Lichens and allied fungi of Mitchell Mill State Natural Area, North Carolina, USA

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Abstract. One hundred five species of lichenized and allied fungi are reported from recent and historical collections made in the Mitchell Mill State Natural Area in northeastern Wake County, North Carolina, USA. Mitchell Mill is unique among granitic flatrock communities in the southeastern United States by having riparian elements from the Little River, which flows directly over the flatrock, supporting semi-aquatic lichen communities along creek edges represented by species in *Dermatocarpon*, *Verrucaria*, and Lichinales. Recently described or renamed species *Cladonia ignatii*, *Lecanora provertula* and *Phyllopsora isidiosa* were found in recent collections. Compared to historical records, 38 taxa including five of six species of large cyanolichen were not found in recent visits, indicating a loss of diversity over the past 100 years, likely due to human activities.

Key words. Lichen biodiversity, conservation, granitic flatrock.

INTRODUCTION

Mitchell Mill State Natural Area in northeastern Wake County has been of scientific and local interest for well over a century. It is a unique area comprising of exposed granitic flatrock and riparian natural communities. While the lichens of this area have been documented since at least 1939 (Oosting and Anderson 1939, McVaugh 1943, Henssen 1969, Wetmore 1970, Esslinger 1975), no comprehensive checklist exists. Here presented is a lichen checklist, compiled from a review of historical specimen records as well recent collections made by the author. Comparison of historical records to recent collections aims to better understand the lichen flora of this site and what changes may have occurred to it over the past 80-100 years.

METHODS AND MATERIALS

Study area

Mitchell Mill State Natural Area (MIMI) is a 42.5 ha (105 acres) tract located 26.9 km (16.72 miles) NE of downtown Raleigh, in northeastern Wake County, North Carolina (Fig. 1), ranging from 82–100 m elevation. It is a satellite natural area of Falls Lake State Recreation Area and includes a portion of the Little River that is dammed to create Mitchell Millpond as well as its tributary Cedar Fork that converges upstream of the millpond from the west. The dam was constructed using local stone circa 1800 (Orcutt 2019). Natural communities include Granitic Flatrock and Granitic Flatrock Border Woodland (Schafale 2012).

CNALH record review

A search was made on the Consortium of North American Lichen Herbaria (CNALH; www.lichenportal.org) for specimens from MIMI by searching for “Wake” in the County field and “Mitchell”, “Mitchells” or “Cedar Fork” in the Locality field. Specimen records were tallied by genus, species and date collected. Records of specimens determined to genus only or of taxa that could be confused with recently collected or examined specimens were not added to the list.
Field visits and specimen curation
Multiple visits were made to MIMI to collect and record lichens on the flatrocks and in adjacent border woodland and forested areas from 2005–2021 to assess the area’s total lichen biodiversity with an attempt to rediscover historically recorded taxa. Collected specimens were studied via examination of morphological features, microscopic examination of reproductive tissues, and chemical spot testing at the University of North Carolina – Chapel Hill Herbarium (NCU). Material was examined using a Nikon SMZ 745T dissecting scope and a Nikon ALPHASHOT-2 YS2 compound microscope. Images were taken using a Samsung Galaxy S9 smart phone 12 MP camera through the eyepiece, then adjusted using the Microsoft Photos app (Microsoft Photos 2021.21120.8011.0, © 2020 Microsoft Corporation). Literature used for species identification included Brodo et al. (2001), Brodo (2016) and other sources. Vouchers were deposited in NCU and their records plus images were uploaded to CNALH. In addition, historical specimens from MIMI at NCU were examined to verify identifications, and their records were similarly uploaded onto CNALH. A checklist was developed on CNALH to accompany that here presented, which can be updated with future collections, determinations and taxonomic/nomenclatural changes.

Air quality assessment
To assess the potential impact of the local air quality on the area’s lichen biota, annual traffic volumes for the period from 2009-2019, in which vehicle traffic data were available, were calculated for an 813.2 ha circular area surrounding the MIMI centroid as a surrogate for vehicle emissions impacting the area following the methods of Perlmutter (2010) and Washburn and Culley (2006). These data were compared to those calculated in the Raleigh area (Perlmutter 2010).
RESULTS AND DISCUSSION

A total of 105 taxa of lichenized fungi were recorded from MIMI. Taxa include at least one species of *Lichenothelia*, a genus of rock-inhabiting fungi considered “borderline lichens” as algal cells are associated with the melanized fungal hyphae, but not forming a true lichen thallus incorporating both bionts (Muggia et al. 2013). The overall lichen biota of Mitchell Mill is larger than those found in similar granitic flatrock habitats in North Carolina and Georgia (Beeching et al. 2008, LaGreca et al. 2018, Perlmutter 2013). This could be due to the greater habitat diversity, as MIMI includes riparian habitats with Little River and Cedar Prong flowing through the area with associated semi-aquatic species.

The high diversity could also reflect depth of study by multiple workers over nearly a century that could have documented species which were present historically but have become rarer or extirpated. Thirty-eight taxa (37% of the total checklist) that were collected historically were not found in recent collecting visits (i.e., since 2000). Among these are pollution-sensitive cyanolichens in genera *Collema, Crocodia, Emmanuelia, Leptogium, Lichina* and *Peltigera*. Cyanolichens that were recently collected include *Leptogium cyanescens, Peltula cylindrica, P. zahlbruchneri* and three additional micro-cyanolichen species of Lichinaceae. *Leptogium cyanescens* is arguably the most common cyanolichen in the North Carolina Piedmont, and is found in impacted forested areas such as near highways (Perlmutter et al. 2017), suggesting this species to be somewhat pollution or disturbance tolerant. Other large cyanolichens appear to be more sensitive as evidenced in their absence from urban or otherwise disturbed areas (Perlmutter 2010, Perlmutter et al. 2017), while historical records have shown these species to be present in the past, a pattern observed in the Piedmont and elsewhere in North America (Perlmutter et al. 2017, Allen et al. 2019).

The apparent loss of cyanolichen diversity in MIMI could be due to changes in local air quality from traffic emissions along the three roads bordering the area: Pulley Town Road, Mitchell Mill Road and Zebulon Rd / NC highway 96. Annual traffic for the area was calculated to be 12.99 million vehicle miles traveled, lower than that for the site with the lowest traffic volume and highest lichen diversity on tree boles reported from city parks in the Raleigh area yet higher than that of the control site in a natural forest in a study wherein no cyanolichens were found (Perlmutter 2010). Annual average daily traffic along NC-96 which forms the eastern border of MIMI, has steadily increased from 6500 vehicles in 2009 to 9200 vehicles in 2019.

The lichen biota of MIMI is an example of a trend of species loss over time due to human activities (Allen et al. 2019). In addition to the increased vehicle traffic and associated emissions, direct disturbance to the flatrocks and surrounding woodlands and forests from recreational activities are reported as a threat to the area’s unique biodiversity (Orcutt 2019). Specific disturbances include vehicle traffic on the flatrocks, campfires, graffiti and litter, evidence of which was observed during recent visits. Mitchell Mill is a protected area within the North Carolina State Parks system, and recognized as a natural area, defined by the North Carolina Natural Heritage Program (NCNHP) as a site of “special biodiversity significance due to the presence of rare species, unique natural communities, important animal assemblages, or other ecological features” (NCNHP: https://www.ncnhp.org/conservation/natural-areas). This report aims to provide insight toward further protection of the area by bringing awareness of its lichen biodiversity which has decreased via a loss of sensitive species over the past several decades.
Annotated checklist of the lichens and allied fungi of Mitchell’s Mill State Natural Area from CNALH records, including those collected here. Names follow Esslinger (2019) unless otherwise indicated. Taxa in **bold** were collected or seen by the author.

1. *Anaptychia palmulata* (Michaux) Vainio – *Dey 404* (NY), substate not recorded.
2. *Bacidia schweinitzii* (Fr. ex E. Michener) A. Schneid. – *Perlmutter 3990, 3993, 4004, 4010* (NCU), on hardwood trees.
3. *Bacidina inundata* (Fr.) Vězda – *Perlmutter 3970* (NCU), on granitic cobble on streambank of Cedar Prong of Little River. This is the first reported specimen from North Carolina. One previous record in CNALH is from New Hanover County along the coast (*W.L. Culberson 10359*, DUKE).
6. *Bulbothrix isidiza* (Nyl.) Hale – *Esslinger 3126* (DUKE), on pine bark.
7. *Candelaria concolor* (Dick.) Stein – *Perlmutter 3976* (NCU photovoucher, images by Robert Lücking), few isolated thalli on vertical rockface below mill dam.
10. *Cladonia apodocarpa* Robbins – *Almeda 928* (CAS, DUKE), on large boulder amidst thick moss cover; *Perlmutter 3985* (NCU), on rock.
12. *Cladonia caroliniana* Tuck. – *Almeda 945* (CAS, MSC); *Esslinger 3112* (hb. Esslinger), on and around large outcrop; *Shriver s.n., 19.X.1974* (BALT), on granite outcrop. This lichen is reported in succession development of *Grimmia* moss mats on flatrocks (*Oosting and Anderson 1939*).
13. *Cladonia coniocrea* (Flörke) Sprengel – *Almeda 929b* (CAS), on rotting hardwood stump. Based on the substrate, this unverified record appears to be *C. ochrochlora* Flörke; *C. coniocrea* is tericolous (*Brodo et al. 2001*).
14. *Cladonia cristatella* Tuck. – *Esslinger 3163* (DUKE), on granitic outcrop, old rags and leather shoes.
15. *Cladonia didyma* var. *vulcanica* (Zoll. & Moritzi) Vainio – *Almeda 932* (DUKE), on rotting hardwood stumps; *Dey 405* (NY), substrate not recorded.
16. *Cladonia fimbriata* (L.) Fr. – *Almeda 930a* (DUKE), on *Juniperus*. Contains fumarprotocetraric acid only. Determined by S. LaGreca.
17. *Cladonia greyi* G. Merr. ex Sandst. – *Almeda 930, 934* (CAS), on *Juniperus*, soil over granite; *Clark 4019-2* (NY), on granite outcropping; *Esslinger 3162* (hb. Esslinger), on and around large outcrop; *Perlmutter et al. MM-1* (NCU), on detritus over rock.
Wake Co., William B. Umstead State Park, Perlmutter 274, 758, 767; Turnipseed County Conservation Area Perlmutter 2569.

19. Cladonia leporina Fr. – Almeda 937 (CAS), on thin soil layer; Esslinger 3100 (hb. Esslinger), on and around large outcrop. This lichen is reported in succession development of Grimmia moss mats on flatrocks (Oosting and Anderson 1939).

20. Cladonia macilenta var. bacillaris (Ach.) Schaerer – Almeda 929a (CAS), on rotting hardwood stump.

21. Cladonia petrophila R.C. Harris – Perlmutter 3972 (NCU), on vertical rock face of granitic boulder in forest.

22. Cladonia peziziformis (With.) J.R. Laundon – Perlmutter 3975 (NCU), on exposed cladonia-moss mat over granitic flatrock.

23. Cladonia rangiferina (L.) F.H. Wigg. – Perlmutter 3975 (NCU), on exposed cladonia-moss mat over granitic flatrock during field visit in April 2011.

24. Cladonia robbinsii A. Evans – Clark 4019-1 (DUKE, NY), on rock; Coker s.n., 9.IV.1932 (NCU), on rocks; Esslinger 3161 (hb. Esslinger), on soil. Observed on moss mats over flatrock.

25. Cladonia squamosa (Scop.) Hoffm. – Almeda 949 (CAS), on soil amidst thick mass of moss.

26. Cladonia subcariosa Nyl. – Almeda 925 (CAS, DUKE). The DUKE specimen has following chemical results: Spot Tests: Medulla K+ yellow, C-, PD+ orange; TLC Atranorin, norstictic and stictic acids. The DUKE specimen verified by S. LaGreca.

27. Cladonia subtenuis (Abbayes) Mattick – Almeda 939 (CAS), on exposed granitic flatrocks; Clark 4019-10 (NY); Esslinger 3111 (hb. Esslinger) and 3100 (ID, WIS), on and among mosses; Perlmutter et al. MM-9 (NCU), on pine needles, detritus on ground; Shriver s.n., 19.X.1974 (BALT), on granite outcrop.


29. Collema pulchellum var. leucopeplum (Tuck.) Degel. – Coker & Totten s.n., 9.IV.1932 (NCU), on trunks and branches of Juniperus virginiana.


31. Dermatocarpon arenosaxi Amtoft – Perlmutter et al. MM-10, Perlmutter 4007-a (NCU; Fig. 2E), on exposed flatrock along rivulet edges. Spores 11.5-15.0 x 6.5-8.5 μm.

32. Dermatocarpon luridum (With.) J.R. Laundon – Almeda 938 (CAS), on exposed flatrock submerged in flowing water; Coker s.n., 9.IV.1932 (NCU), on large rocks in water; Shriver s.n., 19.X.1974 (BALT), on granite outcrop. Spores 13.5-18.0 x 5.5-8.0 μm in the NCU specimen.

33. Emmanuelia ravenelii (Tuck.) Ant. Simon & Goffinet (syn. Lobaria ravenelii (Tuck.) Yoshim.) – Hanssen 17118-a (ASU), substrate not recorded.

34. Flavoparmelia caperata (L.) Hale – Clark 4019-7 (NY), substrate not recorded; Dey 407 (NY), substrate not recorded; Luttrell 1039 (DUKE), on limbs of Juniperus virginiana. Observed during field visits in April 2011, August 2021.

35. Gomphillus americanus Essl. – Buck 48965 (NY), substrate not recorded; Esslinger 3184A (US, Holotype; DUKE, hb. Esslinger, Isotypes), Esslinger 4156 (DUKE, hb. Esslinger), on mosses on hardwood log; Esslinger 4157, 4158 (hb. Esslinger), on mosses over base and branch of Juniperus virginiana; Perlmutter 3748 (NCU, Topotype; Fig. 2D), on moss over Juniperus virginiana limb. This species was first described from Mitchell Mill (Esslinger 1975).

36. Graphis lineola Ach. – Perlmutter 3992 (NCU), on Carpinus caroliniana trunk.

37. Graphis scripta s. lat. – Perlmutter 3755 (NCU), on trunk of Carpinus caroliniana. This taxon represents a species complex that is not fully understood (Kraichak et al. 2015).
38. **Graphis tenella** Ach. – Perlmutter 3981 (NCU), on *Ilex opaca*. Lirellae becoming striate; exciple laterally carbonized; hymenium clear; spores hyaline, 7-septate, 30 x 7 μm. Determined by R. Lücking; also keys to *G. tenella* using Lendemer et al. (2016). This specimen matches descriptions of *G. tenella* in Lücking et al. (2008); *G. tenella* is also reported from the coastal plain of North Carolina (Lendemer et al. 2016); this makes the first report from the North Carolina Piedmont.

39. **Gyalideopsis bartramiorum** Lendemer – Buck 48964 (NY), substate not recorded. This specimen is cited in the description of the species (Lendemer 2017).

40. **Heterodermia echinata** (Taylor) W. L. Culb. – Clark 4019-8 (NY), substrate not recorded; Coker & Totten s.n., 9.IV.1932 (NCU), on bark and dead branches of *Juniperus virginiana*; Esslinger 3103 (hb. Esslinger), on bark of *Betula*; Esslinger 3107 (ID, hb. Esslinger), on bark of *Juniperus virginiana*; LaGrega 2484 (DUKE), on *Juniperus virginiana*; Luttrell 1073 (DUKE), on limbs of *Juniperus virginiana*; Perlmutter et al. MM-4 (NCU; Fig. 2H), on Ulmus alata twigs; Perlmutter 3987 (NCU), on fallen *Carya* branch.

41. **Heterodermia obscurata** (Nyl.) Trevisan – Coker & Totten s.n., 9.IV.1932 (NCU), on *Juniperus virginiana*; Perlmutter et al. MM-21 (NCU), on hardwood branch.

42. **Heterodermia speciosa** (Wulfen) Trevisan – Esslinger 3164 (hb. Esslinger), on mosses over old dead log.

43. **Hypotrachyna horrescens** (Taylor) Krog & Swinscow (filed as *Parmelinopsis horrescens*) – Esslinger 3125 (hb. Esslinger), on pine bark.

44. **Hypotrachyna livida** (Taylor) Hale – Esslinger 3123 (hb. Esslinger), on pine bark.

45. **Hypotrachyna minarum** (Vainio) Krog & Swinscow – Esslinger 3125 (DUKE), on pine bark.

46. **Hypotrachyna osseoalba** (Vainio) Park & Hale – Esslinger 3124 (ID as *Parmelia formosana*, hb. Esslinger), on bark of *Pinus*.

47. **Lecanora hybocarpa** (Tuck.) Brodo – Perlmutter et al. MM-19, MM-24 (NCU), on live and dead hardwood branches.

48. **Lecanora protervula** Stirton (syn. *L. subpallens* Zahlbr.) – Perlmutter 3986 (NCU), on twigs of a fallen *Carya* tree. Apothecia C+ yellow, rim K+ yellowish, PD+ red. This taxon is a recent renaming of *L. subpallens* [syn. *L. caesiorubella* subsp. *prolifera* (Fink in Hedrick) R.C. Harris], a common and widespread species in coastal eastern North America (Brodo et al. 2019).

49. **Leiorreuma explicans** (Fink) Lendemer – Perlmutter 3980 (NCU), on *Ilex opaca* trunk. Norstictic acid present (K+ yellow turning red).

50. **Lepra ophthalmiza** (Nyl.) Hafellner – Perlmutter 4000 (NCU), on fallen *Quercus* limb (UV-; medulla K-, KC-, PD-).

51. **Lepraria finkii** (B. de Lesd.) R.C. Harris – Perlmutter 72, 3958 (NCU), on granite outcrop and exposed root bole, respectively.

52. **Leptogium cyanescens** (Rabenh.) Körber – Clark 4019-9 (NY), substrate not recorded; Perlmutter 3955, 3963, 3964, 3967, 3968, 3973 (NCU, BRIT; Fig. 2F), on *Juniperus* trunks from base to 3 m up, on hardwoods, mosses and rock.

53. **Leptogium hirsutum** Sierk – Coker & Totten s.n., 9.IV.1932 (NCU), on trunks and branches of *Juniperus virginiana*. This species is of conservation concern based on absence of recent records in much of its range in eastern North America including Mitchell Mill of central North Carolina as well as several other sites from Iowa to Massachusetts, presumably from changes in land use and air quality (Stone et al. 2016).

54. **Lichenothelia sp. 1 “piedmonta”** – Perlmutter 3751, 3753, 3754 (NCU), on shaded flatrock under *Juniperus*. Thallus composed of scattered to clumped micro-areoles, measuring 68-120 μm diameter, flat to slightly convex; ascomata not seen. This is an undescribed species of “borderline lichen” or rock-inhabiting fungus that is distinguished
from other species of the genus based on molecular data (Ametrano et al. 2019; Muggia et al. 2013, 2015).


57. *Parmeliopsis subambigua* Gyelnik – *Esslinger 3115* (ID as *P. halei* (Tuck.) Hale, hb. Esslinger), on pine bark.


59. *Parmotrema hypoleucinum* (Steiner) Hale – *Clark 4019-3* (NY), substrate not recorded; *Perlmutter 3971* (NCU), on fallen pine twig (medulla PD+ orange, K+ yellow).

60. *Parmotrema perforatum* (Jacq.) A. Massal. – *Esslinger 3108* (hb. Esslinger), on *Juniperus* bark; *Perlmutter et al. MM-11* (NCU), on twig.

61. *Parmotrema reticulatum* (Taylor) M. Choisy – *Dey 413* (NY), substrate not recorded; *Perlmutter et al. MM-5, MM-6* (NCU), on *Ulmus alata* twig and *Juniperus virginiana* branch, respectively.


63. *Parmotrema submarginale* (Michx.) DePriest & B. Hale – *Esslinger 3114* (hb. Esslinger), on rock; *Perlmutter et al. MM-5, MM-6* (NCU), on *Ulmus alata* twig and *Juniperus virginiana* branch, respectively.

64. *Parmotrema xanthinum* (Müll.Arg.) Hale – *Dey 411* (NY), gyrophoric acid present; substrate not recorded.

65. *Peltigera canina* (L.) Willd. – *Esslinger 3127* (ID, hb. Esslinger), on soil and mosses. This species has historically been reported from the Piedmont (Becker 1977) as well as collected recently [Orange Co., North Carolina Botanical Garden, *Rivas Plata s.n., 5 November 2016* (NCU)]

66. *Peltula cylindrica* Wetmore – *Esslinger 3097* (ID, hb. Esslinger), on *Carpinus* trunk. *Peltula zahlbruckneri* (Hasse) Wetmore – *Henssen & Whitford 17162B* (MIN), substrate not recorded; *Perlmutter 3966* (NCU; Fig. 2A), on exposed flatrock. The Henssen & Whitford specimen is cited in the species treatment in Wetmore (1970).

67. *Peltula zahlbruckneri* (Hasse) Wetmore – *Henssen & Whitford 17162B* (MIN), substrate not recorded; *Perlmutter 3966* (NCU; Fig. 2A), on exposed flatrock. The Henssen & Whitford specimen is cited in the species treatment in Wetmore (1970).

68. *Pertusaria consocians* Dibben – *Perlmutter 3996, 3997* (NCU), on *Carya* trunk.

69. *Pertusaria paratuberculifera* Dibben – *Perlmutter et al. MM-17* (NCU), on *Carya* trunk.

70. *Pertusaria pustulata* (Ach.) Duby – *Perlmutter 3983* (NCU), on *CarPIrus* trunk.

71. *Phaeophyscia rubropulchra* (Degel.) Essl. – *Esslinger 3102* (hb. Esslinger), on *Betula* bark. This distinctive species was observed on rock during a field visit in July 2021.

72. *Phlyctis boliviensis* Nyl. – *Perlmutter 3995* (NCU), on *Ilex opaca* trunk.

73. *Phlyctis petraea* R.C. Harris – *Perlmutter 70* (DUKE as *P. argena*, NCU), on granitic boulders below dam. Atranorin (trace) and norstictic acid detected (TLC run by S. LaGreca).

74. *Phyllopsora isidiosa* Kistenich & Timdal – *Perlmutter 3974, 3989* (NCU), on living *Carya* trunks. This pantropical-temperate species was recently described from the southern Appalachians of western North Carolina, and the specimens here best fit the description by Kistenich et al. (2019) by their crustose, not squamulose habit with richly abundant, long isidia.

75. *Phyllopsora kalbi* Brako – *Perlmutter 3991* (NCU), of living *Liquidambar styraciflua* trunk. This specimen is distinguished from *P. isidiosa* material above by its short, more globular isidia. While sterile *Phyllopsora* can be difficult to determine to species
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(Kistenich et al. 2019), this specimen readily keys to and matches the description of *P. kalbi* using Timdal and Krog (2001).

76. *Physcia americana* G. Merr. – Dey 408 (NY), substrate not recorded.
78. *Polysporina simplex* (Taylor) Vězda – Perlmutter 3962 (NCU), on exposed flatrock.
79. *Porina heterospora* (Fink ex J. Hedrick) R.C. Harris – Perlmutter 3988 (NCU), on *Carpinus caroliniana* trunk.

80. *Pseudosagecia cestrensis* (Michener) R.C. Harris – Perlmutter 3999 (NCU), on *Carya* branch.
81. *Pseudosagedia guentheri* (Flot.) Hafellner & Kalb – Perlmutter 3998 (NCU, photovoucher, image by Robert Lücking), on vertical granitic rock wall of millpond dam.

82. *Psorotichia* sp. – Perlmutter 4007-b (NCU). On exposed flatrock along river edge below mill dam. Thallus crustose, black, rimose-areolate; photobiont cyanobacteria, present in amphitheciurn, *K*+ orange; Ascomata apothecoid, infrequent, locally crowded; epithecium dark brown; hymenium hyaline, ~140 μm high, *K*/*I*+ blue; spores 4-8/ascus, hyaline to brownish, surface warty, 13-18 x 11.5 μm.

83. *Pterygiopsis cf. cava* M. Schultz – Perlmutter 3961 (NCU), on exposed flatrock. Thallus microfruticose, forming cushions ~2 mm diameter, blackish; photobiont *Gloeocapsa*; ascomata not seen. Keyed to species using Brodo (2016); needs confirmation (M. Schultz, pers. comm. 2 Aug 2021).
84. *Pterygiopsis* sp. 1 – Perlmutter 3969 (NCU), on exposed flatrock. Thallus crustose, thin, continuous, black; photobiont *Gloeocapsa*, sheath reddish, *K*+ golden; spores 8/ascus, simple, hyaline, 9-10 x 3.5-5 μm.
85. *Punctelia rudecta* (Ach.) Krog – Almeda 935 (MSC), on *Juniperus virginiana* branches; Dey 410 (NY), substrate not recorded; Esslinger 3116 (hb. Esslinger), on pine bark; Perlmutter et al. MM-3 (NCU), on *Ulmus alata* twig.
86. *Pyxine sorediata* (Ach.) Mont. – Perlmutter 3984 (NCU), on fallen *Quercus* branch.
87. *Pyxine subcinerea* (Ach.) Stirton – Perlmutter 4009 (NCU), on fallen *Carya*.
90. *Rinodina tephraspis* (Tuck.) Herre – Esslinger 3105 (DUKE), on rock; Perlmutter 68, 69, 3750, 3758, 3960 (NCU, DUKE; Fig. 2B), on granitic flatrock.
91. *Sarcogyne hypophaea* (Nyl.) Arnold – Perlmutter et al. MM-20, MM-23 (NCU), on *Juniperus*.
92. *Traponora varians* (Ach.) J. Kalb & Kalb – Perlmutter 4006 (NCU), on hardwood branches. This species is under study and may represent a distinct genus (Brodo, pers. comm.).
93. *Tuckermanopsis americana* (Sprengel) Hale – Esslinger 3121 (hb. Esslinger), on pine bark; Loveless 2562 (DUKE), on dead pine branches; Shelvin 101 (DUKE), on *Juniperus*.
94. *Tuckermanopsis ciliaris* (Ach.) Gyelnik – Culberson 10484 (DUKE), on *Ulmus alata* branch; Plant Taxonomy Class s.n., 19.X.1974 (BALT), on trees.
95. *Usnea rubicunda* Stirton – Luttrell 1056 (DUKE as *U. pensylvanica*), on *Juniperus virginiana*; Perlmutter et al. MM-7 (NCU), on *Juniperus virginiana* branch; Perlmutter 3999 (NCU), on fallen *Quercus* limb.
96. *Usnea strigosa* (Ach.) Eaton – Anderson s.n., 28.VII.1980 (DUKE), substrate not recorded (fallen from oak tree); Plant Taxonomy Class s.n., 19.X.1974 (BALT), on trees. Observed on *Ulmus alata* branches in Granitic Flatrock Border Woodland in April 2011.
97. *Usnea trichodea* Motyka – Dorsey s.n., 10.VII.1961 (NY), substrate not recorded; Luttrel 1055 (DUKE), on Juniperus; Perlmutter 3956 (NCU; Fig. 2J), on exposed Juniperus twigs at border woodland edge.

98. *Verrucaria nigra* Willd. – Perlmutter et al. MM-2 (NCU), on exposed flatrock.

99. *Verrucaria nigrescens* Pers. – Perlmutter 3753, 3965 (NCU; Fig. 2C), on shaded flatrock. This species is historically reported as a rock pioneer on flatrocks (Oosting and Anderson 1939).


101. *Xanthoparmelia angustiphylla* (Gyelnik) Hale – Perlmutter 3757 (NCU; Fig. 2G), on exposed flatrock.

102. *Xanthoparmelia conspersa* (Ehrh. ex Ach.) Hale – Esslinger 3099 (ID, hb. Esslinger), on rock; Luttrel 1045, 1046 (DUKE), on granite outcrop; Perlmutter 71, 3749 (NCU), on exposed and shaded flatrock; Shriver s.n., 19.X.1974 (BALT), on granite outcrop. This species has been historically reported on bare flatrock (Oosting and Anderson 1939).

103. *Xanthoparmelia hypofusca* (Gyelnik) Hodkinson & Lendemer – Esslinger 3098 (ID as *X. tasmanica*), on rock.


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LITERATURE CITED


