.4	0.8	42.9%
9	Plagiomnium cuspidatum	83.9	2.10%	1.0	0.4	60.0%
	Brachythecium salebrosum	13.4	0.34%	2.6	1.5	42.3%
	Entodon seductrix	22.6	0.57%	2.9	1.3	55.2%
10	Brachythecium salebrosum	36.3	0.91%	4.4	2.3	47.7%

N2 Residential, Grassland

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Brachythecium salebrosum	400	10.00%	2.9	1.0	65.5%
2	Brachythecium salebrosum	369.6	9.24%	3.3	1.1	66.7%
3	Brachythecium salebrosum	323.8	8.10%	2.2	1.0	54.5%
4	Brachythecium salebrosum	101.1	2.53%	0.9	0.6	33.3%
5	Brachythecium salebrosum	360.2	9.01%	1.3	0.8	38.5%
6	Brachythecium salebrosum	369.7	9.24%	2.3	1.2	47.8%
7	Brachythecium salebrosum	280.7	7.02%	0.8	0.5	37.5%
8	Brachythecium salebrosum	400	10.00%	0.8	0.3	62.5%
9	Brachythecium salebrosum	392.1	9.80%	1.7	0.8	52.9%
10	Brachythecium salebrosum	357.5	8.94%	0.8	0.5	37.5%
	Plagiomnium cuspidatum	67.7	1.69%	1.9	1.1	42.1%

N3 Residential, Grassland

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Ceratodon purpureus	4.3	0.11%	0.9	0.4	55.6%
2	Ceratodon purpureus	45.8	1.15%	2.7	1.8	33.3%
3	Thuidium delicatulum	10.6	0.27%	0.4	0.2	50.0%
	Ceratodon purpureus	18.7	0.47%	2.6	2.0	23.1%
4	Ceratodon purpureus	50.4	1.26%	3.2	2.1	34.4%
5	Ceratodon purpureus	70.9	1.77%	4.0	3.0	25.0%
6	Ceratodon purpureus	90.8	2.27%	8.6	6.0	30.2%
7	Ceratodon purpureus	86.2	2.16%	6.3	4.2	33.3%
8	Ceratodon purpureus	56.7	1.42%	3.8	2.7	28.9%
9	Ceratodon purpureus	117.5	2.94%	7.1	4.0	43.7%
10	Ceratodon purpureus	216.4	5.41%	2.2	1.6	27.3%

N4 Deciduous Forest, Shrub

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Brachythecium salebrosum	216	5.40%	7.6	2.4	68.4%
2	Brachythecium salebrosum	212.3	5.31%	10.3	5.2	49.5%
3	Brachythecium salebrosum	129.5	3.24%	7.8	3.0	61.5%
4	Brachythecium salebrosum	128.8	3.22%	21.8	13.4	38.5%
5	Polytrichum commune	71.8	1.80%	4.0	2.5	37.5%
6	Polytrichum commune	184.6	4.62%	3.9	2.6	33.3%
7	Brachythecium salebrosum	340.1	8.50%	8.0	3.5	56.3%
8	Brachythecium salebrosum	226.5	5.66%	16.8	5.2	69.0%
9	Brachythecium salebrosum	145.4	3.64%	11.9	6.8	42.9%
10	Brachythecium salebrosum	367.6	9.19%	10.2	4.2	58.8%

N5 Deciduous Forest, Forest

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Brachythecium salebrosum	400	10.00%	11.0	3.5	68.2%
2	Brachythecium salebrosum	348.6	8.72%	6.5	2.1	67.7%
3	Brachythecium salebrosum	400	10.00%	8.5	3.5	58.8%
4	Brachythecium salebrosum	354.4	8.86%	5.2	1.4	73.1%
5	Brachythecium salebrosum	323.3	8.08%	7.3	4.1	43.8%
	Polytrichum commune	13.2	0.33%	1.0	0.5	50.0%
6	Brachythecium salebrosum	362.7	9.07%	6.0	1.2	80.0%
	Dicranum scoparium	5.2	0.13%	0.2	0.1	50.0%
	Fissidens adianthoides	37.3	0.93%	0.8	0.5	37.5%
7	Fissidens adianthoides	290.9	7.27%	1.9	1.1	42.1%
	Brachythecium salebrosum	2.2	0.06%	1.7	1.1	35.3%
8	Brachythecium salebrosum	313	7.83%	12.1	4.4	63.6%
	Dicranum scoparium	1.1	0.03%	0.3	0.1	66.7%
9	Brachythecium salebrosum	367.2	9.18%	15.5	7.9	49.0%
10	Brachythecium salebrosum	255.5	6.39%	6.5	3.4	47.7%

N6 Deciduous Forest

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Brachythecium salebrosum	391.9	9.80%	4.5	2.5	44.4%
2	Brachythecium salebrosum	347.2	8.68%	8.0	4.2	47.5%
3	Brachythecium salebrosum	400	10.00%	6.1	2.1	65.6%
4	Fissidens adianthoides	26	0.65%	3.5	1.4	60.0%
	Brachythecium salebrosum	306.9	7.67%	5.2	2.6	50.0%
5	Brachythecium salebrosum	268.1	6.70%	13.0	5.5	57.7%
6	Brachythecium salebrosum	369.5	9.24%	6.3	2.9	54.0%
7	Brachythecium salebrosum	400	10.00%	7.5	2.5	66.7%
8	Fissidens adianthoides	290.3	7.26%	6.6	2.7	59.1%
	Brachythecium salebrosum	25.3	0.63%	1.2	0.4	66.7%
9	Brachythecium salebrosum	62.2	1.56%	1.5	0.8	46.7%
	Fissidens adianthoides	259.5	6.49%	2.4	1.1	54.2%
	Polytrichum commune	1.6	0.04%	0.2	0.1	50.0%
10	Polytrichum commune	42.9	1.07%	6.2	3.4	45.2%
	Brachythecium salebrosum	357.1	8.93%	8.8	2.8	68.2%

N7	Deciduous Forest					
Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Brachythecium salebrosum	400	10.00%	5.7	1.7	70.2%
	Thuidium delicatulum	118.4	2.96%	3.9	0.7	82.1%
2	Brachythecium salebrosum	322.8	8.07%	7.2	2.2	69.4%
3	Brachythecium salebrosum	351.7	8.79%	9.5	2.9	69.5%
	Thuidium delicatulum	33.4	0.84%	3.9	0.8	79.5%
4	Brachythecium salebrosum	400	10.00%	11.5	2.3	80.0%
5	Brachythecium salebrosum	400	10.00%	10.7	2.6	75.7%
6	Brachythecium salebrosum	400	10.00%	13.4	3.7	72.4%
7	Brachythecium salebrosum	400	10.00%	11.1	2.9	73.9%
8	Brachythecium salebrosum	400	10.00%	18.0	6.9	61.7%
	Thuidium delicatulum	49.3	1.23%	3.3	0.7	78.8%
9	Brachythecium salebrosum	400	10.00%	18.6	4.2	77.4%
	Thuidium delicatulum	228	5.70%	15.2	2.6	82.9%
10	Brachythecium salebrosum	388.1	9.70%	26.0	7.6	70.8%

N8	Residential, Grassland					
Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Polytrichum commune	345.8	8.65%	3.1	1.7	45.2%
2	Polytrichum commune	313.1	7.83%	1.9	0.7	63.2%
	Leucobryum glaucum	44	1.10%	4.3	2.6	39.5%
3	Polytrichum commune	400	10.00%	1.8	0.6	66.7%
4	Polytrichum commune	355	8.88%	2.6	0.9	65.4%
	Leucobryum glaucum	48.2	1.21%	8.6	2.6	69.8%
5	Polytrichum commune	98.8	2.47%	1.4	0.6	57.1%
	Leucobryum glaucum	4.5	0.11%	1.6	0.6	62.5%
	Plagiomnium cuspidatum	296.7	7.42%	2.0	1.1	45.0%
6	Polytrichum commune	128.2	3.21%	1.6	1.0	37.5%
	Entodon seductrix	327	8.18%	2.5	1.7	32.0%
	Ulota crispa	327	8.18%	0.7	0.4	42.9%
7	Polytrichum commune	284.1	7.10%	2.1	1.0	52.4%
	Leucobryum glaucum	41.3	1.03%	2.2	0.7	68.2%
8	Polytrichum commune	123.3	3.08%	1.4	0.6	57.1%
	Leucobryum glaucum	10.2	0.26%	3.6	0.9	75.0%
	Plagiomnium cuspidatum	289.5	7.24%	1.4	0.8	42.9%
9	Polytrichum commune	249.3	6.23%	2.5	1.2	52.0%
	Plagiomnium cuspidatum	383	9.58%	1.8	0.8	55.6%
10	Leucobryum glaucum	150.3	3.76%	2.7	1.3	51.9%
	Plagiomnium cuspidatum	249.7	6.24%	3.7	2.7	27.0%
	Polytrichum commune	2.6	0.07%	0.5	0.3	40.0%

N9 Residential, Grassland

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Leucobryum glaucum	15.7	0.39%	1.3	0.7	46.2%
	Hypnum pallescens	400	10.00%	2.3	1.6	30.4%
2	Leucobryum glaucum	9.7	0.24%	0.6	0.3	50.0%
	Hypnum pallescens	305.7	7.64%	1.9	1.3	31.6%
3	Hypnum pallescens	397.7	9.94%	1.7	1.2	29.4%
4	Leucobryum glaucum	14	0.35%	2.8	1.0	64.3%
	Schwetschkeopisis fabronia	320.6	8.02%	3.1	2.1	32.3%
5	Leucobryum glaucum	45.2	1.13%	4.8	1.8	62.5%
	Hypnum pallescens	228.2	5.71%	0.5	0.2	60.0%
	Schwetschkeopisis fabronia	137.6	3.44%	4.8	2.6	45.8%
6	Polytrichum commune	22	0.55%	1.2	0.3	75.0%
	Leucobryum glaucum	178.2	4.46%	10.3	3.7	64.1%
	Dicranum scoparium	8.2	0.21%	2.7	1.1	59.3%
7	Leucobryum glaucum	299.7	7.49%	3.9	1.2	69.2%
	Hypnum pallescens	49.6	1.24%	0.2	0.1	50.0%
	Dicranum scoparium	43.8	1.10%	2.7	1.8	33.3%
8	Leucobryum glaucum	51.2	1.28%	5.3	2.4	54.7%
	Hypnum pallescens	275.5	6.89%	2.8	1.4	50.0%
9	Leucobryum glaucum	71.2	1.78%	7.7	4.3	44.2%
	Hypnum pallescens	243.3	6.08%	1.5	1.0	33.3%
10	Leucobryum glaucum	9.5	0.24%	1.3	0.6	53.8%
	Hypnum pallescens	272.3	6.81%	4.5	3.4	24.4%

N10 Deciduous Forest

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Leucobryum glaucum	242.6	6.07%	1.2	0.4	66.7%
	Dicranum scoparium	9.2	0.23%	1.4	0.9	35.7%
	Hypnum pallescens	10.6	0.27%	0.2	0.1	50.0%
2	Leucobryum glaucum	388.8	9.72%	3.6	2.5	30.6%
	Dicranum scoparium	3.9	0.10%	0.2	0.1	50.0%
3	Leucobryum glaucum	267.7	6.69%	2.5	1.8	28.0%
	Dicranum scoparium	15.3	0.38%	0.7	0.5	28.6%
4	Leucobryum glaucum	351.9	8.80%	2.4	1.8	25.0%
5	Leucobryum glaucum	311.6	7.79%	1.8	1.1	38.9%
6	Leucobryum glaucum	156.6	3.92%	2.3	1.5	34.8%
	Dicranum scoparium	73.8	1.85%	7.6	5.6	26.3%
	Hypnum pallescens	33.8	0.85%	0.9	0.4	55.6%
7	Hypnum pallescens	380.1	9.50%	1.1	0.6	45.5%
8	Hypnum pallescens	260.4	6.51%	0.7	0.5	28.6%
	Dicranum scoparium	112.9	2.82%	2.7	1.9	29.6%
9	Leucobryum glaucum	113.7	2.84%	1.7	1.0	41.2%
	Dicranum scoparium	151.2	3.78%	1.6	1.1	31.3%
	Hypnum pallescens	63.2	1.58%	1.0	0.8	20.0%
10	Leucobryum glaucum	147.1	3.68%	0.5	0.3	40.0%
	Dicranum scoparium	147.1	3.68%	0.8	0.5	37.5%
	Hypnum pallescens	4.5	0.11%	1.0	0.7	30.0%

N11 Residential, Grassland

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Polytrichum commune	400	10.00%	1.6	0.9	43.8%
	Hypnum pallescens	400	10.00%	0.8	0.3	62.5%
2	Hypnum pallescens	389.9	9.75%	1.0	0.5	50.0%
3	Polytrichum commune	83.2	2.08%	0.7	0.4	42.9%
	Hypnum pallescens	283.5	7.09%	1.1	0.6	45.5%
4	Polytrichum commune	47.6	1.19%	1.0	0.8	20.0%
	Hypnum pallescens	183.1	4.58%	1.2	0.6	50.0%
	Leucobryum glaucum	27.6	0.69%	0.9	0.5	44.4%
5	Polytrichum commune	90.5	2.26%	0.7	0.3	57.1%
	Hypnum pallescens	7.4	0.19%	0.2	0.1	50.0%
	Leucobryum glaucum	38.2	0.96%	0.5	0.2	60.0%
6	Polytrichum commune	263.8	6.60%	0.6	0.3	50.0%
	Hypnum pallescens	17.3	0.43%	0.2	0.1	50.0%
	Leucobryum glaucum	15.5	0.39%	0.9	0.4	55.6%
7	Polytrichum commune	230.1	5.75%	1.7	1.2	29.4%
	Leucobryum glaucum	61.6	1.54%	1.1	0.8	27.3%
8	Polytrichum commune	288.7	7.22%	1.0	0.7	30.0%
	Leucobryum glaucum	8.9	0.22%	0.7	0.5	28.6%
9	Polytrichum commune	119.9	3.00%	0.7	0.4	42.9%
	Leucobryum glaucum	19.4	0.49%	1.0	0.6	40.0%
	Hypnum pallescens	237.9	5.95%	0.7	0.5	28.6%
10	Hypnum pallescens	233.6	5.84%	1.3	0.9	30.8%
	Leucobryum glaucum	3.3	0.08%	0.6	0.3	50.0%

N12 Deciduous Forest

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Atrichum altecristatum	397.4	9.94%	1.5	0.6	60.0%
2	Atrichum altecristatum	365.9	9.15%	1.1	0.6	45.5%
	Dicranum scoparium	27.4	0.69%	0.2	0.1	50.0%
3	Atrichum altecristatum	336.4	8.41%	0.6	0.3	50.0%
4	Atrichum altecristatum	232.2	5.81%	0.7	0.3	57.1%
	Dicranum scoparium	115.3	2.88%	3.3	3.0	9.1%
5	Atrichum altecristatum	206.8	5.17%	0.8	0.3	62.5%
	Dicranum scoparium	23.6	0.59%	2.9	2.2	24.1%
6	Dicranum scoparium	86.6	2.17%	1.5	0.9	40.0%
7	Dicranum scoparium	119.2	2.98%	1.5	1.1	26.7%
8	Dicranum scoparium	57.9	1.45%	1.7	1.3	23.5%
9	Dicranum scoparium	288.5	7.21%	3.0	2.1	30.0%
10	Dicranum scoparium	128.8	3.22%	2.8	2.1	25.0%

N13 Residential, Grassland

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Sphagnum wulfianum	217.1	5.43%	4.8	3.8	20.8%
	Entodon seductrix	178.1	4.45%	0.8	0.5	37.5%
2	Sphagnum wulfianum	267.1	6.68%	3.3	2.0	39.4%
	Entodon seductrix	79.2	1.98%	0.7	0.2	71.4%
3	Sphagnum wulfianum	252.4	6.31%	1.2	0.8	33.3%
	Leucobryum glaucum	35.1	0.88%	0.9	0.5	44.4%
	Hypnum pallescens	124.1	3.10%	1.1	0.8	27.3%
4	Hypnum pallescens	400	10.00%	2.1	1.6	23.8%
5	Sphagnum wulfianum	45.7	1.14%	1.7	1.2	29.4%
	Leucobryum glaucum	29.4	0.74%	0.7	0.4	42.9%
	Hypnum pallescens	320.4	8.01%	1.6	1.3	18.8%
6	Sphagnum wulfianum	50.35	1.26%	4.0	3.0	25.0%
	Leucobryum glaucum	113.5	2.84%	1.0	-0.5	150.0%
	Hypnum pallescens	134.05	3.35%	1.4	0.9	35.7%
7	Leucobryum glaucum	351	8.78%	18.0	4.2	76.7%
8	Sphagnum wulfianum	28.3	0.71%	5.0	3.0	40.0%
	Leucobryum glaucum	222	5.55%	12.8	6.1	52.3%
	Thuidium delicatulum	12.5	0.31%	0.6	0.2	66.7%
9	Sphagnum wulfianum	53.3	1.33%	1.8	1.1	38.9%
	Leucobryum glaucum	86.2	2.16%	8.3	4.2	49.4%
	Thuidium delicatulum	108	2.70%	2.7	1.3	51.9%
	Hypnum pallescens	168.5	4.21%	1.0	0.4	60.0%
10	Sphagnum wulfianum	18.5	0.46%	2.2	1.8	18.2%
	Leucobryum glaucum	139.5	3.49%	1.3	0.8	38.5%
	Thuidium delicatulum	191.1	4.78%	0.9	0.6	33.3%
	Hypnum pallescens	201.1	5.03%	0.6	0.2	66.7%

N14 Residential, Shrub

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Thuidium delicatulum	400	10.00%	3.1	1.9	38.7%
2	Thuidium delicatulum	400	10.00%	2.4	1.7	29.2%
3	Thuidium delicatulum	387.3	9.68%	1.2	0.8	33.3%
	Leucobryum glaucum	12.7	0.32%	0.6	0.4	33.3%
4	Thuidium delicatulum	400	10.00%	4.4	3.5	20.5%
5	Thuidium delicatulum	385.4	9.64%	1.7	1.3	23.5%
6	Thuidium delicatulum	234.7	5.87%	2.8	2.1	25.0%
7	Thuidium delicatulum	324.4	8.11%	2.3	1.7	26.1%
8	Thuidium delicatulum	400	10.00%	3.0	2.3	23.3%
9	Thuidium delicatulum	332.3	8.31%	2.1	1.7	19.0%
10	Thuidium delicatulum	358.3	8.96%	3.0	2.5	16.7%

N15 Deciduous Forest

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Sphagnum wulfianum	322.4	8.06%	0.5	0.4	20.0%
	Platylomella lescurii	77.6	1.94%	4.9	2.0	59.2%
2	Sphagnum wulfianum	180.1	4.50%	1.8	1.3	27.8%
	Platylomella lescurii	283.6	7.09%	1.7	1.1	35.3%
3	Sphagnum wulfianum	281.9	7.05%	3.1	2.5	19.4%
	Thuidium delicatulum	143.7	3.59%	1.1	0.7	36.4%
4	Sphagnum wulfianum	65.1	1.63%	0.7	0.4	42.9%
	Platylomella lescurii	306.7	7.67%	1.2	0.8	33.3%
5	Sphagnum wulfianum	132.2	3.31%	1.9	1.2	36.8%
	Platylomella lescurii	249	6.23%	0.8	0.7	12.5%
6	Sphagnum wulfianum	207.6	5.19%	2.9	2.1	27.6%
	Platylomella lescurii	3.2	0.08%	1.1	0.7	36.4%
7	Sphagnum wulfianum	400	10.00%	2.2	1.7	22.7%
	Polytrichum commune	13.7	0.34%	1.0	0.5	50.0%
8	Sphagnum wulfianum	384.3	9.61%	2.7	1.9	29.6%
	Polytrichum commune	100.2	2.51%	1.6	0.9	43.8%
9	Sphagnum wulfianum	240.8	6.02%	1.9	1.5	21.1%
10	Sphagnum wulfianum	190.9	4.77%	3.1	2.3	25.8%

N16 Residential, Grassland

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Hypnum pallescens	368.1	9.20%	2.5	0.7	72.0%
2	Hypnum pallescens	243.3	6.08%	2.1	0.8	61.9%
	Atrichum altecristatum	0.9	0.02%	0.2	0.1	50.0%
3	Thuidium delicatulum	275.8	6.90%	2.0	0.9	55.0%
	Hypnum pallescens	38.5	0.96%	1.3	0.6	53.8%
	Atrichum altecristatum	3.9	0.10%	0.6	0.3	50.0%
4	Hypnum pallescens	376.6	9.42%	0.2	0.1	50.0%
	Thuidium delicatulum	376.6	9.42%	1.2	0.4	66.7%
5	Hypnum pallescens	391.8	9.80%	2.8	1.0	64.3%
6	Hypnum pallescens	324.2	8.11%	5.1	1.4	72.5%
7	Hypnum pallescens	350.9	8.77%	4.9	1.7	65.3%
8	Hypnum pallescens	175.1	4.38%	1.3	0.4	69.2%
	Atrichum altecristatum	224.9	5.62%	1.5	0.5	66.7%
9	Hypnum pallescens	20	0.50%	1.2	0.4	66.7%
	Plagiomnium cuspidatum	198.7	4.97%	1.1	0.4	63.6%
10	Hypnum pallescens	37.4	0.94%	1.1	0.2	81.8%
	Plagiomnium cuspidatum	130.2	3.26%	1.0	0.4	60.0%

N17 Residential, Grassland

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Climacium dendroides	28.4	0.71%	1.8	1.0	44.4%
2	Climacium dendroides	354.4	8.86%	1.8	0.9	50.0%
3	Climacium dendroides	289.6	7.24%	2.1	1.1	47.6%
4	Climacium dendroides	325.7	8.14%	2.3	1.2	47.8%
5	Climacium dendroides	397.6	9.94%	1.9	1.0	47.4%
	Thuidium delicatulum	2.4	0.06%	0.1	0.0	100.0%
6	Climacium dendroides	86.7	2.17%	1.7	0.7	58.8%
	Thuidium delicatulum	58.1	1.45%	1.8	0.8	55.6%
7	Climacium dendroides	363	9.08%	2.2	1.1	50.0%
8	Climacium dendroides	339.5	8.49%	2.6	1.5	42.3%
9	Climacium dendroides	349.7	8.74%	1.9	1.2	36.8%
10	Climacium dendroides	188.9	4.72%	1.9	0.8	57.9%
	Thuidium delicatulum	2.4	0.06%	0.2	0.1	50.0%

N18	Residential, Grassland					
Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Brachythecium salebrosum	360.2	9.01%	2.2	1.5	31.8%
2	Brachythecium salebrosum	306.9	7.67%	3.5	2.3	34.3%
3	Brachythecium salebrosum	344.8	8.62%	2.0	1.0	50.0%
4	Atrichum altecristatum	30	0.75%	1.4	0.9	35.7%
	Brachythecium salebrosum	118.1	2.95%	0.6	0.3	50.0%
	Fissidens adianthoides	7.7	0.19%	0.9	0.4	55.6%
5	Brachythecium salebrosum	258.2	6.46%	2.9	1.7	41.4%
6	Brachythecium salebrosum	400	10.00%	3.2	1.7	46.9%
7	Brachythecium salebrosum	383.6	9.59%	2.6	1.5	42.3%
8	Brachythecium salebrosum	381	9.53%	3.7	2.2	40.5%
9	Brachythecium salebrosum	312.2	7.81%	2.2	1.3	40.9%
10	Brachythecium salebrosum	371.2	9.28%	5.8	3.6	37.9%

N19 Residential, Grassland

Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Entodon seductrix	237.6	5.94%	3.3	1.8	45.5%
	Plagiomnium cuspidatum	2.8	0.07%	1.7	0.6	64.7%
	Atrichum altecristatum	5	0.13%	0.1	0.1	0.0%
	Hypnum pallescens	32.3	0.81%	0.6	0.2	66.7%
2	Plagiomnium cuspidatum	325.1	8.13%	5.1	2.9	43.1%
	Atrichum altecristatum	3.3	0.08%	0.1	0.0	100.0%
3	Entodon seductrix	61.7	1.54%	2.4	1.2	50.0%
	Hypnum pallescens	177	4.43%	0.5	0.3	40.0%
	Atrichum altecristatum	34.8	0.87%	0.4	0.2	50.0%
4	Atrichum altecristatum	355.4	8.89%	0.3	0.1	66.7%
	Plagiomnium cuspidatum	22	0.55%	9.2	6.3	31.5%
5	Plagiomnium cuspidatum	274.4	6.86%	4.0	1.9	52.5%
6	Plagiomnium cuspidatum	298.3	7.46%	5.7	3.1	45.6%
	Hypnum lindbergii	5.4	0.14%	0.2	0.1	50.0%
7	Plagiomnium cuspidatum	195.5	4.89%	3.1	2.0	35.5%
8	Hypnum lindbergii	265	6.63%	2.6	1.5	42.3%
	Atrichum altecristatum	3.7	0.09%	1.1	0.6	45.5%
9	Hypnum pallescens	102.2	2.56%	2.7	1.4	48.1%
	Hypnum lindbergii	67	1.68%	1.5	0.9	40.0%
10	Hypnum pallescens	115.9	2.90%	3.6	2.1	41.7%
	Hypnum lindbergii	29.7	0.74%	1.0	0.4	60.0%

N20	Deciduous Forest					
Sample #	Species	Total Coverage (cm^2)	Percent Coverage	Wet Weight (g)	Dry Weight (g)	% Water
1	Fissidens adianthoides	48.3	1.21%	2.4	1.1	54.2%
2	Thuidium delicatulum	104.4	2.61%	3.7	1.3	64.9%
3	Thuidium delicatulum	53.9	1.35%	0.2	0.1	50.0%
4	Thuidium delicatulum	148.6	3.72%	10.9	4.4	59.6%
	Plagiomnium cuspidatum	8.5	0.21%	0.6	0.3	50.0%
5	Thuidium delicatulum	45.9	1.15%	0.8	0.3	62.5%
6	Thuidium delicatulum	22.1	0.55%	1.1	0.7	36.4%
7	Thuidium delicatulum	104.1	2.60%	4.7	2.0	57.4%
8	Brachythecium salebrosum	312.9	7.82%	1.8	1.2	33.3%
9	Brachythecium salebrosum	235.1	5.88%	10.1	6.6	34.7%
10	Brachythecium salebrosum	364.4	9.11%	3.4	1.8	47.1%

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