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The Lichens and Allied Fungi of Mercer County, New Jersey

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ABSTRACT. – A checklist of the lichens and allied fungi from Mercer County, New Jersey, is presented. It was derived from inventories of 14 tracts of preserved and undeveloped land, which yielded 905 collections and 174 taxa. These include 37 new records for New Jersey, two of which, *Catinaria neuschildii* and *Strangospora pinicola*, have been rarely reported from North America. It also includes *Agonimia flabelliformis*, which is newly reported for North America from localities throughout the Appalachian and Ozark Mountains. *Catillaria patteeana* is described as new to science as well. These inventories demonstrate that substantial lichen diversity remains undiscovered even in densely populated regions of the Mid-Atlantic characterized by highly fragmented and disturbed natural landscapes with relatively small areas of unaltered, contiguous core-natural habitat.

KEYWORDS. – Biogeography, Coastal Plain, diabase, floristics, Piedmont, rare species, species-richness, symbiosis.

INTRODUCTION

Mercer County is located in central New Jersey, bounded on the west by the Delaware River (Fig. 1). It is home to the New Jersey state capital, Trenton, including the New Jersey State Museum and the New Jersey Geological Survey. Princeton University, the Institute for Advanced Study, Rider University, The College of New Jersey, and Thomas Edison State University are also within its boundaries. Despite this scientific and political infrastructure, and its central location on the New York-Philadelphia corridor, the lichen biota of the county has been poorly documented.

Prior to the present study, 53 lichen specimens from Mercer County were included in the Consortium of North American Lichen Herbaria (CNALH 2018), and all but eight of those belong to the genus *Cladonia*. In addition, prior to the present study the herbarium at the New York Botanical Garden (NY), which houses the largest collection of New Jersey lichens, contained no collections from Mercer County. The paucity of collections from the county is surprising considering that the lichens of New Jersey have been studied for nearly two centuries, including intensive inventories in nearby regions such as the Pine Barrens (Waters & Lendemer in press).

In light of the lack of study that Mercer County lichens had received, the first author was inspired to undertake a large-scale inventory of lichens and allied fungi in the region. To carry out this inventory, he enlisted the help of two major owners of preserved and undeveloped land, the Mercer County Park Commission and the D&R (Delaware & Raritan) Greenway Land Trust, who consented to collections being made on their properties. The collecting sites comprise over 8,000 acres, about 5% of the county land area, and represent habitats in the county that have not been converted to residential or commercial uses. The results of this work are presented here.

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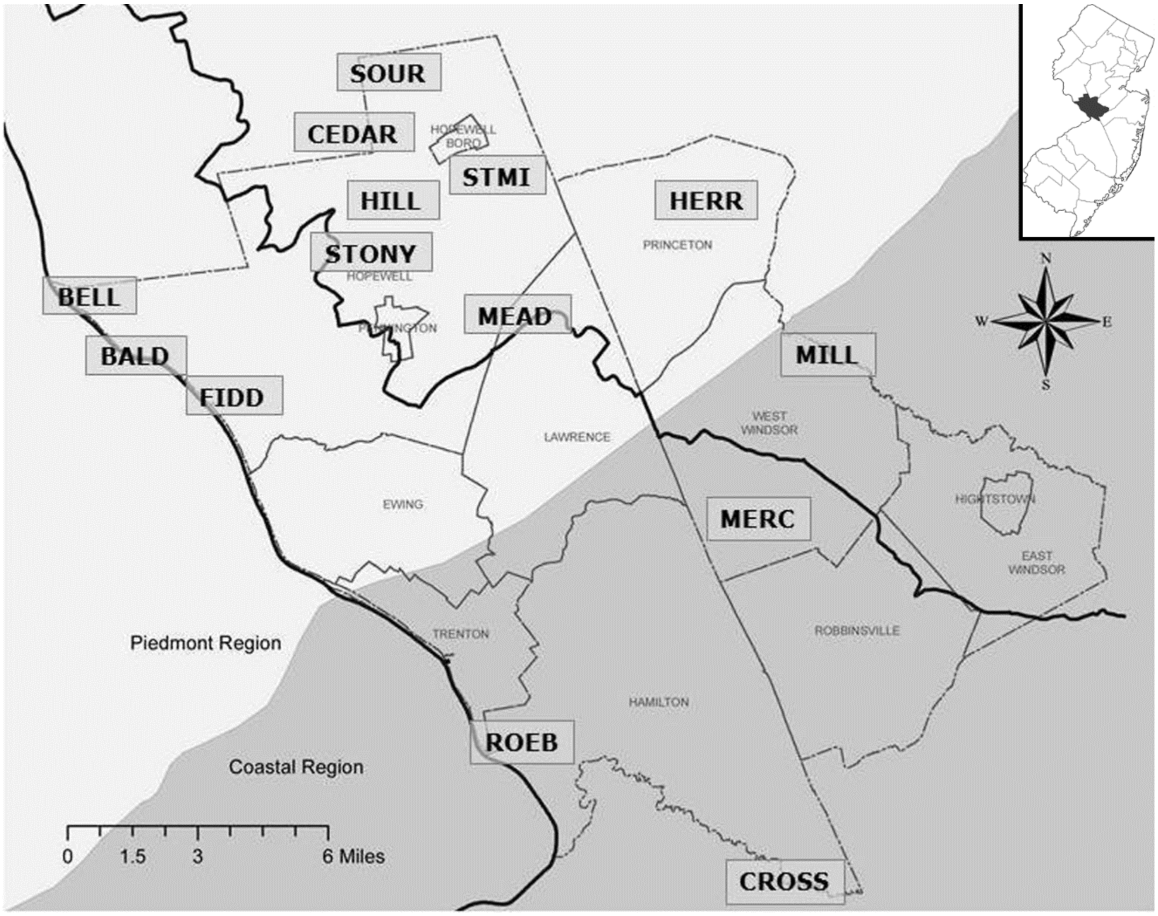

Figure 1. Map of the study area illustrating the general location of Mercer County within New Jersey (inset), physiographic regions (dark shaded area is the Inner Coastal Plain, lighter shading is the Piedmont), collecting sites (see Table 1 for summary of abbreviations), and division between the Raritan Valley (right) and Delaware Valley (left) denoted by a central dark line.

MATERIALS AND METHODS

The Study Area. – Mercer County is just under 59,286 hectares (146,500 acres) in area, with approximately 98% land cover. In 2007, 48% of the land area was classified as urban (Hasse & Lathrop 2010). Physiographically, the county is divided from northwest to southeast by the line separating the Delaware and Raritan River watersheds (Fig. 1). Drainage in the county includes a major tributary of the Delaware River, Assunpink Creek, in the central and southeastern portions, Crosswicks Creek in the far south, Stony Brook and Millstone River, major tributaries of the Raritan River, in the northeast, and several small streams that drain directly into the Delaware River in the northwest. In the 2010 U.S. Census, the population of the county was 366,513, a density of 1,632 persons per square mile.

The county is divided from northeast to southwest by the fall line that separates the Piedmont physiographic province from the Inner Coastal Plain in New Jersey (Widmer 1977). This dividing line roughly follows the US-1 highway northeast from Trenton (Fig. 1). The Inner Coastal Plain is relatively flat, with an elevation of 3–46 meters (10–150 ft.), and is underlain by sands, clays, and gravels (Widmer 1977). It has been extensively farmed since Colonial times, and much of what was farmed is now given over to housing subdivisions and commercial development (Woods et al. 2007, who treated the ecoregion as belonging to the "Middle Atlantic Coastal Plain"). A sliver of land along the Delaware River in the southwestern corner of the county is tidal estuary (Woods et al. 2007, who defined the ecoregion as "Delaware River Terraces and Uplands"). The Inner Coastal Plain constitutes 57% of the county land area (Jablonski 1972).

Compared with the Coastal Plain, the Piedmont is more diverse topographically and geologically, with elevations of 18–64 meters (60–210 ft.). Lower elevations are underlain by Triassic sandstones and shales of the Newark Formation (Jablonski 1972, Widmer 1977). The higher elevations of the lowlands comprise argillite ridges that are about 64 meters (210 ft.) in elevation (Widmer 1977). Wood et al. (2007) defined this ecoregion as the "Triassic Lowlands." The Piedmont uplands comprise diabase intrusions that include the highest point in the county, Baldpate Mountain, at 480 feet (Widmer 1977). This Jurassic diabase is part of the same formation that was studied in Pennsylvania by Lendemer (2005). Wood et al. (2007) define this ecoregion as "Trap Rock Ridges and Palisades" (2007) and it has been extensively quarried. The Piedmont constitutes 43% of the county's land area (Jablonski 1972).

At the turn of the last century, State Geologist John Smock reported that Mercer County had 6,475 hectares (16,000 acres) of forest as of 1899, or 11% of its land area (Vermeule 1900). At that time, Mercer had the second-lowest forest cover percentage of any county in the state. Only the small and urban Hudson County had a lower percentage of forest cover. More recently, forest cover has been estimated at 12,950 hectares (32,000 acres) or 20% of land area (Ferguson & Mayer 1974), and 10,522 hectares (26,000 acres) or 18% of land area (Thompson & Hoffman 2013). However, about one-third of the currently forested area is palustrine wetlands (Tiner 1985).

There are no synoptic studies of forest age in Mercer County, but two Piedmont lowland forest tracts have been studied intensively and shown to contain trees of varying ages (Horn 1975, 1997; Druckenbrod 2017), including individuals that predate the period of minimum forest cover around 1860 (Vermeule 1900). It is likely that Mercer County followed the pattern of northern New Jersey, where extensive deforestation occurred prior to 1850, with subsequent partial recovery (Russell 1980). In this respect, it is similar to nearby Franklin Township in Somerset County, where the few small stands of mature forest that survived the period of deforestation have been supplemented by younger forests that developed as agricultural land was abandoned (White et al. 1990).

Ferguson and Mayer (1974) reported the forests of Mercer County as 98% hardwood, with the 2% exception being the Eastern Redcedar Type, dominated by *Juniperus virginiana*. The hardwood forests are defined as Oak-Chestnut by Braun (1950), Mixed Oak by Robichaud and Anderson (1994), and Appalachian Oak by Dyer (2006). Thus, the bulk of corticolous and lignicolous lichens are found on hardwoods.

Rock substrates for lichens are found primarily in the Piedmont, and are almost entirely absent from the Coastal Plain where they are restricted to stream beds, small pebbles, tombstones and building stones, and artificial substrates such as concrete. Rock substrates in the Piedmont include igneous diabase boulders at the highest elevations and sedimentary argillites, sandstones, and shales at the lowest elevations (Widmer 1977). The latter two rock types are commonly encountered only near stream channels where they have been exposed by erosion. Except for manufactured construction materials, there are no calcareous substrates in Mercer County; all of the rock types are siliceous (Widmer 1977).

Field study. – To establish a baseline, vouchers were collected at each of 14 sites for all taxa encountered. In many cases multiple collections were made of species that were not identifiable in the field. Three sites comprised tracts of over 405 hectares (1,000 acres) each and were sampled as above but at more than one location within the tract. The data from these sites have been aggregated for reporting purposes but the discrete sampling locations are available in the individual collection records through the C.V. Starr Virtual Herbarium at NY (http://sweetgum.nybg.org/science/vh/). At each individual location, the first author carried out an intensive expert-based search for all species, including taxa that appeared to be unknown or unfamiliar. These field methods followed those of other similar surveys elsewhere in temperate eastern North America (e.g., Lendemer et al. 2013, McMullin & Lendemer 2013). Sampling was carried out for 3–4 hours until no additional new taxa were located after twenty minutes of searching.

The 14 inventoried sites are distributed throughout the physiographic subregions of the study area (Table 1, Fig. 1): Piedmont-Delaware Valley ("P-DV"–3 sites), Piedmont-Raritan Valley ("P-RV"–7 sites), Coastal Plain-Delaware Valley ("CP-DV"–3 sites), and Coastal Plain-Raritan Valley ("CP-RV"–1 site). Three of the four subregions include large tracts of preserved and undeveloped land. However, the physiographic region with the smallest land area, the Coastal Plain-Raritan Valley, has been converted largely to residential and commercial development and thus only one collecting site was available there.

Identification and herbarium study. – All specimens were initially studied dry using Zeiss Stemi DV4 (DPW) or Olympus SZ-STB (JCL) dissecting microscopes. Microscopic morphology and anatomy were then studied using Zeiss Primo Star R (DPW) or Olympus BX53 (JCL) compound microscopes, with

Protected Area	Code	Size (ha)	Size (ac)	Total Spp.	Unique Spp.	Spp. / ha	Spp. / ac
Delaware Valley - Piedmont							
Ted Stiles Preserve - Baldpate Mountain	BALD	728	1800	66	14%	0.09	0.04
Belle Mountain	BELL	30	75	47	21%	1.55	0.63
Fiddler's Creek Preserve	FIDD	40	100	26	23%	0.64	0.26
Raritan Valley - Piedmont							
Mercer Meadows	MEAD	647	1600	64	19%	0.10	0.04
Herrontown Woods Arboretum	HERR	57	140	40	10%	0.71	0.29
St Michael's Preserve	STMI	109	270	39	8%	0.36	0.14
Hillman Tract	HILL	28	70	12	0%	0.42	0.17
Sourlands Ecosystem Preserve	SOUR	283	700	50	16%	0.18	0.07
Cedar Ridge Preserve	CEDAR	65	160	33	9%	0.51	0.21
Stony Brook	STONY	18	45	12	8%	0.66	0.27
Delaware Valley - Coastal Plain							
Mercer County Park	MERC	1012	2500	47	19%	0.05	0.02
John A Roebling Memorial Park	ROEB	162	400	25	8%	0.15	0.06
Crosswicks Creek Greenway	CROSS	182	450	43	26%	0.24	0.1
Raritan Valley - Coastal Plain							
Millstone River Preserve	MILL	24	60	27	3%	1.11	0.45

Table 1. Protected areas inventoried in Mercer County as part of the present study, indicating the physiographic subregion, abbreviation used throughout the manuscript (code), protected area size (in hectares and acres), taxonomic diversity (total spp.), number of unique species (unique spp.), and the number of species per hectare (spp./ha) and per acer (spp./ac).

sections prepared by hand with a razor blade and mounted in water or iodine. Chemistry was studied using standard spot tests (C, I, KC, K, P, UV) following Brodo et al. (2001) and supplemented by thin layer chromatography using solvents A and C following Culberson and Kristinsson (1970) but as modified for the peanut butter jar by Lendemer (2011).

Biodiversity dataset assembly and analysis. – Georeferenced specimen data for the specimens collected during this study were downloaded from the C.V. Starr Virtual Herbarium and used to assemble a presence/absence matrix of the lichens collected within each preserve, as well as within each physiographic region and watershed. These data were then used to calculate taxonomic diversity and other diversity metrics (e.g., Sørensen Index) in EstimateS 9.1.0 (Colwell 2013). Lichen traits for photobiont and growth form were scored *de novo* from examination of the specimens. Reproductive mode was also scored in this manner; however, the reproductive modes were assigned based on the dominant mode present (e.g., sorediate lichens were uniformly treated as asexually reproducing, even if an individual thallus produced a small number of apothecia as well).

Results and Discussion

Nine hundred and five collections of lichens and allied fungi were made during this study, representing 174 taxa (see Appendix I), of which 37 (21%) were not previously reported from New Jersey (Waters & Lendemer in press). One of these is reported as new to North America (*Agonimia flabelliformis*, see Appendix III), and one is new to science (*Catillaria patteeana*, see Appendix II). Although this study focused primarily on lichens, the inclusion of allied fungi follows the established tradition in lichenology

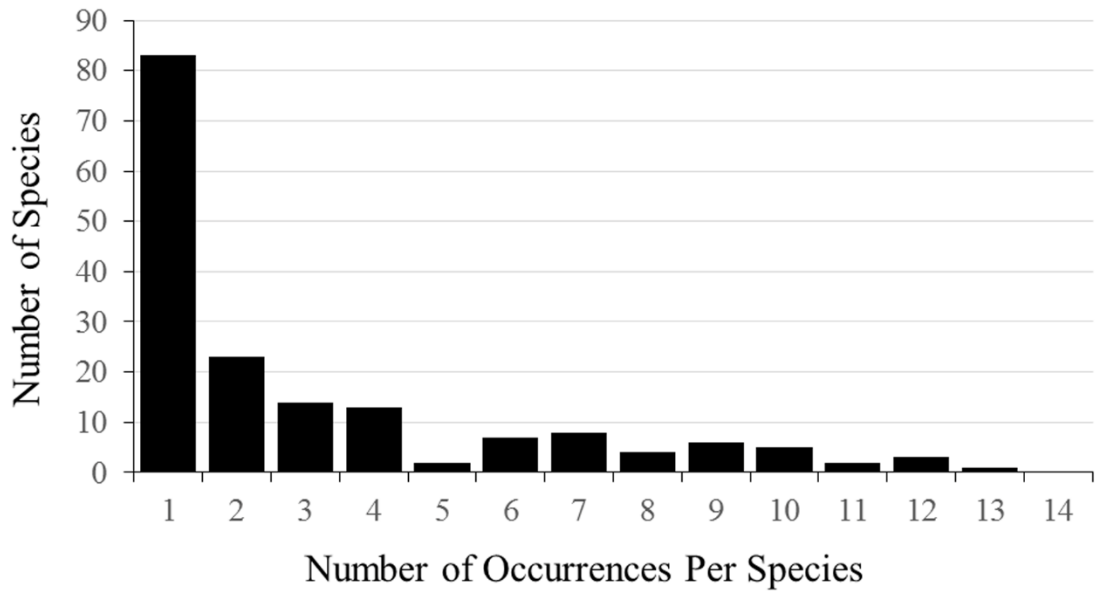

Figure 2. Bar graph summarizing the number of species collected at a given number of sites as part of this study (multiple collections of a species at a given site are treated as a single occurrence for that site).

also treating both lichenicolous fungi, and certain groups of non-lichen fungi that resemble lichens (e.g., Mycocaliciaceae).

Species frequencies in the study area. – Of the 174 taxa documented during the study, 83 (48%) were collected at only a single site, and 106 (61%) were collected at no more than two sites (Fig. 2). For example, of the 23 *Cladonia* taxa, 12 were collected at a single site. In contrast to the large number of species represented by few occurrences, only 11 species (8%) were found at ten or more sites, and no species was found at all of the 14 sites. Other studies in eastern North America have documented similar trends of rarity (Lendemer 2018; Lendemer et al. 2016, 2017). Nonetheless, the proportion of species that apparently are restricted to a single site is striking and may reflect the large amount of habitat fragmentation in Mercer County compared with the aforementioned studies.

The most common taxa in the county, ranked by the total number of sites where they were documented, were: *Pyrrhospora varians* (13 sites), *Flavoparmelia caperata* (12), *Lepraria finkii* (12), *Physcia millegrana* (12), *Amandinea polyspora* (11), *Phaeophyscia rubropulchra* (11), *Candelaria concolor* (10), *Lecanora strobilina* (10), *Punctelia rudecta* (10), *Pyxine subcinerea* (10), and *Ropalospora viridis* (10). With the exception of *L. finkii*, these species were found in all four physiographic regions. The frequency of these species throughout the study area is logical as they are common and widely distributed in the Mid-Atlantic Region of eastern North America (e.g., Brodo et al. 2001, Hinds & Hinds 2007, Lendemer & Noell 2018). The absence of saxicolous lichens from the most frequent taxa likely reflects the scarcity of rock substrates in the Coastal Plain.

New State Records. – More than one in five of the taxa collected in Mercer County are new state records. The most diverse genera in the county are *Cladonia* (23 taxa), *Lepraria* (10), *Parmotrema* (8), and *Lecanora* and *Physcia* (7 each), and they include new state records such as *Lecanora argentata*, *Lepraria oxybapha, L. vouauxii*, *Parmotrema austrosinense, P. perlatum* and *P. submarginale* (Waters & Lendemer in press). New state records also include species with very few North American records in CNALH (*Catinaria neuschildii*, *Strangospora pinicola*) and range extensions for southeastern species (*Gyalideopsis buckii, Parmotrema austrosinense*).

A majority of the new state records are saxicolous taxa, including *Aspicilia caesiocinerea, A. laevata, Flavoparmelia baltimorensis, Halecania pepegospora, Myelochroa obsessa, Rimularia badioatra, Rinodina moziana, R. oxydata, Xanthoparmelia angustiphylla,* and *X. cumberlandia.* That many of these are common elsewhere in the Mid-Atlantic region suggests that little attention has historically been paid to rock

Figure 3. Photograph of maple (*Acer*) trunk at MEAD illustrating thalli of *Evernia* and *Ramalina* suspected of being adventives.

	Physiographic Region									
	Delaware Valley Piedmont		**Raritan Valley Piedmont**		**Delaware Valley Coastal Plain**		**Raritan Valley Coastal Plain**		**Total (All Regions)**	
	Spp.	%	Spp.	%	Spp.	%	Spp.	%	Spp.	%
Trait - Growth Form										
Crustose	54	53%	61	54%	37	51%	18	62%	95	55%
Foliose	31	31%	33	29%	24	33%	11	38%	48	28%
Polymorphic	14	14%	14	12%	10	14%	0	0%	23	13%
Fruticose	1	1%	4	4%	1	1%	0	0%	5	3%
Other	1	1%	2	2%	0	0%	0	0%	2	1%
Trait - Reproduction										
Sexual	51	50%	51	45%	27	38%	13	18%	85	49%
Asexual	35	35%	46	40%	31	43%	13	18%	64	37%
Both	14	14%	14	12%	12	17%	3	4%	21	12%
Trait - Photobiont										
Green algal	96	95%	110	96%	72	100%	29	40%	165	95%
Cyanobacterial	3	3%	2	2%	0	0%	0	0%	4	2%
None	2	2%	2	2%	0	0%	0	0%	4	2%

Table 2. Tabular summary of lichen traits for species assembles within a given physiographic region, and across the total study area.

habitats in New Jersey. In addition, some new state records may have been previously overlooked because they are easily confused with more common species, e.g., *Rimularia badioatra*, *Catillaria nigroclavata*, *Chaenothecopsis debilis*, and *Xanthoparmelia cumberlandia*.

Several collections could not be determined beyond the level of genus. These include *Agonimia*, *Bacidina*, *Myriospora*, and *Verrucaria*, genera that are poorly understood in temperate eastern North America. In addition, several specimens of sterile crustose lichens that produce soredia represent species that have been previously collected in eastern North America but remain undescribed.

Lichens transplanted on nursery stock. – Five of the new state records were collected from recently transplanted nursery stock (*Acer* and *Quercu*s saplings) and are suspected of being adventives (Fig. 3). Four of the suspected adventives (*Evernia prunastri, Ramalina americana, R. farinacea,* and *Xanthoria parietina*) were almost certainly transplanted from further north along the Atlantic Coast in New England where they are presumed to be native (Brodo et al. 2001, Hinds & Hinds 2007). Based on its documented range, the fifth species, *Ramalina culbersoniorum*, was likely transplanted from the southern Appalachian Mountains or southeastern Coastal Plain (Brodo et al. 2001, LaGreca 1999). The role of nurseries in expanding or altering the distribution of lichen species in North America has not been studied in detail. However, *Xanthoria parietina* in particular is suspected to have been reintroduced to southern Ontario via nursery stock (Brodo et al. 2007).

Lichen traits in the study area. – A summary of several major traits that are frequently studied in lichens is provided in Table 2. The most species rich growth was crustose, with 95 species (54% of the total). The polymorphic species were members of the genus *Cladonia*, which is known to produce dimorphic thalli that consist of a primary thallus (crustose or squamulose) and a fruticose secondary thallus (Brodo et al. 2001). There were 48 foliose species (27% of the total), 23 polymorphic species (13%) and five fruticose

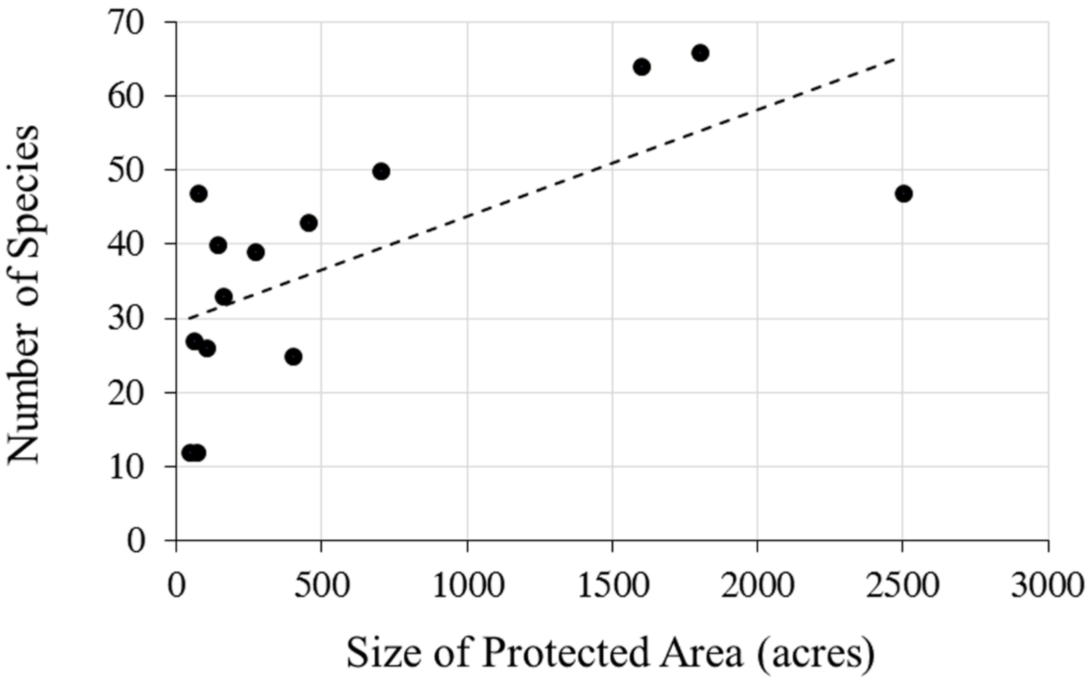

Figure 4. Scatter plot illustrating the relationship between taxonomic diversity (number of species, x-axis) and the size of the protected area (y-axis).

species (3%). The most common reproductive mode was sexual (apothecia and perithecia), with 85 species (49% of the total). There were 62 species (36% of the total) that reproduce asexually using lichenized propagules (e.g., soredia, isidia). Twenty-one species (12%) reproduce both sexually and asexually; these were mostly *Cladonia* species that routinely produce soredia, pycnidia and apothecia (Brodo et al. 2001). The overwhelming majority of species (165 taxa, 95%) have green algal photobionts. Four species (2%) have cyanobacterial partners and another four are allied fungi that are not lichenized.

Cyanolichens in the Study Area. – Lichens that associate with cyanobacteria are generally considered to be sensitive to both air pollution and habitat disturbance (Richardson & Cameron 2004). Despite extensive inventory efforts, we documented only four cyanolichen species in Mercer County: *Collema flaccidum, Leptogium cyanescens*, *L. dactylinum*, and *Peltigera praetextata*. All four species were rare in the study area, and only *L. cyanescens* was found at more than one location. The overall rarity of cyanolichens in Mercer County is similar to other areas with fragmented natural landscapes in temperate eastern North America (e.g., Lendemer & Noell 2018), where *L. cyanescens* in particular is often the only species encountered with any degree of frequency. It is important to highlight that, based on historical records of lichens from elsewhere in New Jersey (Waters & Lendemer in press.), the rarity of cyanolichens in modern times is almost certainly not reflective of the past distribution or abundance of these taxa.

Lichen diversity and communities across physiographic regions and watersheds. – Taxonomic diversity was unevenly distributed in the study area. The four sites with the highest lichen diversity corresponded to the largest protected areas. These are the Ted Stiles Preserve-Baldpate Mountain (66 taxa), Mercer Meadows (64 taxa), Sourland Ecosystem Preserve (50 taxa) and Mercer County Park (47 taxa). Analysis of the relationship between taxonomic diversity and total size of the protected area revealed a strong positive correlation for both total number of lichen species ($p<0.005$*, $r^2=0.46$; Figure 4) and number of species unique to each protected area ($p=0.03$, $r^2=0.33$). Nonetheless, while there was strong support for an overall trend of higher diversity in larger areas, the largest protected area (Mercer County Park, 2500 acres) is ranked fourth in terms of the highest species richness. As is summarized in Table 1, species-rich and species-poor sites occur in both the Piedmont and Coastal Plain.

Despite having both high- and low-diversity sites in the Piedmont and Coastal Plain, total lichen diversity differed strongly between them. Almost twice as many species were collected in the Piedmont (146, 84% of the total) as compared with the Coastal Plain (76, 44% of the total). This disparity is partly because the Coastal Plain lacks rock substrates for saxicolous species and partly because there is less preserved and undeveloped land and intact natural habitat. More than half (97 taxa, 65%) of the assemblage of lichen species in the Piedmont are unique to that region, including all saxicolous species and all cyanolichens. In contrast, nearly a third (24 taxa, 32%) of the species in the Coastal Plain are unique to that region.

While the number of species unique to the Coastal Plain is considerably lower than the Piedmont, the high percentages in both regions highlight that lichen taxa are not uniformly distributed across the landscape. Indeed, while the pooled assemblages of species are similar (pooled Piedmont vs. Coastal Plain, Sørensen = 0.517), the individual sites are on average less similar between the regions (comparisons of Piedmont vs. Coastal Plain sites, average Sørensen 0.396 $\pm$ 0.107 n=40). Interestingly, the Piedmont sites were on average less similar to the overall pooled assemblage of Piedmont sites (average Sørensen 0.452 $\pm$ 0.174 n=10) then the Coastal Plain sites were to the pooled assemblage of Coastal Plain sites (average Sørensen 0.640 $\pm$ 0.120 n=4). Nonetheless, the above must be evaluated in light of the fact that the Piedmont was sampled more intensely than the Coastal Plain due to greater availability of natural habitats and protected areas.

The non-saxicolous taxa unique to the Piedmont include common and widely distributed species such as *Cladonia cylindrica* (3 sites), *C. peziziformis* (4), *C. rei* (3), *Micarea prasina* (3), *Phaeocalicium polyporaeum* (4), *Physciella chloantha* (3), and *Placynthiella icmalea* (3) (Brodo et al. 2001, Hinds & Hinds 2007, Lendemer & Noell 2018). The absence of *Physciella chloantha* from the Coastal Plain is particularly noteworthy give that it occurs on roadside trees in coastal areas of the Mid-Atlantic (Allen & Howe 2016, Lendemer & Noell 2018). It is possible that the species was not detected in the Coastal Plain as part of this study because all of the inventoried sites were located away from roads, and were mostly areas of closed forest. The only unique Coastal Plain species found at more than one site was *Parmotrema hypoleucinum*, a foliose sorediate lichen that is rare in New Jersey and adjacent Long Island but is common further south on the Delmarva Peninsula and north on Cape Cod (Lendemer et al. 2015, Lendemer & Noell 2018).

We also examined species assemblages from the two watersheds that were studied, to provide a comparison of the communities in the two physiographic provinces. Taxonomic diversity was similar between the two, with the Delaware Valley hosting 132 taxa (76% of the total) and the Raritan Valley hosting 117 taxa (68% of the total). Fifty-six taxa (42%) were unique to the Delaware Valley, while 41 (35%) of the taxa in the Raritan Valley were unique to that watershed. Among the taxa unique to the Delaware Valley, only five were found at more than one site, *Caloplaca flavocitrina* (2 sites), *C. subsoluta* (2), *Cladonia cylindrica* (3), *Parmotrema hypoleucinum* (2), and *Rinodina moziana* (2). Among the taxa unique to the Raritan Valley, only seven occur at more than one site, *Agonimia flabelliformis* (2 sites), *Candelariella xanthostigmoides* (2), *Cladonia chlorophaea* (2), *Endococcus propinquus* (2), *Melanelixia subaurifera* (2), *Scoliciosporum umbrinum* (2), and *Myriospora* sp. (2). When compared to the assemblages of sites pooled by physiographic province, the patterns of sites pooled by watershed were remarkably similar, particularly that large numbers of species unique to each watershed were not found at more than one site (51 taxa or 29% of the Delaware Valley assemblage, 33 taxa or 28% of the Raritan Valley assemblage).

Lichens in the Piedmont-Delaware Valley – Three sites located in Hopewell Township were inventoried for this physiographic subregion and they yielded 101 taxa, 30 of which were unique to the region (Table 1). In general, the sites within the Piedmont-Delaware Valley have similar lichen assemblages (average Sørensen 0.505 $\pm$ 0.171 n=6), and the pooled assemblage of species from the subregion represent almost the full complement of species found in the Piedmont (Sørensen 0.979). Unique taxa at more than one site were *Caloplaca flavocitrina*, *C. subsoluta*, *Cladonia cylindrica*, and *Rinodina moziana.*

Of the inventoried sites, two included diabase rock outcrops. One of these, Ted Stiles Preserve-Baldpate Mountain (hereafter BALD), is a diabase sill adjacent to the Delaware River, the highest point in the Mercer County, and the largest tract of upland forest. The other, Belle Mountain (hereafter BELL), is atop a diabase formation in the northwestern corner of the county, adjacent to the Delaware River, and is a former ski area where the south face has been extensively quarried. The third site, Fiddler's Creek Preserve (hereafter FIDD), follows a small stream that flows from the south slope of BALD to the Delaware River, forming a shallow ravine lined by Triassic shales of the Newark Basin (Fig. 5A; Widmer 1977). Although BELL was the smallest protected area inventoried in the Piedmont-Delaware Valley, it hosted the highest density of species (0.63 species/acre) and the largest number of taxa not found at other sites (21%). These

Figure 5. Representative habitats from protected areas in Mercer County, New Jersey. **A,** Triassic shales in and along stream in Piedmont hardwood forest at Fiddler's Creek Preserve (FIDD). **B,** mixed hardwood Coastal Plain forest at Mercer County Park (MERC).

were *Cladonia cryptochlorophaea*, *C. pleurota*, *C. polycarpoides*, *Lecidella enteroleucella*, *Lepraria vouauxii*, *Mycobilimbia berengeriana*, *Parmotrema austrosinense*, *Rimularia badioatra*, and *Xanthoparmelia conspersa*.

Lichens in the Piedmont-Raritan Valley. – Seven areas were inventoried in this physiographic subregion, and these were found to host a total of 114 taxa, 39 unique to the region. Lichen assemblages at sites within the Piedmont-Raritan Valley were found to have lower levels of similarity (average Sørensen 0.319 $\pm$ 0.150 n=21) than among sites in the Piedmont-Delaware Valley. The pooled species assemblage of lichens in the subregion was also less similar to the total Piedmont lichen diversity (Sørensen 0.644). Unique taxa found at more than one site were *Candelariella xanthostigmoides*, *Cladonia chlorophaea*, *Endococcus propinquus*, *Melanelixia subaurifera*, *Scoliciosporum umbrinum*, and *Myriospora* sp.

Four of the protected areas studed included diabase outcrops or boulders. Herrontown Woods Arboretum (hereafter HERR) is a small site on the Princeton Ridge that includes streams, diabase boulder fields, and a mature upland Piedmont forest. Subsequent to this inventory it was acquired by Princeton and is now a municipal park. St. Michael's Preserve (hereafter STMI) includes the northern slope of the diabase Mount Rose, which overlooks the Triassic shales of Bedens Brook and the Hopewell Valley. Hillman Tract (hereafter HILL) is an upland site on the southwest slope of Mount Rose, with diabase and argillite outcrops. Although this site exhibits low species diversity, it was found to host the newly described *Catillaria patteeana*. Sourlands Ecosystem Preserve (hereafter SOUR; Fig. 6B) is located on Sourland Mountain, which forms much of Mercer County's northern border. SOUR comprises upland palustrine forest, diabase boulders, and the headwaters of Stony Brook. The diabase boulders along stream beds at SOUR support a particularly high concentration of infrequently collected taxa, including *Anaptychia palmulata, Cladonia petrophila, Dermatocarpon luridum, Myelochroa obsessa*, *Peltigera praetextata*, *Punctelia missouriensis*, and *Xanthoparmelia angustiphylla*.

Cedar Ridge Preserve (hereafter CEDAR), located on the south slope of Sourland Mountain, contains a large tract of upland hardwood-*Juniperus* forest and hosts nine unusual species including *Agonimia flabelliformis*, reported here as new to North America.

Of the two other areas inventoried in this subregion, Stony Brook (hereafter STONY) comprises two small, spatially proximal floodplain forests with exposed Triassic shales along Stony Brook. Mercer Meadows (hereafter MEAD), one of the largest areas inventoried during this study, is a largely flat site in the Piedmont lowlands, mostly in the Raritan Valley, and consists of former farmland and a decommissioned shortwave transmitting station.

Two Notable Piedmont Habitats. – The Triassic shales of the Newark Basin and the Upland Diabase Forests are two rock habitats of the Piedmont that are inhabited by unique assemblages of lichens. The Triassic shales are outcropped along the channels of Stony Brook (MEAD, STONY), Fiddlers Creek (BALD, FIDD), and Bedens Brook (STMI). These shales occur along stream channels at lower and middle elevations of the Piedmont and are colonized by a distinctive community of pyrenolichens (*Pseudosagedia guentheri, Verrucaria* sp., *Willeya diffractella*), cyanolichens (*Collema flaccidum, Leptogium cyanescens, L. dactylinum*), and other saxicolous crustose taxa such as *Fellhanera fallax*, *F. silicis*, and *Ionaspis alba*.

Upland Diabase Forests are characterized by diabase boulder fields, and this habitat type was sampled at four higher-elevation sites (BALD, BELL, HERR, SOUR). Of the 37 new state records discovered during this study, almost half (19) are from this habitat type. Most of the new records are saxicolous taxa, including *Aspicilia caesiocinerea, A. laevata, Halecania pepegospora, Myelochroa obsessa, Rimularia badioatra, Rinodina moziana, R. oxydata, Xanthoparmelia angustiphylla,* and *X. cumberlandia.* The preponderance of new state records from this habitat suggests that it has rarely been visited by lichenologists.

Lendemer (2005) inventoried the diabase region across the Delaware River in adjacent Pennsylvania, which is geologically interconnected with the Upland Diabase Forests of the Mercer County region (Harper 2013). That study reported 71 species, compared with 108 species from comparable sites in Mercer County. Surprisingly, only 38 species were found to be shared between the two regions and of those, 17 were saxicolous. The saxicolous species shared between the diabase regions of New Jersey and Pennsylvania are: *Acarospora fuscata, Anaptychia palmulata, Caloplaca sideritis, Cladonia petrophila, Dermatocarpon luridum, Fellhanera silicis, Flavoparmelia baltimorensis, Lecidea berengeriana, Leprocaulon adhaerens, Leptogium cyanescens, Myelochroa obsessa, Physcia subtilis, Porpidia albocaerulescens, Rinodina oxydata, Scoliciosporum umbrinum, Trapelia placodioides* and *Xanthoparmelia*

Figure 5. Representative habitats from protected areas in Mercer County, New Jersey. **A,** Coastal Plain stream corridor at Crosswicks Creek Greenway (CROSS). **B,** diabase boulders and outcrops in uplands at Sourlands Ecosystem Preserve (SOUR).

conspersa. One notable difference between the two regions is the genus *Aspicilia*, which is widespread and diverse on diabase boulders in Mercer but was not reported by Lendemer (2005).

Lichens in the Coastal Plain–Delaware Valley. – Three areas were inventoried in this physiographic subregion, and they were found to host 72 species, 23 of which were unique to the subregion. The sites within the Coastal Plain-Delaware Valley have the highest degree of within-subregion similarity (average Sørensen 0.584 $\pm$0.139 n=6) of any subregion studied. Also, much like the Piedmont-Delaware Valley, the pooled species assemblage of the Coastal Plain-Delaware Valley contains almost the entire complement of species found in the Coastal Plain (Sørensen 0.986). The only unique species found at more than one site was *Parmotrema hypoleucinum*.

All of the sites inventoried were typical of Coastal Plain habitats, with a mosaic of upland hardwood forests, lowland swamp forests, and in some cases marshes or wetlands. Mercer County Park (hereafter MERC; Fig. 5B) is a large park centered on Lake Mercer, which was created by damming the Assunpink Creek in the 1970s (Bellard 1974). The south side of the lake has been developed with recreational facilities, including extensive sports fields, but the northern shore contains the largest Coastal Plain forest in the county, much of it Hardwood Swamp Forest (Robichaud & Anderson 1994). Crosswicks Creek Greenway (hereafter CROSS; Fig. 6A) is a linear fringe of floodplain forest adjacent to Crosswicks Creek, which forms part of the southern boundary of the county. CROSS is in a rural location surrounded by farmland. John A. Roebling Memorial Park (hereafter ROEB) is on the Delaware River floodplain and is part of the Abbott Marshlands, with a large area of tidal and non-tidal freshwater wetlands.

The most notable Coastal Plain area in the Delaware Valley subregion is CROSS, which is the farthest southern extension of Mercer County into the Coastal Plain. Of 43 taxa collected at CROSS, 11 (26%) were unique to the site, including several new state records: *Biatora pontica, Catinaria neuschildii, Gyalideopsis buckii, Physciella melanchra,* and *Strangospora pinicola*. This site is worthy of further investigation due to the rarely collected species found there.

Lichens in the Coastal Plain–Raritan Valley. – Due to the paucity of public lands and intact natural habitat in this subregion, only one small site was inventoried and it yielded 29 species, one of which, *Lecanora argentata*, is a new state record, and another, *Agonimia flabelliformis*, is reported as new to North America. Millstone River Preserve (MILL) is in the floodplain of the Millstone River, which forms the northeast border of the county.

Comparison with historical data. – New Jersey was home to several productive lichenologists in the 19th century, such as C.F. Austin, H.A. Green, J.B. Ellis and J.W. Eckfeldt (Waters & Lendemer in press). However, with the exception of one collection attributed to Austin, it appears as though none of them studied the lichens of Mercer County. Prior to the present survey, there were no Mercer County collections at NY, which holds the largest collection of New Jersey lichens. Likewise, the CNALH database contained only 53 specimens from the county, of which seven were 19th century records and 45 were collections, mostly of *Cladonia*, made by W.L. Dix, who was associated with the Academy of Natural Sciences of Philadelphia (PH) beginning in the 1930's.[3] The most recent Mercer County collection in the CNALH database was made in 1953 by B. Long, well over half a century ago. It is interesting to compare this collecting drought with adjacent Burlington County, where more than 1,400 collections have been made since 1953, mostly by the second author (Waters & Lendemer in press).

The first and only published records of Mercer County lichens that we are aware of appeared in A. Evans's second supplement to his *Cladoniae of New Jersey* (Evans 1940; see Appendix IV). These comprised fifteen species, including nine collected by Dix in 1939 as well as thirteen collected by G.G. Nearing. Dix's collecting sites in the county included Hopewell (near STMI), Pennington (near MEAD), Sourland (near SOUR), and the city of Trenton. Nearing's foray into the county brought him to Mount Rose (near STMI,

[3]Although he lived across the Delaware River in Morrisville, Pennsylvania, Dix was employed in Mercer County for 30 years as a teacher and principal in the Trenton school system. His work in lichenology and affiliation with the Academy of Natural Sciences of Philadelphia began following his retirement in 1937 (Trenton *Sunday Times-Advertiser*, January 3rd, 1960). He lived to be 97 (Trenton *Evening Times*, December 28, 1972).

HILL) and Dutch Neck (near MERC). While NY houses many of Nearing's New Jersey collections, his Mercer County *Cladonia* are not among them.

Although a small number of Dix's collections from Mercer County appear to have been published, he continued collecting into the 1940's as he was preparing his *Cladoniae of Pennsylvania* (Dix 1942a). Nonetheless, his Mercer County collections were neither included that work, nor in any subsequent contributions (e.g., Dix 1942b). Equally interesting, and more mysterious, are the choices Dix made while collecting in Mercer County (see Appendix V). Among his 43 Mercer County *Cladonia* collections were nine representatives of *C. grayi*, eight *C. cristatella*, six *C. furcata*, five *C. atlantica*, four *C. rei*, and three *C. peziziformis*. It appears that he made no collections of taxa that we find to be common in modern times, such as *C. macilenta*, *C. ochrochlora*, *C. parasitica*, or *C. ramulosa*.

Given that the aforementioned species are all common and widely distributed in eastern North America (Brodo et al. 2001, Hinds & Hinds 2007), and apparently relatively tolerant of anthropogenic disturbance (e.g., Brodo 1968), they almost certainly were present in the area when Dix would have been collecting there. Why he collected multiple examples of certain species while seemingly ignoring other prominent taxa is unclear. While it is possible that some of Dix's specimens remain undatabased and unrecognized in an herbarium somewhere in North America, the large-scale digitization efforts associated with the CNALH make this fairly unlikely. Dix's collections referenced here are maintained at DUKE.

As part of a survey using lichen indices to assess local climate and air quality status in the Mid-Atlantic, Will-Wolf et al. (2018) published lichen collection data from Mercer County, at one of the sites studied in the present survey, John A. Roebling Park (ROEB). The collections were made in 2004 and determinations followed standards of the U.S. Forest Service Forest Inventory and Analysis Program, which include macrolichens only (Will-Wolf et al 2018, supplement 1). They identified ten species, of which six were also found at that site in the present survey. The four not found at ROEB in the present survey were *Canoparmelia caroliniana*, *Crespoa crozalsiana*, *Phaeophyscia pusilloides*, and *Punctelia caseana*. Of these, three were found elsewhere in the county in the present survey. However, *C. caroliniana* was not found elsewhere in the present survey. It is included and discussed in the checklist below.

The historical records of Mercer County lichens from Evans (1940), the CNALH database, and Will-Wolf et al. (2018) comprise 37 taxa. Of these, 20 were also found in the present survey. Of the remaining 17, 11 were not found in the present survey but have been collected in New Jersey (Waters & Lendemer in press) and have been included in the checklist presented here. The balance are treated as excluded species, mostly either due to historical patterns of misidentification or to lack of recent collections in the state.

CONCLUSION

Mercer County is a populous and developed county traversed by major transportation corridors including the New Jersey Turnpike, Amtrak's Northeast Corridor, Interstate 295, US Highway Route 1, and (historically) the Delaware and Raritan Canal. The present study demonstrates that substantial lichen diversity remains even in densely populated regions of the Mid-Atlantic characterized by highly fragmented and disturbed natural landscapes with relatively small areas of unaltered, contiguous core-natural habitat. Such areas have received little study in the past, compared to regions with large areas of intact natural habitats. Nonetheless, there is increasing recognition that urbanized and industrialized areas can not only host unexpected levels of lichen biodiversity, but also potentially serve as integral refuges and migration corridors as lichens respond to changing climates and environmental conditions (Allen & Howe 2016; Kowarik et al. 2016; McMullin et al. 2014, 2016; Prather et al. 2018).

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APPENDIX I – CHECKLIST OF LICHENS, LICHENICOLOUS AND ALLIED FUNGI FROM MERCER COUNTY, NEW JERSEY

The checklist below is arranged alphabetically by genus and species, and includes abbreviations for the relevant collecting sites following Table 1 (a small number of specimens collected at locations other than those listed in Table 1 are cited using the location abbreviation "OTHER"). Lichenicolous fungi are denoted with an asterisk (*) and non-lichenized species with a plus sign (+). Species known only from historical publications or herbarium records are marked with a dagger (†). New state records were determined as such based on the current checklist of New Jersey lichens (Waters & Lendemer in press) and are listed in bold. Nomenclature generally follows Esslinger (2016) and deviations from that work reflect the taxonomic preferences of the authors. A list of excluded species is appended to the end of the checklist.

Acarospora fuscata (Schrader) Arnold – BALD.

***Agonimia flabelliformis* Halda, Czarnota & Guzow-Krzemińska – CEDAR, MILL.** Initially we considered the possibility that our material was a previously undescribed species characterized by a thallus with coralloid isidia and apparent presence of interascal filaments. However, study of a large number of additional specimens from throughout eastern North America led us to conclude that the material falls within the range of variation of *A. flabelliformis*, which is here reported for the first time from North America (see Appendix III for a description, discussion and micrographs of the species).

Agonimia sp. – HERR, MILL, SOUR. This genus is poorly understood in eastern North America and these collections do not appear to correspond with any described species. They are characterized by their green, areolate thalli, hyaline, muriform ascospores that are 8 per ascus and 33–42 × 20–23 µm in size, and bryicolous habit. The same taxon has been reported from Pennsylvania (Lendemer 2005).

Amandinea milliaria (Tuck.) P. May & Sheard – MERC.

Amandinea polyspora (Willey) E. Lay & P. May – BALD, BELL, CROSS, HERR, MEAD MERC, ROEB, CEDAR, MILL, STMI, STONY.

Anaptychia palmulata (Michaux) Vainio – SOUR.

***Anisomeridium carinthiacum* (J. Steiner) R.C. Harris – BALD.** This species is widespread in temperate eastern North America where it occurs on siliceous and weakly calcareous rocks in riparian corridors (Harris 1995). This species has previously been found in adjacent Pennsylvania (Lendemer in prep.).

Anisomeridium leucochlorum (Müll. Arg.) R.C. Harris – MERC.

Anisomeridium polypori (Ellis & Everh.) M.E. Barr – BALD, CROSS, MEAD, MERC, CEDAR, SOUR.

***Arthonia apatetica* (A. Massal.) Th. Fr. – CROSS, STONY.** This species is infrequent but widespread in temperate eastern North America where it occurs on the bark of trees and shrubs in high humidity habitats, especially near riparian corridors (Lendemer, unpublished data). It has previously been reported from adjacent areas of Pennsylvania (Harris & Lendemer 2005).

***Aspicilia caesiocinerea* (Malbr.) Arnold – BALD, BELL, SOUR.** The taxonomy of *Aspicilia* in eastern North America is poorly understood and the genus has never been the subject of a detailed monographic revision in the region. In eastern North America, *A. caesiocinerea* is generally applied to a species that resembles *A. laevata* in thallus morphology, but which lacks lichen substances (Lendemer 2010). While it is possible that the material is not conspecific with *A. caesiocinerea* in the sense of its type (Rico et al. 2007), further study is needed.

Aspicilia cinerea (L.) Körber – BALD, CEDAR, HERR, SOUR.

***Aspicilia laevata* (Ach.) Arnold – BALD, BELL, HERR, SOUR.** As is the case for *A. caesiocinerea*, the delimitation of *A. laevata* in eastern North America requires further study. In eastern North America, the name is generally applied to thalli with stictic acid. This species has previously been reported from adjacent Pennsylvania (Harris & Lendemer 2005, 2006).

Bacidia coprodes (Körber) Lettau – MEAD.

Bacidia schweinitzii (Fr. ex Tuck.) A. Schneider – CROSS, CEDAR.

Bacidia sorediata Lendemer & R.C. Harris – CROSS.

Bacidina sp. – FIDD, STONY. This genus is poorly understood in eastern North America and the collection cannot be referred to a species at present. The material has a thin, continuous thallus that lacks soredia and blastidia, pale yellow-brown pycnidia, hyaline filiform conidia 17–40 µm long, and pale yellow-brown apothecia with acicular ascospores 30–40 × 1.2–5.0 µm in size.

Biatora longispora (Degel.) Lendemer & Printzen – BALD, SOUR.

***Biatora pontica* Printzen & Tønsberg – CROSS.** This is a sorediate species that is widespread in temperate eastern North America, particularly the Appalachian Mountains (Lendemer 2010, Printzen & Tønsberg 2003). It is uncommon in the Mid-Atlantic Region (Lendemer & Noell 2018).

Biatora printzenii Tønsberg – BALD, CROSS, HERR, MEAD, MERC, CEDAR, MILL, SOUR, STONY.

Buellia curtisii (Tuck.) Imshaug – BELL, MEAD, MERC, CEDAR, HILL, MILL.

Buellia stillingiana J.Steiner – CROSS, MEAD, SOUR, STMI.

Caloplaca flavocitrina (Nyl.) H. Olivier – BALD, BELL.

Caloplaca flavovirescens (Wulfen) Dalla Torre & Sarnth. – MEAD.

Caloplaca sideritis (Tuck.) Zahlbr. – BALD, HILL.

Caloplaca subsoluta (Nyl.) Zahlbr. – BALD, FIDD.

Candelaria concolor (Dickson) Stein – BALD, BELL, CROSS, FIDD, MEAD, MERC, CEDAR, MILL, SOUR, STMI.

Candelariella efflorescens R.C. Harris & W.R. Buck – ROEB, BALD, MEAD, SOUR, STMI.

Candelariella xanthostigmoides (Müll. Arg.) R.W. Rogers – CEDAR, HILL.

† *Canoparmelia caroliniana* (Nyl.) Elix & Hale. Will-Wolf et al. (2018) reported this species from ROEB based on a 2004 collection, with determination made to program standards of the U.S. Forest Service Forest Inventory and Analysis Program (Will-Wolf et al 2018, supplement 1). Although the collection was not available for further study, we are provisionally including the species in the checklist as it has recently been reported from New Jersey, which appears to be the northern limit of its range (Waters & Lendemer in press). The only other large, isidiate, foliose lichen with which it might be confused is the more common *Punctelia rudecta*, which has a different chemistry (lecanoric acid, C+ red medulla) and pseudocyphellae in the upper cortex.

***Catillaria nigroclavata* (Nyl.) Schuler – BALD, SOUR.** This common crustose lichen is widespread in temperate eastern North America where it grows on the bark and branches of tree and shrubs (Hodkinson et al. 2009, Lendemer 2008, McMullin & Lendemer 2016, Seaward et al. 2017). It may be casually overlooked due to the superficial resemblance to *Amandinea polyspora* and *A. punctata*, from which it can readily be distinguished by its 2-celled, hyaline ascospores and hyaline hypothecium.

***Catillaria patteeana* D.P. Waters & Lendemer – HILL.** This species is newly described in Appendix II.

***Catinaria neuschildii* (Körber) P.James – CROSS.** This polysporous crustose species is known from Northern Europe and Scandinavia (Hafellner 1993, James 1965, Suppan & Mayrhofer 2002, Zhdanov 2010). This is only the second published report from North America (Harris & Ladd 2005). It is possible that the species has been overlooked due to a superficial resemblance to some forms of *Pyrrhospora varians*, which can readily be distinguished by the production of xanthones and the presence of simple (vs. 2-celled) ascospores that are 8 per ascus (vs. 16 per ascus).

***Chaenothecopsis debilis* (Turner & Borrer ex Sm.) Tibell – STONY.** This may be the most common and frequently encountered member of *Chaenothecopsis* in eastern North America and is often found on the dry wood of standing snags (Selva 2014). Despite its broad distribution, the species may have been previously overlooked due to its small size in comparison to other calicioid fungi such as *Mycocalicium subtile*.

Chrysothrix caesia (Flotow) Ertz & Tehler – CROSS, MEAD, MERC, ROEB, MILL, STMI.

† *Cladonia apodocarpa* Robbins – W.L. Dix made a single collection of this species in 1940, near Pennington (*Dix s.n.*, DUKE[n.v.]). It has been widely collected in New Jersey (Waters & Lendemer in press).

† *Cladonia atlantica* A. Evans – W.L. Dix collected this species in 1940 and 1942 in Pennington, Hopewell, and Trenton (*Dix 399, 548, s.n.*, DUKE[n.v.]). It has been widely collected in New Jersey and is extremely common in the southern portions of the state (Waters & Lendemer in press).

Cladonia caespiticia (Pers.) Flörke – OTHER (Lawrence Twp.), also collected by G. Nearing in 1939 (Evans 1940).

Cladonia chlorophaea (Flörke ex Sommerf.) Sprengel – CEDAR, MEAD, also collected by W.L. Dix in 1940 (*Dix s.n.*, DUKE[n.v.]).

† *Cladonia conista* (Nyl.) Robbins – G. Nearing collected this species near Dutch Neck (Evans 1940). It has previously been collected in New Jersey (Waters & Lendemer in press).

Cladonia cristatella Tuck. – BALD, MEAD, ROEB, also collected by W.L. Dix in 1940, 1944 (*Dix s.n.*, DUKE[n.v.]) and by B. Long in 1953 (*Long s.n.*, PH[n.v.]).

Cladonia cryptochlorophaea Asahini – BELL.

Cladonia cylindrica (A. Evans) A. Evans – BALD, BELL, FIDD.

Cladonia didyma var. *didyma* (Fée) Vainio – HERR.
Cladonia dimorphoclada Robbins – STMI. See note under *C. subtenuis* below.
Cladonia furcata (Hudson) Schrader – STMI, also collected by W.L. Dix in 1939, 1940 (*Dix 10, 147, 149, 271, s.n.*, DUKE[n.v.]). See note under *C. subtenuis* below.
Cladonia grayi G. Merr. ex Sandst. – BELL, CROSS, HERR, MEAD, MERC, CEDAR, STMI, also collected by Dix in 1939, 1940, 1944, 1948 (*Dix 145, 146, 229, 269, 270, s.n.*, DUKE[n.v.]).
Cladonia incrassata Flörke – MERC.
Cladonia macilenta var. *bacillaris* (Ach.) Schaerer – BALD, BELL, MEAD, MERC, ROEB, also collected by E. Leue in 1874 (as *C. macilenta*) (*Leue s.n.*, OS[n.v.]).
Cladonia macilenta var. *macilenta* Hoffm. – MERC.
Cladonia ochrochlora Flörke – BALD, HERR, MEAD, MERC, ROEB, CEDAR, HILL, SOUR, STMI.
Cladonia parasitica (Hoffm.) Hoffm. – BALD, HERR, MERC, STMI.
Cladonia petrophila R.C. Harris – SOUR.
Cladonia peziziformis (With.) J.R. Laundon – BELL, HERR, MEAD, CEDAR, also collected by W.L. Dix in 1939, 1940 (*Dix 152, s.n.*, DUKE[n.v.]).
† *Cladonia piedmontensis* G.Merr. – W.L. Dix made a single collection of this species in 1942 in Pennington (*Dix 1061*, DUKE[n.v.]). It has been reported from New Jersey, but there are no recent collections (Waters & Lendemer in press).
Cladonia pleurota (Flörke) Schaerer – BELL.
Cladonia polycarpoides Nyl. – BELL.
Cladonia ramulosa (With.) J.R. Laundon – BALD, HERR, MEAD, MERC, ROEB, CEDAR, SOUR, STMI.
† *Cladonia rangiferina* (L.) F.H. Wigg. – A.C.V. Schott made a single collection of this species in 1851 at Rocky Hill (Princeton) (*Schott s.n.*, F[n.v.]). It has been previously collected in New Jersey (Waters & Lendemer in press).
Cladonia rappii A. Evans – OTHER (Lawrence Twp).
Cladonia rei Schaerer – MEAD, CEDAR, also collected by W.L. Dix 1939, 1940 (*Dix 226, 540, 542, s.n.*, DUKE[n.v.]).
Cladonia sobolescens Vainio – MERC.
† *Cladonia squamosa* (Scop.) Hoffm. – G. Nearing collected this species near Dutch Neck and W.L. Dix collected it on Sourland Mountain (Evans 1940). It has been previously collected in New Jersey (Waters & Lendemer in press).
† *Cladonia submitis* A. Evans – W.L. Dix made a single collection of this species (as *Cladina submitis*) in 1946 at Strawberry Hill, Titusville (BALD in this survey) (*Dix 1460*, DUKE[n.v.]). It has been previously collected in New Jersey (Waters & Lendemer in press).
Cladonia subtenuis (Abbayes) Mattick – HERR, MERC, STMI. The only significant *Cladonia* mat found in Mercer County is at STMI. It is about 1 acre in size and comprises primarily *C. subtenuis and C. furcata,* with some *C. dimorphoclada.* About 10% of the area is covered with lichens, mostly growing among bryophytes.
† *Cladonia verticillata* (Hoffm.) Schaerer – G. Nearing collected this species near Mount Rose (Evans 1940) and W.L. Dix made a single collection of this species in Pennington in 1941 (*Dix 706*, DUKE[n.v.]). It has been previously collected in New Jersey (Waters & Lendemer in press).
Coenogonium pineti (Ach.) Lücking & Lumbsch – MEAD, OTHER (Lawrence Twp).
Collema flaccidum (Ach.) Ach. – FIDD.
Crespoa crozalsiana (B.de Lesd. ex Harm.) Lendemer & Hodkinson – MEAD. This is primarily a southeastern species in North America and Mercer County is at the northern edge of its range (Brodo et al. 2001). Nonetheless, it is also easily overlooked due to its superficial resemblance to *Myelochroa aurulenta*, which is much more common and differs noticeably in lacking stictic acid in the medulla (P- vs. P+ orange in *C. crozalsiana*) and in having a smooth upper surface (vs. wrinkled and scrobiculate in *C. crozalsiana*) (Brodo et al. 2001, Hale 1976). Will-Wolf et al. (2018) reported a collection of this species made at ROEB in 2004.
Dermatocarpon luridum (With.) J.R. Laundon – FIDD, SOUR.
Diploschistes muscorum (Scop.) R. Sant. – BALD.
*** *Endococcus propinquus* (Körber) D. Hawksw. – HERR, SOUR.** This is a common lichenicolous fungus that infects thalli of *Porpidia albocaerulescens* (Hawksworth 1979, Ihlen & Wedin 2008). It has previously been reported from adjacent Pennsylvania (Harris & Lendemer 2005).

***Evernia prunastri* (L.) Ach. – MEAD.** In North America this species is distributed primarily in humid, coastal areas with an oceanic climate (Brodo et al. 2001). Scattered occurrences are known from coastal areas of Connecticut northward toward the Canadian Maritime provinces where it is common (Hinds & Hinds 2007). In Mercer County, it was collected on recently planted nursery stock and is suspected of being an adventive.

Fellhanera fallax R.C. Harris & Lendemer – FIDD.

***Fellhanera silicis* R.C. Harris & Ladd – BALD, CEDAR, STMI.** This crustose lichen is widespread on siliceous rocks throughout much of temperate eastern North America (Harris & Lendemer 2009). Although it is not the most common member of the genus in most areas of the Appalachians (Lendemer, unpublished data), the species appears to be locally common in Mercer County.

***Flavoparmelia baltimorensis* (Gyelnik & Fóriss) Hale – BALD, BELL, SOUR.** In our opinion, it is nothing short of remarkable that this species has not previously been reported from New Jersey. *Flavoparmelia baltimorensis* is a very common foliose lichen that grows on acidic rocks throughout much of eastern North America, and can easily be recognized by its coarsely pustulose thallus (Brodo et al. 2001, Hale 1976, Hinds & Hinds 2007). Confusion with the ubiquitous *F. caperata* frequently occurs when that species grows on rocks, especially when small or immature thalli are involved. However, that species can be distinguished by having soredia rather than coarse pustules (Brodo et al. 2001).

Flavoparmelia caperata (L.) Hale – BALD, BELL, CROSS, FIDD, HERR, MEAD, MERC, ROEB, CEDAR, MILL, SOUR, STMI.

Graphis scripta (L.) Ach. – BALD, CROSS, MEAD, SOUR. In Mercer County this species is most commonly found on bark of *Carpinus* in riparian corridors.

***Gyalideopsis buckii* Lücking, Sérus. & Vězda – CROSS.** This species is primarily distributed in the southeastern United States and appears to be near the northern edge of its range in Mercer County (Lendemer 2017a, Lücking et al. 2007). This is a somewhat surprising discovery and a noteworthy range extension.

***Halecania pepegospora* (H. Magn.) van den Boom – BALD.** This species was originally described from Connecticut (Hale 1950) but was little discussed in modern times until it was discovered to be common and abundant in Pennsylvania (Lendemer 2008). Subsequent study has shown it to be common and widespread throughout the Appalachian Mountains on sun-exposed siliceous rocks (Lendemer 2008, Lendemer et al. 2013, Seaward et al. 2017). In the past it was likely overlooked because cursory examination would lead one to think that the thallus was a non-lichenized sterile black fungus (e.g., *Lichenothelia)*, rather than a crustose lichen with abundant black, granular blastidia.

Heterodermia obscurata (Nyl.) Trevisan – MEAD.

Heterodermia speciosa (Wulfen) Trevisan – HERR.

Hypotrachyna horrescens (Taylor) Krog & Swinscow – MERC.

Hypotrachyna minarum (Vainio) Krog & Swinscow – MEAD.

Hypotrachyna showmanii Hale – MERC.

Ionaspis alba Lutzoni – FIDD, MEAD, STONY.

+ *Julella fallaciosa* (Arnold) R.C. Harris – FIDD.

Lecania croatica (Zahlbr.) Kotlov – BALD, CROSS, HERR, MEAD, MILL, STMI, STONY.

Lecanora appalachensis Lendemer & R.C. Harris – CROSS.

***Lecanora argentata* (Ach.) Malme – MILL.** This species is rare but widely distributed in temperate eastern North America where *L. chlarotera* Nyl. and *L. hybocarpa* are the most frequently encountered taxa (Brodo 1984).

Lecanora caperatica O. Asher & Lendemer **–** MEAD, MERC. This typically sterile, sorediate species containing caperatic acid was recently described (Asher & Lendemer 2018). It was found to be widely distributed in eastern North America, particularly in the Mid-Atlantic.

Lecanora hybocarpa (Tuck.) Brodo – BALD, BELL, MEAD, MERC, CEDAR, MILL, SOUR, STMI.

Lecanora layana Lendemer – CROSS, HERR, MEAD, ROEB, CEDAR, MILL, STONY.

Lecanora nothocaesiella R.C. Harris & Lendemer – CEDAR.

Lecanora strobilina (Sprengel) Kieffer – BALD, BELL, CROSS, FIDD, MEAD, MERC, CEDAR, MILL, SOUR, STMI.

Lecanora subpallens Zahlbr. – BALD, MEAD, MERC, OTHER (Hamilton Twp).

Lecanora thysanophora R.C. Harris – MEAD.

Lecidea cyrtidia Tuck. – STMI.

***Lecidella enteroleucella* (Nyl.) Hertel – BELL.** This species is infrequent but widely distributed throughout southeastern North America and has previously been reported from Pennsylvania (Knoph & Leuckert 1994). This is the first report for New Jersey and the record appears to be near the northern edge of the range for the species.

Leimonis erratica (Körber) R.C. Harris & Lendemer – MEAD.

Lepra pustulata (Brodo & W. Culb.) Lendemer & R.C. Harris – BALD.

Lepraria caesiella R.C. Harris – BALD, HERR, MEAD, ROEB, CEDAR, SOUR, STMI.

Lepraria finkii (B. deLesd.) R.C. Harris – BALD, BELL, CROSS, FIDD, HERR, MEAD, ROEB, CEDAR, HILL, SOUR, STMI, STONY.

Lepraria harrisiana Lendemer – CROSS, HERR, MEAD, MERC, ROEB, MILL, SOUR.

Lepraria hodkinsoniana Lendemer – BALD, MILL, SOUR, STMI.

Lepraria neglecta (Nyl.) Erichsen – BALD (alectorialic acid chemotype), SOUR (psoromic acid chemotype).

Lepraria normandinoides Lendemer & R.C. Harris – SOUR, STMI; protocetraric acid chemotype: BELL, MEAD.

***Lepraria oxybapha* Lendemer – HERR.** This species was separated from *L. normandinoides* by Lendemer (2012), differing in the production of fumarprotocetraric acid instead of protocetraric acid. Although both species are common and widespread in eastern North America (Lendemer 2013), this is the first report from New Jersey.

***Lepraria vouauxii* (Hue) R.C. Harris – BELL.** – This species is relatively infrequent, but widely distributed, in eastern North America (Lendemer 2013).

***Leprocaulon adhaerens* (K.Knudsen, Elix & Lendemer) Lendemer & Hodkinson – BALD, CROSS, HERR, HILL, MILL, SOUR.** – Knudsen et al. (2007) described this species from scattered locations in the United States and it has been reported from many areas of temperate eastern North America (Hodkinson et al. 2009, Lendemer 2017b, Lendemer et al. 2013, Seward et al. 2017), including Pennsylvania (Knudsen et al. 2007).

Leptogium cyanescens (Rabenh.) Körber – FIDD, HERR, STMI.

Leptogium dactylinum Tuck. – FIDD.

+ *Leptorhaphis epidermidis* (Ach.) Th. Fr. – MERC. This species is primarily distributed in northeastern North America and the Great Lakes (Harris 1973), where it typically occurs on the bark of white birch. Mercer County appears to be the southern edge of its range.

† *Lobaria pulmonaria* (L.) Hoffm. – E. Leue made a single collection of this species (identified as "*Sticta pulmonarea*") in Princeton in approximately 1874 (*Leue s.n.*, OS[n.v.]). It has previously been reported from New Jersey based on historical collections, but no recent occurrences are known (Waters & Lendemer in press).

Melanelixia subaurifera (Nyl.) O. Blanco et al. – MEAD. DW also observed this species at SOUR but did not collect it as the thallus was very small.

Micarea melaena (Nyl.) Hedl. – BALD.

Micarea prasina Fr. – BELL, SOUR, STONY; ramulose morphotype: HERR.

Mycobilimbia berengeriana (A. Massal.) Hafellner & V. Wirth – BELL.

Myelochroa aurulenta (Tuck.) Elix & Hale – BALD, CROSS, HERR, MEAD, MERC, ROEB, CEDAR, SOUR.

***Myelochroa obsessa* (Ach.) Elix & Hale – SOUR.** This is a very common and widely distributed macrolichen that grows on siliceous rocks in eastern North America (Brodo et al. 2001). It is known from adjacent Pennsylvania (Harris & Lendemer 2005, Lendemer 2005).

Myriolecis dispersa (Pers.) Śliwa, Zhao Xin & Lumbsch – BELL, OTHER (Trenton City).

Nadvornikia sorediata R.C. Harris – CROSS.

Ochrolechia arborea (Kreyer) Almb. – CEDAR.

Parmelia sulcata Taylor – BALD, BELL, CROSS, MEAD, MERC, ROEB, CEDAR, MILL, STMI.

***Parmotrema austrosinense* (Zahlbr.) Hale – BELL.** This species was mapped by Brodo et al. (2001) as having a disjunct distribution in southeastern North America, with a core range from Texas to Mississippi and a small population in the southern Appalachian Mountains. The occurrence of the species in central New Jersey is unusual, but we are hesitant to consider it an introduced species given that it was not found on planted nursery stock, and was independently collected in adjacent Middlesex County (*Lendemer 51290*, NY!).

Parmotrema gardneri (C.W. Dodge) Sérus. – BALD, HERR, MEAD, MERC, CEDAR.

Parmotrema hypoleucinum (J. Steiner) Hale – MERC, ROEB.

Parmotrema hypotropum (Nyl.) Hale – BALD, CROSS, FIDD, MEAD, MERC, ROEB, CEDAR, MILL, STMI.

Parmotrema perlatum **(Hudson) M. Choisy – MERC.** This species has an Appalachian-Great Lakes distribution in eastern North America (Brodo et al. 2001) and is widespread in New England (Hinds & Hinds 2007).

Parmotrema reticulatum (Taylor) M. Choisy – BALD, BELL, MEAD, MERC, ROEB.

Parmotrema subisidiosum (Müll. Arg.) Hale – BALD, CROSS, MEAD, MERC, HILL, STMI.

Parmotrema submarginale **(Michx.) DePriest & B. Hale – BALD.** This species is common and widely distributed in southeastern North America, with a distribution that extends north in the Coastal Plain to Massachusetts (Brodo et al. 2001). Somewhat surprisingly, despite the extensive collecting in southern New Jersey, this is the first report for the state.

Peltigera praetextata (Flörke ex Sommerf.) Zopf – SOUR.

Pertusaria paratuberculifera Dibben – ROEB.

Pertusaria pustulata (Ach.) Duby – BELL, CROSS, MEAD, MERC, ROEB, HILL, MILL, SOUR, STMI.

+ *Phaeocalicium polyporaeum* (Nyl.) Tibell – BALD, BELL, MEAD, STMI.

Phaeophyscia adiastola (Essl.) Essl. – BALD, BELL, CROSS, FIDD, HERR, MEAD, MERC, MILL, SOUR.

Phaeophyscia pusilloides (Zahlbr.) Essl. – BALD, BELL, CROSS, HERR, MEAD, MERC, SOUR, STMI. This species is very common and widespread in temperate eastern North America (Brodo et al. 2001, Esslinger 1978, Hinds & Hinds 2007). Will-Wolf et al. (2018) reported a collection made at ROEB in 2004.

Phaeophyscia rubropulchra (Degel.) Essl. – BALD, BELL, CROSS, FIDD, HERR, MEAD, ROEB, CEDAR, MILL, STMI.

Physcia adscendens (Fr.) H. Olivier – MEAD.

Physcia americana G. Merr. – CROSS.

Physcia millegrana Degel. – BALD, BELL, CROSS, FIDD, HERR, MEAD, MERC, ROEB, CEDAR, MILL, SOUR, STMI.

Physcia pumilior R.C. Harris – BELL, CROSS, MERC, MILL.

Physcia stellaris (L.) Nyl. – BALD, BELL, CROSS, MEAD, MERC, MILL, SOUR, STMI.

Physcia subtilis Degel. – BALD.

Physcia thomsoniana Essl. – BALD, HERR.

Physciella chloantha (Ach.) Essl. – BELL, MEAD, STMI.

Physciella melanchra **(Hue) Essl. – CROSS.** This species is widely distributed in North America, but is relatively rare in the temperate eastern United States where it is known from scattered occurrences (e.g., Esslinger 1986, LaGreca et al. 2005, Seaward et al. 2017).

Physconia leucoleiptes (Tuck.) Essl. – BELL.

Placynthiella dasaea (Stirton) Tønsberg – SOUR.

Placynthiella icmalea (Ach.) Coppins & P. James – BALD, HERR, MEAD.

Porpidia albocaerulescens (Wulfen) Hertel & Knoph – BALD, BELL, FIDD, HERR, CEDAR, SOUR. This is the most common saxicolous species in the county. Thallus color is variable, ranging from light brown to light gray (Lendemer 2005).

Pseudosagedia cestrensis (Tuck. ex E. Michener) R.C. Harris – CROSS, STONY.

Pseudosagedia guentheri **(Flotow) Hafellner & Kalb – FIDD.** This species is widely distributed in the Appalachian Mountains (Harris 1995, Hodkinson et al. 2009, Lendemer et al. 2013, Seaward et al. 2017) and is known from Pennsylvania (Lendemer 2010).

Psilolechia lucida **(Ach.) M. Choisy – CEDAR.** This species is common and widely distributed in the Appalachian Mountains and Great Lakes Region (Brodo et al. 2001), including Pennsylvania (e.g., Harris & Lendemer 2005).

Punctelia caseana Lendemer & Hodkinson – BALD, CROSS, HERR, MEAD, MERC, CEDAR, STMI. Will-Wolf et al. (2018) reported a collection of this species made at ROEB in 2004.

Punctelia missouriensis **G. Wilh. & Ladd – SOUR.** This species is widespread in temperate eastern North America (Hodkinson et al. 2009, Lendemer et al. 2013, Wilhelm & Ladd 1992) but relatively uncommon in the Mid-Atlantic (Lendemer, unpublished data).

Punctelia rudecta (Ach.) Krog – BALD, BELL, CROSS, FIDD, HERR, MERC, ROEB, CEDAR, MILL, STMI.

† *Pycnothelia papillaria* Dufour – W.L. Dix made a single collection of this species (as *Cladonia papillaria* f. *prolifera*) in Woodsville (Hopewell Township) in 1940 (*Dix 267*, DUKE[n.v.]). It has been widely collected in New Jersey (Waters & Lendemer in press).

Pyrrhospora varians (Ach.) R.C. Harris – BALD, BELL, CROSS, FIDD, HERR, MEAD, MERC, ROEB, CEDAR, MILL, SOUR, STMI, STONY.

Pyxine subcinerea Stirton – BALD, BELL, CROSS, FIDD, MEAD, MERC, HILL, MILL, SOUR, STONY.

***Ramalina americana* Hale – MEAD.** – Although this species was once widespread in parts of northeastern North America (Brodo et al. 2001), it appears to have been extirpated from many areas in modern times (Lendemer & Noell 2018). It was collected on recently planted nursery stock and is suspected to be an adventive.

***Ramalina culbersoniorum* LaGreca – OTHER (Lawrence Twp).** – This taxon is very common and widespread throughout southeastern North America (Brodo et al. 2001, LaGreca 1999) and was not previously known from New Jersey (Waters & Lendemer in press). It was collected on recently planted nursery stock and is suspected to be an adventive.

***Ramalina farinacea* (L.) Ach. – MEAD.** – In eastern North America this is a species of coastal New England (Brodo et al. 2001, Hinds & Hinds 2007). It was collected on recently planted nursery stock and is suspected to be an adventive.

***Rimularia badioatra* (Kremp.) Hertel & Rambold – BELL.** – The small, brown, areolate thallus and immersed apothecia of *R. badioatra* almost certainly led it to be overlooked in the past, particularly given its tendency to resemble poorly developed thalli of other common saxicolous lichens, such as *Acarospora fuscata* and *Rinodina tephraspis*. It was reported from the Delaware Water Gap in Pennsylvania (Harris & Lendemer 2005, 2006), and seems to be widespread in eastern North America.

Rinodina maculans Müll. Arg. – MEAD, MERC, HILL, MILL.

***Rinodina moziana* (Nyl.) Zahlbr. (syn. *R. destituta* (Nyl.) Zahlbr., *fide* Sheard 2018) – BALD, BELL.** – This species is widespread on siliceous rocks in temperate eastern North America (Lendemer et al. 2014, Sheard 2010) and its occurrence in New Jersey is not unexpected. The species can be separated from *R. oxydata* by its larger ascospores and thicker, areolate thallus (Sheard 2010).

***Rinodina oxydata* (A. Massal.) A. Massal. – BELL, FIDD, STMI.** – This species is widespread on siliceous rocks in temperate eastern North America (Lendemer et al. 2014, Sheard 2010) and its occurrence in New Jersey is not unexpected. The species can be separated from *R. moziana* by its smaller ascospores and thin, rimose to rimose-areolate thallus (Sheard 2010).

Ropalospora viridis (Tønsberg) Tønsberg – BALD, BELL, HERR, MEAD, MERC, ROEB, CEDAR, MILL, SOUR, STMI.

Scoliciosporum chlorococcum (Stenh.) Vězda – ROEB.

Scoliciosporum umbrinum (Ach.) Arnold – HERR, SOUR.

Segestria leptalea (Durieu & Mont.) R.C. Harris – BALD, MILL.

Myriospora sp. – HERR, SOUR. This genus is poorly understood in eastern North America. Both collections were made on diabase boulders.

Sterile sorediate crust 1 – MEAD, SOUR, MILL. – This is a corticolous sorediate crustose lichen that produces usnic acid and zeorin. It is widespread in northeastern North America and almost certainly belongs to the genus *Lecanora*.

Sterile sorediate crust 2 – HERR, STMI. – This is a sorediate crustose lichen that lacks secondary compounds and is easily recognized by its thin, continuous thallus with small soralia and bright green soredia, and a conspicuous white fibrous prothallus. It is widespread throughout temperate eastern North America and grows on strongly to weakly calcareous rocks in habitats associated with water.

***Strangospora pinicola* (A.Massal.) Körber – CROSS.** This polysporous crustose species is known from northern Europe and Scandinavia but has rarely been collected in North America (e.g., Wong & Brodo 1990). This is its first report from New Jersey and from the Atlantic Coastal Plain.

Trapelia placodioides Coppins & P. James – BALD, HERR, MEAD, SOUR.

Trapeliopsis flexuosa (Fr.) Coppins & P. James – BALD, SOUR.

Trypethelium virens Tuck. ex E. Michener – CROSS.

Usnea sp. – MEAD, MERC. No fertile collections of this genus have been made in Mercer County. These are probably *Usnea strigosa* (Ach.) Eaton, but the specimens are small and lack the characters needed for determination.

Verrucaria sp. 1 – FIDD. – This species was found growing on concrete and is characterized by a thin, gray thallus, perithecia that lack an involucrellum, an exciple that is laterally carbonized, and ascospores that are 18-20 × 7-9 µm.

Verrucaria sp. 2 – FIDD, HILL. – This species was found growing on weakly calcareous shales associated with streams. It is characterized by a thin, green thallus, perithecia that lack an involucrellum, an exciple that is laterally carbonized, and ascospores that are 16-20 × 6-8 µm.

Verrucaria sp. 3 – FIDD, STMI. – This species was found growing on weakly calcareous shales associated with streams. It is characterized by a thin, green thallus, perithecia that lack an involucrellum, an exciple that is laterally carbonized, and ascospores that are 25-30 × 8-12 µm.

Verrucaria sp. 4 – FIDD. – This species was found on shale associated with a seep. It is characterized by a densely blastidiate, areolate thallus. Several sterile perithecia were present on the single collection that was made; however, all lacked asci and ascospores.

Willeya diffractella (Nyl.) Müll. Arg. – FIDD.

***Xanthoparmelia angustiphylla* (Gyelnik) Hale – SOUR.** This species is widespread in temperate eastern North America but known from relatively scattered locations (Hale 1990). It has been reported from eastern Pennsylvania (Harris & Lendemer 2005, 2006). The species can be distinguished from other members of the genus in the region by its black lower surface, absence of isidia, and the production of stictic acid in the medulla, usually together with menegazziaic acid (Hale 1990).

Xanthoparmelia conspersa (Ehrh. ex Ach.) Hale – BELL.

***Xanthoparmelia cumberlandia* (Gyelnik) Hale – BALD.** This species is widespread in temperate eastern North America (Hale 1955, 1990) but has been rarely collected in New Jersey and eastern Pennsylvania (Harris & Lendemer 2005; Lendemer & Macklin 2006a, b; Lendemer & Waters in press.). It can be distinguished from other, more common *Xanthoparmelia* species, by the brown lower surface, absence of isidia, and production of stictic acid in the medulla (Hale 1990, Hinds & Hinds 2007).

Xanthoparmelia plittii (Gyelnik) Hale – BALD, HERR, MERC, SOUR.

Xanthoria parietina (L.) Th. Fr. – MEAD. In eastern North America, this is a species of coastal New England (Hinds & Hinds 2007, Lindblom 1997). In Mercer County, it was collected on recently planted nursery stock and is suspected of being an adventive. Elsewhere in North America, *X. parietina* has become established in areas where it did not previously occur (Brodo et al. 2007) and sites where the species has been introduced should be monitored to document population trends.

Excluded Species

Cladonia subcariosa Nyl. – W.L. Dix made a single collection he identified as this species at Washington Crossing, Hopewell Township, in 1940 (*Dix 268*, DUKE[n.v.]). As is outlined by Waters & Lendemer (in press), this name was widely misapplied in the past to different members of the *C. subcariosa* group, with the majority of New Jersey species corresponding to *C. polycarpoides*.

Cladonia subcariosa f. *ramosa* Dix – W.L. Dix made a single collection he identified as this intraspecific taxon at Washington Crossing, Hopewell Township, in 1942 (*Dix D-1097*, US[n.v.]). The specimen was subsequently determined to correspond to *C. polycarpoides* (T. Ahti, annotation 2000).

Peltigera canina (L.) Willd. – W.L. Dix made a single collection he identified as this taxon on Sourland Mountain (in or near SOUR in this survey) in 1948 (*Dix s.n.*, DUKE[n.v.]). The record almost certainly refers to *P. praetextata* as the majority of historical reports of *P. canina* refer to other species (Waters & Lendemer in press).

Peltigera rufescens (Weiss) Humb. – J.E. Peters made a single collection of this species in 1887 near Princeton (*Peters s.n.*, PH[n.v.]). It has been reported from New Jersey, but there are no recent collections (Waters & Lendemer in press).

Psorula rufonigra (Tuck.) Gotth. Schneider – This species was collected in 1850 (as *Biatora rufonigra*), possibly by C.F. Austin, on “rocks along Stony Brook” (*Austin s.n.*, FH[n.v.]) It has been reported from New Jersey, but there are no recent collections (Waters & Lendemer in press). We exclude the species here because we have not examined the original specimen at FH.

Stereocaulon paschale (L.) Hoffm. – W.L. Dix made a collection in 1939 on Sourland Mountain (in or near SOUR in this survey) “on rock” that he identified as this species (*Dix s.n.*, DUKE[n.v.]). The distribution of *S. paschale* is not known to include New Jersey (Brodo et al. 2001) and the record likely refers to *S. saxatile*.

Usnea cavernosa Tuck. – C.C. Frost made a collection in 1849 at Five Mile Woods, Lawrence Township, that he assigned to this species (*Frost s.n.*, MIN[n.v.]). The range of the species is not known to include New Jersey (Brodo et al. 2001, Waters & Lendemer in press) and the record likely corresponds to *U. trichodea*.

APPENDIX II – DESCRIPTION OF A NEW *CATILLARIA* SPECIES

***Catillaria patteeana* D.P. Waters & Lendemer, sp. nov.**
Mycobank #829587.

FIGURE 7.

DIAGNOSIS. – Similar to *Catillaria lenticularis* but differing in the presence of soredia.

TYPE: U.S.A. NEW JERSEY. MERCER CO.: Hopewell Township, Hillman Tract (D&R Greenway), adjacent Hopewell-Princeton Rd., mixed hardwood forest (*Acer, Carya, Fagus*) with diabase boulders, 1 Aug. 2017, on siliceous rock, *D.P. Waters 2966* (NY!, holotype).

DESCRIPTION. – **Thallus** crustose, thin, continuous but frequently cracked, minutely rimose-areolate, dull, green to green-brown; *soralia* small, 0.5–0.2 mm in diameter, ellipsoid to elongate and irregular in outline, forming along the cracks in the thallus and margins of the apothecia; *soredia* fine, light gray-green to green-gray, lighter in color than thallus, 15–30(–50) µm in diameter; **apothecia** biatorine, immersed to sessile, plane to slightly convex, 0.2–0.4 mm in diameter; *discs* brown, epruinose; *margins* opaque white to light brown, smooth, epruinose; *epihymenium* brown, not inspersed with granules; *hymenium* hyaline, *hypothecium* hyaline, *exciple* hyaline, outer portions paraplectenchymatous; *paraphyses* simple, apices abruptly swollen with brown caps; *asci Catillaria*-type; *ascospores*: 8 per ascus, ellipsoid, hyaline, 1-septate, (6–)8–9(–15) × 2–3(–5) µm (Fig. 5). **Photobiont** coccoid green alga, Trebouxioid, cells globose, 6-10 µm in diameter.

ETYMOLOGY. – The species is named in honor of Dr. Howard H. Pattee, emeritus professor at the Thomas J. Watson School of Engineering and Applied Science at Binghamton University, who was DPW's Ph.D. adviser and remains his mentor and friend. Howard is a biophysicist and theoretical biologist who studies the origin of life and symbolic control of physical systems. A collection of his papers 1967–2007 was recently published (Pattee & Rączaszek-Leonardi 2012).

ECOLOGY AND DISTRIBUTION. – This species is so far known from a single location in central New Jersey, in eastern North America. It was found growing on a siliceous outcrop in a mixed hardwood forest near the top of a south-facing ridge at an elevation of 100 meters (328 ft.). Other taxa collected on the same outcrop were *Caloplaca sideritis* and *Leprocaulon adhaerens*. It is noteworthy that despite the extensive studies of sorediate crustose lichens in New Jersey and the surrounding region by the second author, this species was not encountered previously.

DISCUSSION. – *Catillaria patteeana* is most notably distinguished from other members of the genus by the combination of its saxicolous habit and the production of soredia (Hertel et al. 2007, Kilias 1981, McCune 2017). Although the rimose-areolate thallus and apothecia with well-developed pale margins are somewhat unusual when compared to common taxa such as *C. lenticularis* (Ach.) Th. Fr. and *C. nigroclavata*, the placement of the taxon in *Catillaria* is logical when considering the *Catillaria*-type asci, capitate paraphyses with brown pigmentation, and small, 2-celled ascospores that lack a gelatinous halo. In eastern North America, the principal saxicolous species of *Catillaria* are *C. lenticularis* on calcareous substrates and *C. chalybeia* (Borrer) A. Massal. on siliceous substrates (Brodo 2016). *Catillaria patteeana* more closely resembles *C. lenticularis* in thallus and apothecial morphology but differs from both species in the presence of soredia.

Based on the overall appearance and coloration of the thallus and apothecia, in the field the new species would be mostly likely to be confused with *Halecania* or *Lecania*. Nonetheless, it differs from both genera in having biatorine apothecia (vs. lecanorine in both *Halecania* and *Lecania*). *Halecania* does share the *Catillaria*-ascus type and small, two-celled, hyaline ascospores with the new species. However, in addition to its different apothecial type, *Halecania* species differ from *C. patteeana* in typically lacking

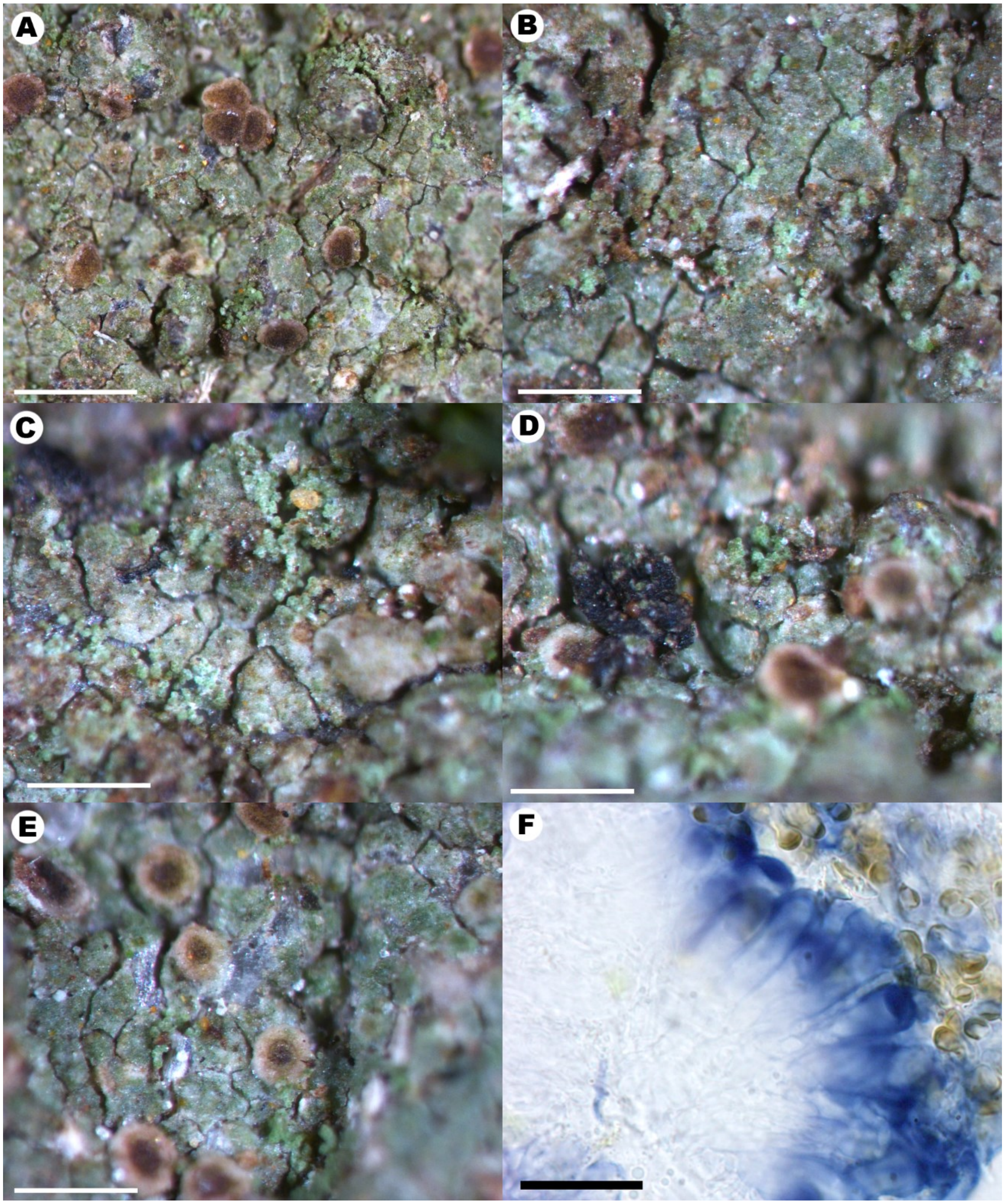

Figure 7. Morphology of *Catillaria patteeana* (all from the holotype). **A,** gross morphology of the thallus and apothecia. **B-D,** detail of the soralia. **E,** detail of the apothecia. **F,** section of the hymenium in IKI illustrating the asci. Scales = 0.5 in A-E, 20 µm in F.

capitate paraphyses with brown pigmentation and in often producing substances such as argopsin (Coppins 1989, Fryday & Coppins 1996, Mayrhofer 1987). Likewise, *Lecania* species differ from *C. patteeana* in having *Bacidia*-type asci (Ekman 1996; Mayrhofer 1987, 1988).

The discovery of the present species in central New Jersey is somewhat surprising given the attention that has been given to typically sterile, asexually reproducing crustose lichens in the region by the second author (e.g., Hodkinson & Lendemer 2012; Lendemer 2013, 2016). Nonetheless, as we have

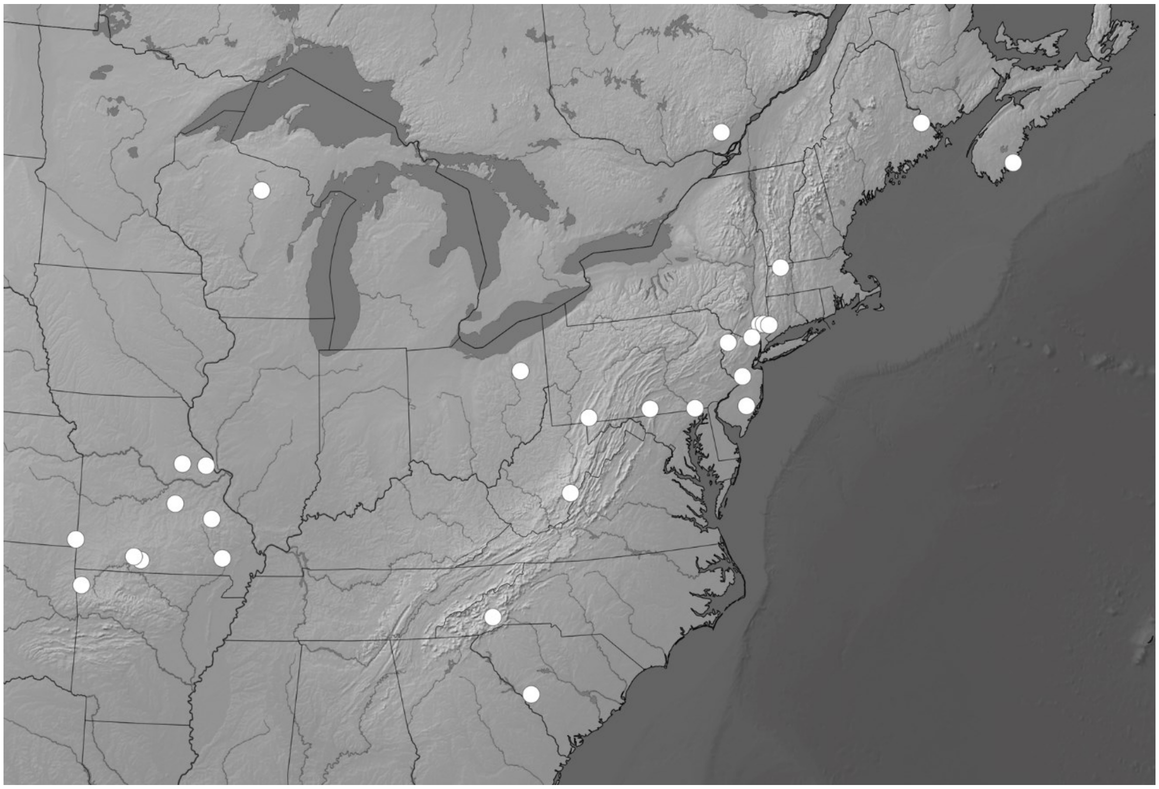

Figure 8. North American distribution of *Agonimia flabelliformis* based on specimens examined for this study.

demonstrated here, the lichens of central New Jersey have previously been little studied. Furthermore, while the occurrence of rare or narrowly endemic taxon may seem somewhat improbable given the overall fragmented natural landscape of the study area, it should be noted that similar taxa have been found on rock outcrops in northern New Jersey and adjacent Pennsylvania (e.g., *Bacidia phyllopsoropsis* R.C. Harris & Lendemer; see Harris & Lendemer 2006).

APPENDIX III – FIRST REPORT OF *AGONIMIA FLABELLIFORMIS* FROM NORTH AMERICA

Agonimia flabelliformis **Halda, Czarnota & Guzow-Krzemińska**, *in* Guzow-Krzemińska, Halda & Czarnota, The Lichenologist 44(1): 63. 2011[2012]. **TYPE: CZECH REPUBLIC.** BOHEMIA: Novohradské hory, ad marginem sylvae senectae 'Žofínský prales', 28 Oct. 2009, on lignum at base of *Fagus*, *Z. Palice 12763 & J. Malíček* (PRA[n.v.], holotype).

FIGURES 8–10.

DESCRIPTION OF NORTH AMERICAN SPECIMENS. – **Thallus** crustose, green, discontinuous, composed of dispersed goniocysts that aggregate and become finely divided to form elongate, flattened decumbent flabellate or even coralloid proliferations; *goniocysts* minute, granular to flattened and irregular in shape, 75–150 × 25–50 µm, with an algal core sheathed in a thin cortex (2–5 µm thick) of gelatinized fungal hyphae, with abundant flabellate to coralloid proliferations, the proliferations sparingly to heavily branched and often decumbent and flattened, sometimes forming a tangled mass, or becoming erect and then forming a dense thicket; **perithecia** frequent, globose, superficial or slightly nestled between the goniocysts, 160–200 µm in diameter, dark brown to black, smooth, with slightly offset whitish or rarely reddish ostiole, visible due to the presence of periphyses; *periphysoids* present, surrounding the inner rim of ostiole, 6–10 µm long; *interascal filaments* present, sparse; *asci* 75–120 × 25–38 µm; *ascospores* 8 per ascus, ellipsoid, hyaline, submuriform, with 14–18 countable cells in optical section (7–10 × 3–6 celled), (25.7–)28.3–33.7(–36.4) × (9.2–)10.8–13.2(–15.1) µm (n=45). **Photobiont** green, coccoid, cells (4.3–)5.0–7.8(–10.6) µm in diameter (n=60).

ECOLOGY AND DISTRIBUTION. – This species is widespread throughout temperate eastern North America, with a distribution that extends throughout the northeastern United Sates and adjacent Canada, south down the Appalachian Mountains and with a disjunct subpopulation in the Ozarks (Fig. 8). It was most frequently found growing amongst and over bryophytes on bark or humus surrounding the bases of both hardwood and conifer trees.

The ecology appears to be similar to that of *Agonimia flabelliformis* in Europe, where the species is widespread (Fałtynowicz et al. 2015, Grünberg et al. 2017, Guzow-Krzemińska et al. 2012, Kison et al. 2016, Motiejûnaitë & Grochowski 2014). Given that the species has also been reported from Asia in far eastern Russia (Tchabanenko et al. 2018), it is not surprising that it also occurs in temperate eastern North American given the biogeographic affinities of the two regions (e.g., Lendemer et al. 2014, Sheard et al. 2017).

DISCUSSION. – *Agonimia flabelliformis* is distinguished from other members of the genus by its small ascospores, eight-spored asci, and green thallus composed of goniocysts that become flabellate to coralloid (Guzow-Krzemińska et al. 2012). Of the *Agonimia* species reported from North America, the only one with comparable ascospore size is *A. allobata* (Stizenb.) P. James ((25–)29–35(–44) × 10–15(–16.5) µm *fide* Orange & Purvis 2009). While the perithecia and ascospores of *A. allobata* are comparable those of *A. flabelliformis*, *A. allobata* has a thin, poorly-developed, continuous to granular, greenish-grey to brown thallus (Orange & Purvis 2009). In cases where the thallus of *A. flabelliformis* becomes strongly coralloid, the species could be confused with *A. octospora* Coppins & P. James or *A. tristicula* (Nyl.) Zahlbr. While those species have squamulose thalli that can become elongate and coralloid or digitate, both differ in having larger ascospores than *A. flabelliformis* (60–75(–85) × 20–26(–30) µm and that are 8 per ascus in *A. octospora*, (42–)57–120(–150) × 26–50 µm and 1–2 per ascus in *A. tristicula*; *fide* Coppins & James 1978).

When we first found *Agonimia flabelliformis* in Mercer County, we thought it likely represented an undescribed species because the material had extremely coralloid, ascending goniocysts (Fig. 9) and sparse interascal filaments present between the asci (Fig. 10D–E). Study of the numerous undetermined specimens of *Agonimia* at NY led to the discovery of many additional collections from throughout temperate eastern North America. This in turn led us to conclude that the morphology of the thallus in our New Jersey collections fell within that described previously for *A. flabelliformis* (Guzow-Krzemińska et al. 2012) and observed in North American material generally (Figs. 9–11).

As is highlighted in the description of North American material presented above, the only disagreement with published accounts of *Agonimia flabelliformis* appears to be the presence of interascal filaments, which are considered to be absent from all species of *Agonimia* (Guzow-Krzemińska et al. 2012, Hafellner 2014, Orange & Purvis 2009, Sérusiaux et al. 1999). Initially, we were skeptical as to the presence of these structures, particularly given their stated absence in mature perithecia of Verrucariaceae (Gueidan et al. 2009), however we observed them in many of the specimens examined, and confirmed their identity with colleagues (R.C. Harris pers. comm.) cf. Fig. 11D–E to Ertz & Deiderich 2004: Fig. 6F–G). Rather than describe the North American material as a new species that differs from *A. flabelliformis* in the presence of interascal filaments, it seems prudent that a broader study of *Agonimia* should be undertaken to determine whether these structures have been overlooked previously.

SELECTED SPECIMENS EXAMINED. – **CANADA. NEW BRUNSWICK.** CHARLOTTE CO.: Saint James Parish, Grand Falls Flowage on St. Croix River, 30 Apr. 2011, on humus, *J.C. Lendemer 27817* (NY). **NOVA SCOTIA.** QUEENS CO.: Thomas H. Raddall Provincial Park, Moody Barrens, 7 May 1999, on *Quercus* base, *W.R. Buck 35610* (NY), on *Acer* base, *W.R. Buck 35613* (NY). **QUEBEC.** Comte de Terrebonne, Universite de Montreal Station de Biologie des Laurantides, 3 Aug. 1997, on humus, *W.R. Buck 32309* (NY). **U.S.A. ARKANSAS.** BENTON CO.: Ozark National Forest, Wedington Wildlife Management Area, jct of FSR1479 & FSR1752, 12 Apr. 2004, on moss over rock, *W.R. Buck 46327* (NY). **KANSAS.** CHEROKEE CO.: Spring River Wildlife Area, N of NW 100th St., 13 Apr. 2004, on bryophytes, *W.R. Buck 46397* (NY). **MASSACHUSETTS.** FRANKLIN CO.: Town of Rowe, just off Tunnel Rd., 3.8 mi NW of Zoar on River Rd., 19 Sept. 1998, on *Quercus* base, *W.R. Buck 34571* (NY). **MISSOURI.** AUDRAIN CO.: Marshall I. Driggs Conservation Area, 0.4 mi E of Hwy. RA, 13 Apr. 2005, on *Quercus* base, *W.R. Buck 48466* (NY), on *Prunus* base, *W.R. Buck 48467* (NY). BUTLER CO.: University Forest Conservation Area, along MO-KK, 23 Oct. 2001, on tree base, *W.R. Buck 40200A* (NY). CHRISTIAN CO.: Mark Twain National Forest, E of MO UU, 3.4 mi S of Merritt Rd., 21 May 2003, on lignum, *W.R. Buck 44604* (NY). LINCOLN

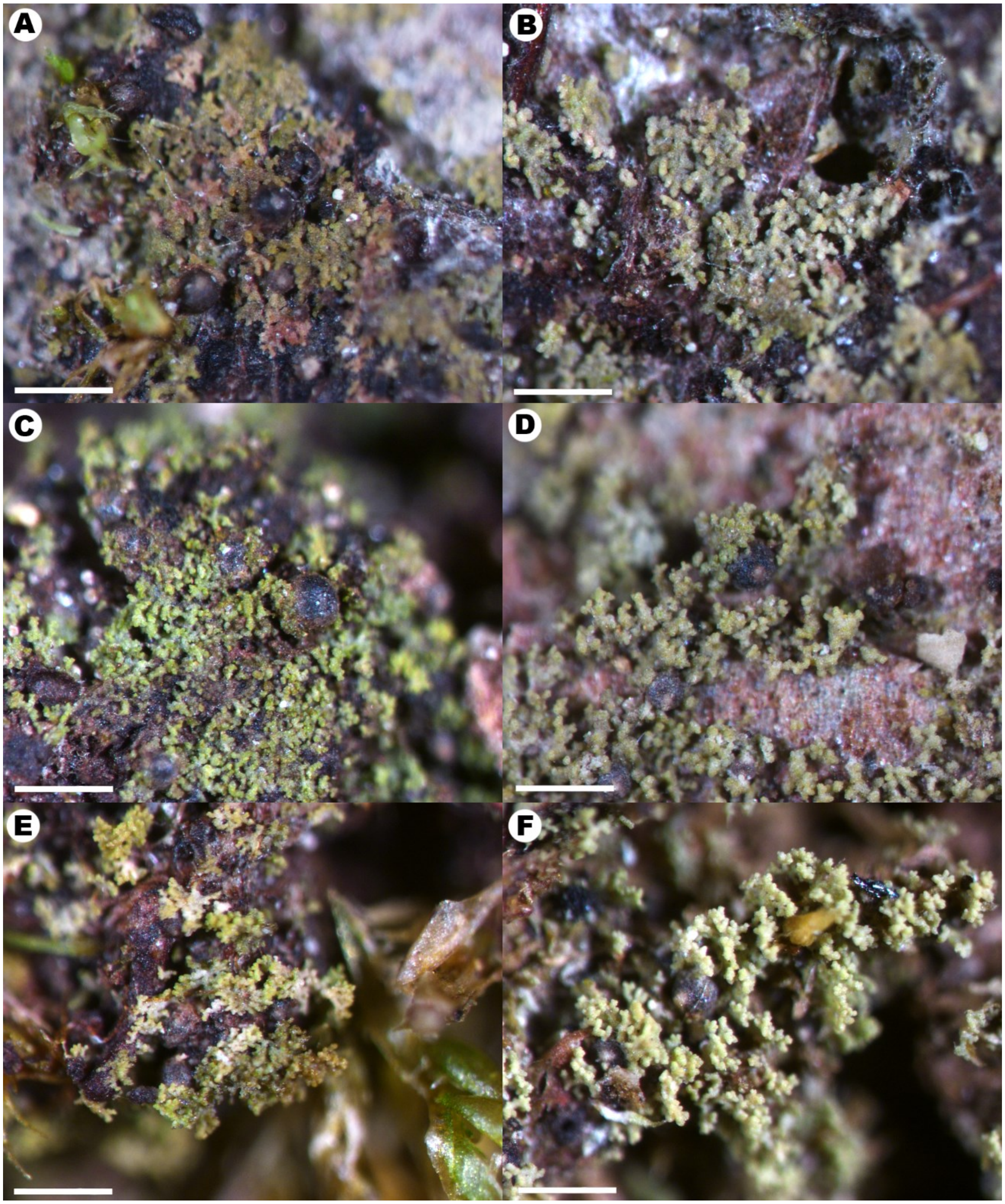

Figure 9. Variation in thallus morphology of *Agonimia flabelliformis*. **A,** flattened and decumbent flabellate isidia (*Buck 50179*). **B,** weakly divided goniocysts with short, knob-like isidia (*50179*). **C,** granular goniocysts only weakly elongated and divided (*Buck 56153*). **D,** ascending goniocysts with short, knob-like isidia (*Buck 36738*). **E,** ascending goniocysts with elongate isidia (*Lendemer 27817*). **F,** strongly ascending goniocysts with short isidia (*Lendemer 3905*). All scales = 0.5 mm.

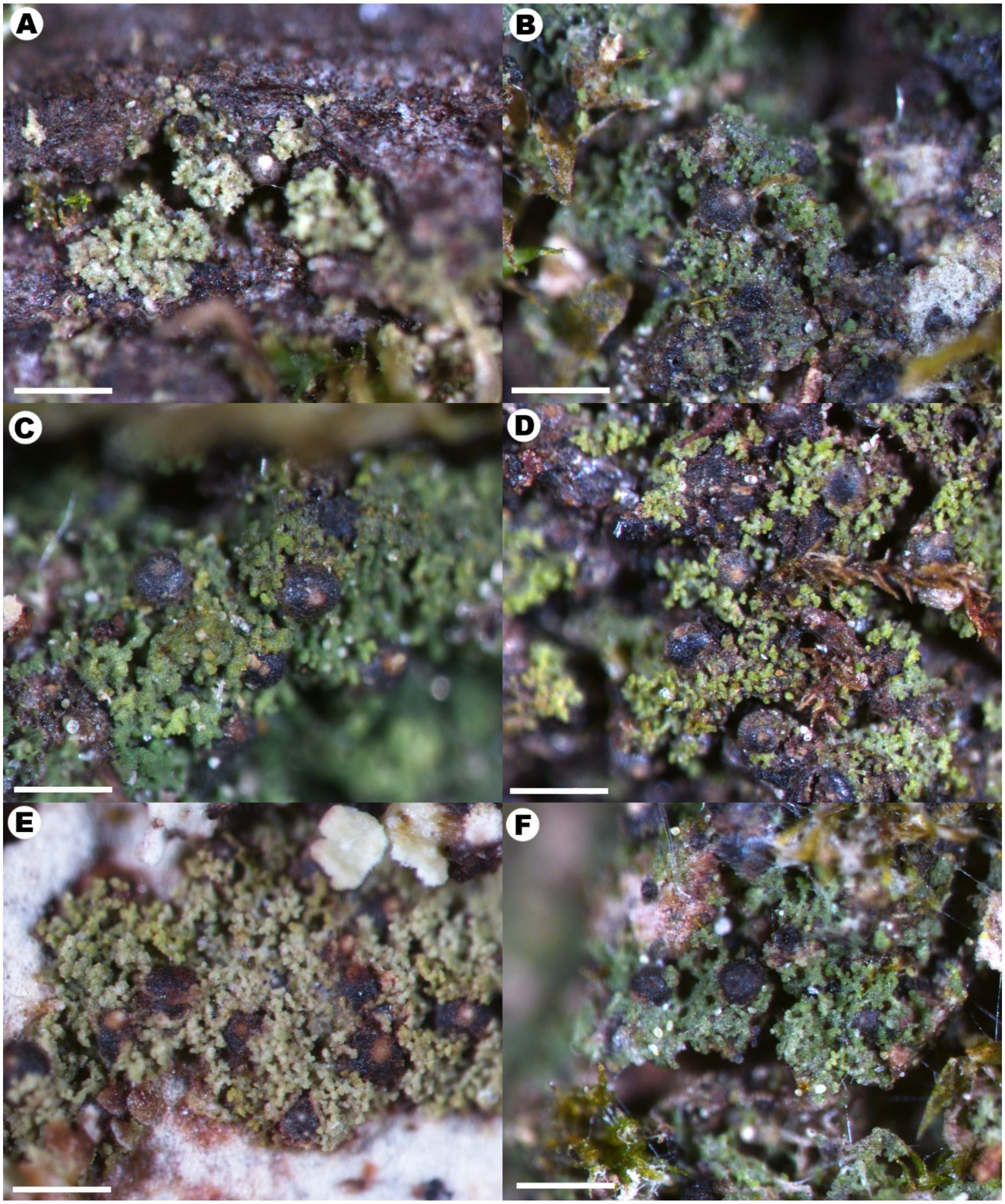

Figure 10. Variation in perithecium morphology of *Agonimia flabelliformis*. **A,** solitary perithecium with conspicuous white ostiole caused by profusion of periphyses (*Buck 35202*). **B,** perithecium with only slightly whitened ostiole (*Waters 2850*). **C-E,** perithecia with slightly reddened ring surrounding the whitened area of the ostiole (C from *Waters 2848*, D from *Buck 56153*, E from *Buck 35610*). **F,** perithecia with dark ostiolar region (*Waters 2850*). All scales = 0.5 mm.

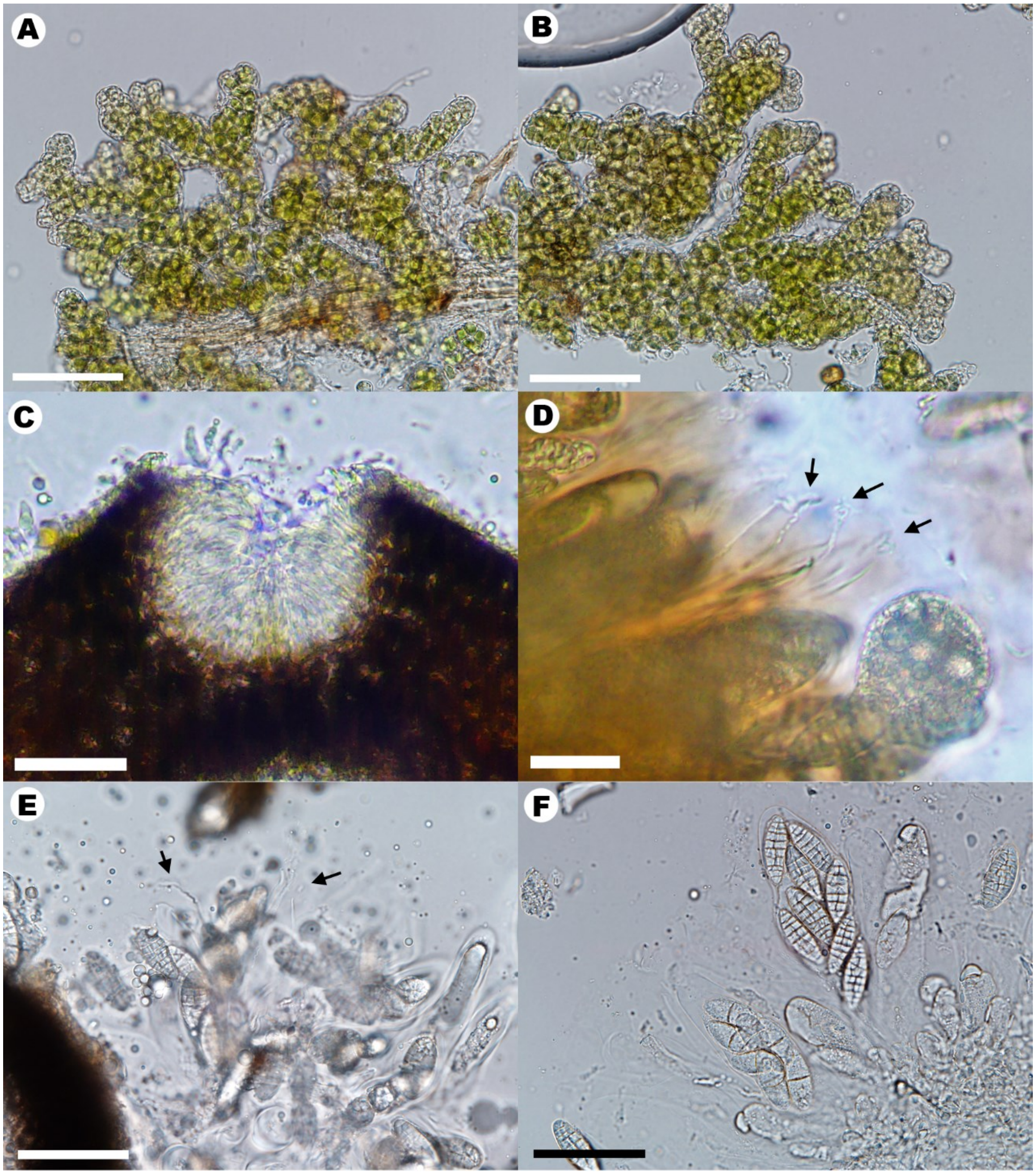

Figure 11. Internal anatomy of *Agonimia flabelliformis*. **A** and **B,** morphology of the thallus (*Buck 34486*). **C,** transverse section of ostiole illustrating abundant periphyses (*Waters 2850*). **D,** asci and hymenial gel in Iodine with arrows pointing to interascal filaments (*Waters 2850*). **E,** squash preparation of perithecium illustrating typical appearance of interascal filaments in water (*Buck 51079*). **F,** asci with immature (lower left) and mature (upper right) ascospores in water (*Buck 34486*). Scales = 50 µm, in A, B, E and F; 10 µm in C, and 25 µm in D.

CO.: Cuiver River State Park, Big Sugar Creek Wild Area, 23 May 2003, on mosses over soil, *W.R. Buck 44667* (NY). MARIES CO.: Spring Creek Gap Conservation Area and Spring Creek Gap Glades Natural Area, E of CR340/Old Hwy. 63, 4 Nov. 2002, on *Quercus* base, *W.R. Buck 42738* (NY). OZARK CO.: Mark Twain National Forest, along ridge E of Waterhole Hollow, 19 May 2003, on *Quercus* base, *W.R. Buck 44389* (NY). WASHINGTON CO.: Hughes Mountain Conservation Area, E of CR540, 3 Nov. 2002, on bryophytes, *W.R. Buck 42626* (NY). **NEW JERSEY.** BURLINGTON CO.: Sweetwater, ~2.8 km SE of Batsto, 19 Apr. 2005, on *Quercus* base, *J.C. Lendemer 3905* (NY). MERCER CO.: Hopewell Township, Cedar Ridge Preserve, 27 April 2017, on fallen *Juniperus*, *D.P. Waters 2828* (NY), West Windsor Township, Millstone River Preserve, 3 May 2017, on *Juglans* base, *D.P. Waters 2848* (NY), on *Quercus*, *D.P. Waters 2850* (NY). SUSSEX CO.: Stokes State Forest, Tillman Ravine, 30 Aug. 1998, on bryophytes, *W.R. Buck 34486* (NY). **NEW YORK.** PUTNAM CO.: Clarence Fahnestock Memorial State Park, 15 Nov. 1998, on bark, *W.R. Buck 35202 & R.C. Harris* (NY); Ninham Mountain Multiple Use Area along Nicholas St., 6 Apr. 2002, on decaying stump, *W.R. Buck 41553* (NY); Town of Southeast, Devils Den, 3 May 2001, on *Quercus* base, *W.R. Buck 39135* (NY). ROCKLAND CO.: Harriman State Park, along Woodtown Rd. West near dam at S end of Lake Sebago, 19 Apr. 1998, on *Quercus* base, *W.R. Buck 34136* (NY), on humus, *W.R. Buck 34138* (NY), on tree base, *W.R. Buck 34140* (NY). **NORTH CAROLINA.** HENDERSON CO., Pisgah National Forest, North Mills River Recreation Area, 30 Apr. 2006, on humus, *W.R. Buck 50179* (NY). **OHIO.** PORTAGE CO.: Mogadore Reservoir, 8 Jul. 2016, on *Quercus* base, *T. Curtis s.n.* (KE[digital images!]). **PENNSYLVANIA.** FAYETTE CO.: Ohiopyle State Park, along the Great Allegheny Passage paralleling the Youghiogheny River from Ramcat Launch Area, 28 Apr. 2012, on large *Liriodendron*, *R.C. Harris 57412* (NY). FRANKLIN CO.: Michaux State Forest, W-slopes of Monalto Mountain, 1 Jun. 2009, on humus at *Quercus* base, *J.C. Lendemer 18097* (NY). LANCASTER CO.: New Texas Serpentine Barrens, 14 Mar. 2000, on *Juniperus* base, *W.R. Buck 36738* (NY). MONROE CO.: Delaware Water Gap National Recreation Area, along Freeman Rd., 1.2 mi NE of River Rd., 25 Apr. 2004, on bark, *W.R. Buck 46985* (NY). **SOUTH CAROLINA.** AIKEN CO.: The Hitchcock Woods, just SW of city of Aiken, 14 Mar. 2010, on soil, *W.R. Buck 56153* (NY). **WEST VIRGINIA.** POCAHONTAS CO.: Watoga State Park, Brooks Memorial Arboretum, 15 May 2000, on bryophytes, *W.R. Buck 37074* (NY). **WISCONSIN.** ONEIDA. CO.: Oneida County Forest, 0.2 mi N of South Exit off Langlade Co. Hwy. Q, 27 Apr. 2002, on bark, *W.R. Buck 41643* (NY).

APPENDIX IV – *CLADONIA* SPECIES REPORTED BY EVANS (1940) FROM MERCER COUNTY

Below we present a tabular summary of the species of *Cladonia* collected in Mercer County by G.G. Nearing and W.L. Dix as they were reported by Evans (1940). This summary relates to the discussion herein of historical reports and collections made in Mercer County.

Taxon	Nearing	Dix
Cladonia caespiticia	✓	
Cladonia conista	✓	
Cladonia cristatella	✓	✓
Cladonia furcata		✓
Cladonia grayi	✓	✓
Cladonia macilenta var. *bacillaris*	✓	
Cladonia ochrochlora	✓	
Cladonia peziziformis	✓	✓
Cladonia piedmontensis		✓
Cladonia pleurota	✓	
Cladonia polycarpoides	✓	✓
Cladonia rei	✓	✓
Cladonia squamosa	✓	✓
Cladonia subtenuis	✓	✓
Cladonia verticillata	✓	

APPENDIX V – COMPARISON OF *CLADONIA* SPECIES COLLECTED BY W.L. DIX AND D.P. WATERS IN MERCER COUNTY

Below we present a tabular summary of the *Cladonia* species collected in Mercer County by W.L. Dix compared those collected as part this study. This summary relates to the discussion herein of historical reports and collections made in Mercer County.

Species	Dix 1940's	Waters 2015-2017
Cladonia ochrochlora	0	22
Cladonia macilenta	0	13
Cladonia ramulosa	0	13
Cladonia grayi	9	10
Cladonia parasitica	0	7
Cladonia cristatella	8	4
Cladonia peziziformis	3	4
Cladonia rei	4	3
Cladonia furcata	6	2
Cladonia atlantica	5	0