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LICHENS AND AIR QUALITY IN

CUYAHOGA VALLEY NATIONAL RECREATION AREA

FINAL REPORT

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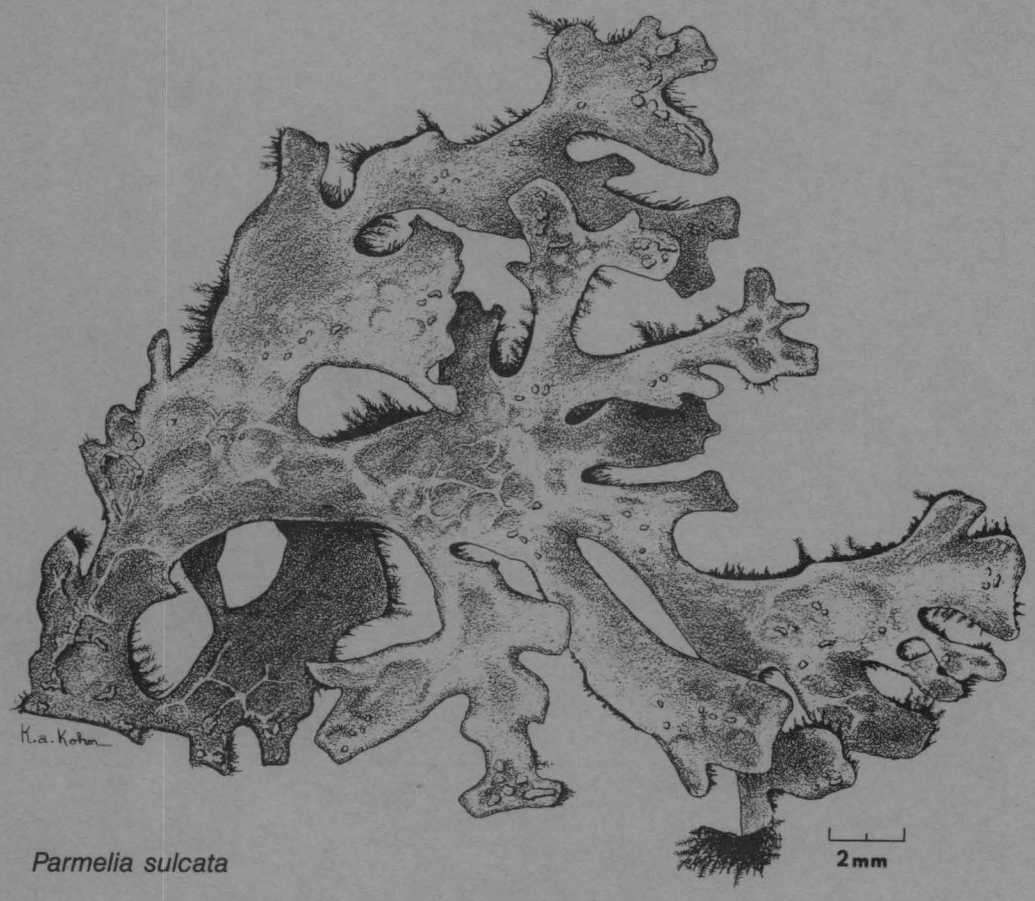

Parmelia sulcata

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IN
CUYAHOGA VALLEY NATIONAL RECREATION AREA

Final Report

National Park Service
Contract CX 0001-2-0034

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LICHENS OF CUYAHOGA VALLEY NATIONAL RECREATION AREA

PREFACE

Under a grant from the National Park Service (USDI CX 0001-2-0034) a lichen study was to be performed in Cuyahoga Valley National Recreation Area. This study was to survey the lichens of the park, produce a lichen flora, collect and analyze lichens for chemical contents and evaluate the lichen flora with reference to the air quality. This study is to establish baseline data for future restudy and determine the presence of any air quality problems as might be shown by the lichens at the time of the study. All work was done at the University of Minnesota with frequent consultation with Dr. James Bennett, NPS-AIR, Denver and with personnel in the park.

The park personnel have been very helpful during the field work which has contributed significantly to the success of the project. The study was made possible by funds from the National Park Service. Dr. E. D. Rudolph provided copies of some of the literature. This assistance is gratefully acknowledged.

INTRODUCTION

Lichens are composite plants composed of two different types of organisms. The lichen plant body (thallus) is made of fungi and algae living together in a symbiotic arrangement in which both partners are benefited and the composite plant body can grow in places where neither component could live alone. The thallus has no protective layer on the outside, such as the epidermis of a leaf, so the air in the thallus has free exchange with the atmosphere. Lichens are slow growing (a few millimeters per year) and remain alive for many years and so must have a habitat that is relatively undisturbed in order to survive. Lichens vary greatly in their ecological requirements but almost all of them can grow in places that only receive periodic moisture. When moisture is lacking they go dormant until the next rain or dew-fall. Some species can grow in habitats with very infrequent occurrences of moisture while others need high humidity and frequent wetting in order to survive. This difference in moisture requirements is very important in the distribution of lichens.

Lichens are known to be very sensitive to low levels of many atmospheric pollutants. Some are damaged or killed by levels of sulfur dioxide as low as 13 ug/cubic meter (annual average) or by nitrogen oxides at 3834-7668 ug/cubic meter or by other strongly oxidizing compounds such as ozone. Other lichens are less sensitive and a few can tolerate levels of sulfur dioxide over 300 ug/cubic meter. The algae of the

thallus are the first to be damaged in areas with air pollution and the first indication of damage is discoloring and death of the algae, which quickly leads to the death of the lichen. Lichens are more sensitive to air pollution when they are wet and physiologically active and are least sensitive when dry. The nature of the substrate is also important in determining the sensitivity to sulfur dioxide since substrates with high pH seem to buffer the fallout and permit the persistence of more sensitive species than one would expect. After the lichen dies it disappears from the substrate within a few months to a year as it disintegrates and decomposes (Wetmore, 1982).

Lichens are able to accumulate chemical elements in excess of their metabolic needs depending on the levels in the substrate and the air and, since lichens are slow growing and long lived, they serve as good summarizers of the environmental conditions in which they are growing. Chemical analysis of the thallus of lichens growing in areas of high fallout of certain elements will show elevated levels in the thallus. Toxic substances (such as sulfur) are also accumulated and determination of the levels of these toxic elements can provide indications of the sub-lethal but elevated levels in the air.

The Cuyahoga Valley National Recreation Area is situated along the Cuyahoga River between Akron and Cleveland. The river is in a fairly deep valley but the park includes some of the upland back from the river also. In some areas there are

sandstone cliffs where streams have cut through the rocks. The vegetation is mostly northern hardwoods with sugar maple (Acer saccharum), hickory (Carya) oaks (Quercus) and beech (Fagus grandifolia) on the slopes and ridgetops. Most of the american elm (Ulmus americana) are dead. In the valleys are red maple (Acer rubrum), boxelder (Acer negundo), ash (Fraxinus), willow (Salix) and some cottonwood (Populus deltoides). Most of the area was probably logged many years ago and the uplands were cleared for farming and homes but many woodlots remain on the uplands and most of the steep hillsides are forested. There are numerous abandoned fields and gravel pits within the park.

There are only a few lichens known from the park prior to this study. Most of the historical species for the area come from the papers by Claassen (1895a, 1895b, 1898, 1903, 1912, 1913, 1914, 1917) who collected in Cuyahoga County around Cleveland. Most of the later literature reports are just citations of these original collections. The most recent summaries of these reports are the two papers on the macrolichens of Ohio by Taylor (1967, 1968) who checked many of the original specimens for his papers. Any lichen species reported from Cuyahoga County or Summit County (where the park is located) were included in the species list in this report. Only a few of the original collections have been cited by monographers. A total of 172 lichens have been reported from these two counties prior to 1920 and another 5 names have been reported that are certain misidentifications.

METHODS

Field work was done during July, 1985 when 304 lichen collections were made at 31 localities in the park. A complete list of collection localities is given in Appendix I and are indicated on Fig. 1. Localities for collecting were selected first to give a general coverage of the park, second, to sample all vegetational types, third, to be in localities that should be rich in lichens. At each locality voucher specimens of all species found were collected to record the total flora for each locality and to avoid missing different species that might appear similar in the field. At some localities additional material of selected species was collected for chemical analysis (see below). While collecting at each locality observations were made about the general health of the lichens.

Identifications were carried out at the University of Minnesota with the aid of comparison material in the herbarium and using thin layer chromatography for identification of the lichen substances where necessary. The original packet of each collection has been deposited in the University of Minnesota Herbarium and a representative set of duplicates will be sent to the Smithsonian Institution. All specimens deposited at the University of Minnesota are being entered into the computerized data base maintained there. Lists of species found at each locality are indicated in Appendix III and are available from this data base at any time on request.

LICHEN FLORA

The following list of lichens is based on my collections

and those reported in the literature. This list includes 66 species found during this study and 139 additional species not found in this study but previously reported from Cuyahoga and Summit Counties. There are an additional 4 unidentified species. In the first columns the letters indicate the sensitivity to sulfur dioxide, if known, according to the categories proposed by Wetmore (1983).: S=Sensitive, I=Intermediate, T=Tolerant. S-I is intermediate between Sensitive and Intermediate and I-T is intermediate between Intermediate and Tolerant. Species in the Sensitive category are absent when annual average levels of sulfur dioxide are above 50ug per cubic meter. The Intermediate category includes those species present between 50 and 100ug and those in the Tolerant category are present at over 100ug per cubic meter.

SPECIES LIST FOR CUYAHOGA VALLEY

205 Potential total species
172 species reported in literature (not counting 5 certain misidentifications)
139 (=*) of these not found in 1985 (=81%) [139/172]
66 species found in 1985
32 of those in literature found in 1985
34 new records found in 1985
38 species found only 1 or 2 times indicated as "Rare"

*Acarospora fuscata (Nyl.) Arn. Claassen, 1912, Claassen, 1917, Wolfe, 1940
*Acarocordia gemmata (Ach.) Mass. Claassen, 1912, Wolfe, 1940
Acarospora immersa Fink Rare
*Anaptychia palmulata (Michx.) Vain. Claassen, 1912, Wolfe, 1940, Taylor, 1967
I Anisomeridium biforme (Borr.) R. Harris Rare
Arthonia caesia (Flot.) Körb.
*Arthonia punctiformis Ach. Claassen, 1912, Wolfe, 1940
I *Arthonia radiata (Pers.) Ach. Claassen, 1912, Wolfe, 1940
1 additional unidentified species of Arthonia
*Arthopyrenia finkii Zahlbr. Claassen, 1917, Wolfe, 1940
*Arthopyrenia punctiformis Mass. Claassen, 1912,

Claassen, 1917, Wolfe, 1940
1 additional unidentified species of Arthopyrenia
*Arthothelium spectabile (Flot. ex Fr.) Mass. Claassen, 1912, Wolfe, 1940
I Bacidia chlorococca (Stizenb.) Lett.
*Bacidia inundata (Fr.) Körb. Claassen, 1917, Wolfe, 1940
*Bacidia laurocerasi (Del. ex Duby) Ozenda & Clauz. Claassen, 1917, Wolfe, 1940
*Bacidia naegelii (Hepp) Zahlbr. Claassen, 1912, Wolfe, 1940
*Bacidia polychroa (=fuscorubella) (Th. Fr.) Körb. Claassen, 1912, Wolfe, 1940
I *Bacidia rubella (Hoffm.) Mass. Claassen, 1912, Wolfe, 1940
Bacidia sabuletorum (Schreb.) Lett. Claassen, 1912, Wolfe, 1940 Rare
*Bacidia schweinitzii (Tuck.) Schneid. Claassen, 1912, Wolfe, 1940
*Bacidia sphaeroides (Dicks.) Zahlbr. Claassen, 1912, Wolfe, 1940
Bacidia trachona (Ach.) Lett. Claassen, 1917, Fink, 1921, Wolfe, 1940 Rare
*Bacidia umbrina (Ach.) Bausch Claassen, 1912, Wolfe, 1940
1 additional unidentified species of Bacidia
*Baeomyces fungoides (Sm.) Ach. Taylor, 1968
*Baeomyces rufus (Huds.) Rebent. Claassen, 1912, Wolfe, 1940
*Biatorella moriformis (Ach.) Th. Fr. Claassen, 1917, Wolfe, 1940
*[Bryoria chalybeiformis Claassen, 1912, Wolfe, 1940, misident.]
S *Bryoria furcellata (Fr.) Brodo & Hawksw. Taylor, 1968
*Buellia disciformis (Fr.) Mudd Claassen, 1912, Wolfe, 1940
T Buellia punctata (Hoffm.) Mass. Claassen, 1917, Fink, 1921, Wolfe, 1940 Rare
*Buellia spuria (Schaer.) Anzi Claassen, 1917, Wolfe, 1940
S-I *Caloplaca cerina (Ehrh. ex Hedw.) Th. Fr. Claassen, 1895b, 1912, Wolfe, 1940
*Caloplaca cinnabarina (Ach.) Zahlbr. Wolfe, 1940
Caloplaca citrina (Hoffm.) Th. Fr. Rare
Caloplaca feracissima Magn.
S *Caloplaca flavorubescens (Huds.) Laund. Claassen, 1912, Wolfe, 1940
I *Caloplaca holocarpa (Hoffm.) Wade. Claassen, 1914, 1917, Wolfe, 1940
Caloplaca sideritis (Tuck.) Zahlbr. Rare
S-I Candelaria concolor (Dicks.) B. Stein Claassen, 1895b, 1912, Wolfe, 1940, Taylor, 1967
*Candelaria fibrosa (Fr.) Müll. Arg. Taylor, 1967
Candelariella effloresceens Harris & Buck
I *Candelariella vitellina (Hoffm.) Müll. Arg. Claassen,

1912
*Cetraria aurescens Tuck. Taylor, 1967
S-I *Cetraria ciliaris Ach. Claassen, 1895b,1912, Wolfe, 1940, Taylor, 1967
*Cetraria ericetorum Opiz Taylor, 1968, Taylor, 1967
*[Cetraria islandica Claassen, 1895a, 1895b, 1912, Wolfe, 1940, misident.,=Cetraria ericetorum]
*Cladina arbuscula (Wallr.) Hale & W. Culb. Claassen, 1912, Wolfe, 1940, Taylor, 1968
Cladina rangiferina (L.) Harm. Claassen, 1895b, 1912, Wolfe, 1940, Taylor, 1968 Rare
*Cladonia apodocarpa Robb. Taylor, 1968
Cladonia bacillaris (Ach.) Nyl. Claassen, 1912, Wolfe, 1940, Taylor, 1968
Cladonia caespiticia (Pers.) Flörke Claassen, 1912, Wolfe, 1940, Taylor, 1968
Cladonia chlorophaea (Flörke ex Somm.) Spreng. Rare
Cladonia coccifera (L.) Willd. Claassen, 1912, Wolfe, 1940 Rare
I Cladonia coniocraea (Flörke) Spreng. Taylor, 1968
Cladonia cornuta (L.) Hoffm. Rare
I Cladonia cristatella Tuck. Claassen, 1895b, 1912, Wolfe, 1940, Taylor, 1968
*Cladonia cryptochlorophaea Asah. Taylor, 1968
Cladonia cylindrica (Evans) Evans Taylor, 1968 Rare
S-I *Cladonia fimbriata (L.) Fr. Claassen, 1912, Taylor, 1968
Cladonia furcata (Huds.) Schrad. Claassen, 1895b, 1912, Wolfe, 1940, Taylor, 1968 Rare
*Cladonia gracilis (L.) Willd. Claassen, 1912, Wolfe, 1940
Cladonia grayi Merr. ex Sandst. Taylor, 1968
*Cladonia humilis (With.) Laund. Taylor, 1968
*Cladonia macilenta Hoffm. Claassen, 1917, Wolfe, 1940, Taylor, 1968
*Cladonia parasitica (Hoffm.) Hoffm. Claassen, 1895b, 1917, Wolfe, 1940, Taylor, 1968
Cladonia peziziformis (With.) Laundon Claassen, 1895b, 1912, Wolfe, 1940, Taylor, 1968
Cladonia polycarpoides Nyl. Claassen, 1912, Wolfe, 1940, Taylor, 1968
*Cladonia pyxidata (L.) Hoffm. Claassen, 1895b, 1903, 1912, Wolfe, 1940, Taylor, 1968
Cladonia ramulosa (With.) Laund. Rare
Cladonia rei Schaer. Taylor, 1968 Rare
Cladonia robbinsii Evans Rare
Cladonia squamosa (Scop.) Hoffm. Claassen, 1895b, 1912, Wolfe, 1940, Taylor, 1968 Rare
Cladonia strepsilis (Ach.) Vain. Rare
*Cladonia subulata (L.) Webb. in Wigg. Claassen, 1912, Wolfe, 1940
Cladonia verticillata (Hoffm.) Schaer. Claassen, 1895b, 1912, Wolfe, 1940, Taylor, 1968 Rare
*Collema nigrescens (Huds.) DC. Claassen, 1912, Wolfe, 1940

*Collema subflaccidum Degel. (=subfurvum) Taylor, 1967
*Collema tenax (Sw.) Ach. Taylor, 1967
*Coniocybe pallida (Pers.) Fr. Claassen, 1912, Wolfe, 1940
*Dermatocarpon luridum (With.) Laund. Taylor, 1967
*Dermatocarpon miniatum (L.) Mann Claassen, 1912, Wolfe, 1940, Taylor, 1967
Endocarpon pusillum Hedw. Rare
*Eopyrenula leucoplaca (Wallr.) R. Harris Claassen, 1912, Wolfe, 1940
I *Evernia mesomorpha Nyl. Claassen, 1912, Wolfe, 1940, Taylor, 1968
I *Graphis scripta (L.) Ach. Claassen, 1912, Wolfe, 1940
*Heterodermia granulifera (Ach.) W. Culb. Taylor, 1967
*Heterodermia hypoleuca (Muehl.) Trev. Claassen, 1912, Wolfe, 1940, Taylor, 1967
*Heterodermia leucomelos (L.) Poelt Wolfe, 1940
*Heterodermia obscurata (Nyl.) Trev. Taylor, 1967
*Heterodermia speciosa (Wulf.) Trev. Claassen, 1912, Taylor, 1967
Hymenelia lacustris (With.) Poelt & Vezda Rare
I *Hyperphyscia adglutinata (Flörke) Mayrh. & Poelt Claassen, 1912, Wolfe, 1940, Taylor, 1967
*Hyperphyscia syncolla (Tuck. ex Nyl.) K. Kalb Taylor, 1967
I *Hypogymnia physodes (L.) Nyl. Claassen, 1912, Wolfe, 1940, Taylor, 1967
I *Lecanora allophana Nyl. Claassen, 1895b, 1989, 1912, Wolfe, 1940
*Lecanora campestris (Schaer.) Hue Claassen, 1917, Wolfe, 1940
T Lecanora dispersa (Pers.) Somm.
T *Lecanora hagenii (Ach.) Ach. Claassen, 1912, Wolfe, 1940
T *Lecanora muralis (Schreb.) Rabenh. Claassen, 1912, Wolfe, 1940
I *Lecanora pallida (Schreb.) Rabenh. Claassen, 1912, Wolfe, 1940
Lecanora polytropa (Hoffm.) Rabenh. Rare
*Lecanora varia (Hoffm.) Ach. Claassen, 1895b, 1912, Wolfe, 1940
Lecidea aeruginosa Borr. in Hook. & Sowerb. Rare
Lecidea cyrtidia Tuck. Claassen, 1912, Wolfe, 1940
Lecidea erratica Körb.
Lecidea granulosa (Ehrh.) Ach. Rare
*Lecidea lactea Flörke ex Schaer. Claassen, 1917, Wolfe, 1940
I Lecidea scalaris (Ach.) Ach.
*Lecidea spirea (Ach.) Ach. Claassen, 1912, Wolfe, 1940
S *Lecidea vernalis (L.) Ach. Claassen, 1912, Wolfe, 1940
*Lecidea viridescens (Schrad.) Ach. Claassen, 1912, Wolfe, 1940
Lepraria finkii (B. de Lesd. in Hue) R. Harris
*Lepraria membranacea auct. Claassen, 1917, Wolfe, 1940
Lepraria neglecta (Nyl.) Lett. Rare

*Leptogium burnetiae Dodge Taylor, 1967
*Leptogium corticola (Tayl.) Tuck. Claassen, 1895b, 1912, Wolfe, 1940, Taylor, 1967
*Leptogium cyanescens (Rabenh.) Körb. Claassen, 1903, 1912, Wolfe, 1940, Taylor, 1967
*Leptogium dactylinum Tuck. Taylor, 1967
*Leptogium juniperinum Tuck. Taylor, 1967
*Leptogium lichenoides (L.) Zahlbr. Claassen, 1912, Wolfe, 1940, Taylor, 1967
S *Lobaria pulmonaria (L.) Hoffm. Claassen, 1895b, 1912, Wolfe, 1940, Taylor, 1967
*Lobaria quercizans Michx. Claassen, 1895b, 1912, Wolfe, 1940, Taylor, 1967
Micarea melaena (Nyl.) Hedl. Rare
*Microthelia micula Körb. ex Körb. Claassen, 1912, Wolfe, 1940
*Mycocalicium subtile (Pers.) Szat. Claassen, 1912, Wolfe, 1940
*Nephroma bellum (Spreng.) Tuck. Claassen, 1895b, 1912, Wolfe, 1940
*Ochrolechia pallescens (L.) Mass. Claassen, 1912, Wolfe, 1940
I *Opegrapha varia Pers. Claassen, 1912, Wolfe, 1940
*Opegrapha viridis (Pers. ex Ach.) Nyl. Claassen, 1912, Wolfe, 1940
I *Opegrapha vulgata Ach. Claassen, 1912, Wolfe, 1940
Parmelia aurulenta Tuck. Taylor, 1967 Rare
*Parmelia bolliana Müll. Arg. Taylor, 1967
I Parmelia caperata (L.) Ach. Claassen, 1895b, 1903, 1912, Wolfe, 1940, Taylor, 1967
*Parmelia conspersa (Ehrh. ex Ach.) Ach. Claassen, 1912, Wolfe, 1940
*Parmelia crinita Ach. Claassen, 1895b, Wolfe, 1940
Parmelia flaventior Stirt. Rare
*Parmelia galbina Ach. Claassen, 1912, Wolfe, 1940, Taylor, 1967
*Parmelia livida Tayl. Taylor, 1967
*Parmelia margaritata Hue Taylor, 1967
I *Parmelia olivacea (L.) Ach. Claassen, 1912, Wolfe, 1940
*Parmelia perforata (Jacqu.) Ach. Claassen, 1912, Wolfe, 1940
S *Parmelia perlata (Huds.) Vain. Claassen, 1912, Wolfe, 1940, Taylor, 1967
*Parmelia plittii Gyeln. Taylor, 1967
I Parmelia rudecta Ach. Claassen, 1912, Wolfe, 1940, Taylor, 1967
S *Parmelia squarrosa Hale Claassen, 1903, 1912, Wolfe, 1940, Taylor, 1967
S Parmelia subaurifera Nyl. Taylor, 1967 Rare
I Parmelia subrudecta Nyl. Taylor, 1967 Rare
*Parmelia subtinctoria Zahlbr. Taylor, 1967
I-T Parmelia sulcata Tayl. Taylor, 1967
I *Parmeliopsis aleurites (Ach.) Nyl. Taylor, 1967
*Peltigera aphthosa (L.) Willd. Claassen, 1912, Wolfe,

1940

*Peltigera canina (L.) Willd. Claassen, 1895b, 1903, 1912, Corrington, 1921, Wolfe, 1940, Taylor, 1967

*Peltigera didactyla (With.) Laund. Claassen, 1912, Wolfe, 1940, Taylor, 1967

Peltigera evansiana Gyeln. Rare

I *Peltigera horizontalis (Huds.) Baumg. Claassen, 1912, Wolfe, 1940, Taylor, 1967

*Peltigera polydactyla (Neck.) Hoffm. Claassen, 1912, Wolfe, 1940, Taylor, 1967

*Peltigera rufescens (Weis) Humb. Corrington, 1921, Wolfe, 1940

*Pertusaria leioplaca DC. in Lam. & DC. Claassen, 1912, Wolfe, 1940

*Pertusaria ophthalmiza (Nyl.) Nyl. Claassen, 1912, Wolfe, 1940

*[Pertusaria pertusa Claassen, 1912, Wolfe, 1940, misident.]

*Pertusaria pustulata (Ach.) Duby Claassen, 1912, Wolfe, 1940

*Pertusaria velata (Turn.) Nyl. Claassen, 1912, Wolfe, 1940

Phaeophyscia adiastola (Essl.) Essl.

*Phaeophyscia ciliata (Hoffm.) Moberg Claassen, 1912, Wolfe, 1940, Thomson, 1963, Taylor, 1967

I *Phaeophyscia orbicularis (Neck.) Moberg Taylor, 1967

Phaeophyscia pusilloides (Zahlbr.) Essl.

Phaeophyscia rubropluchra (Degel.) Moberg Claassen, 1912, Wolfe, 1940

I *Physcia aipolia (Ehrh. ex Humb.) Furnrohr Taylor, 1967

*Physcia americana Merr. Taylor, 1967

I Physcia millegrana Degel. Claassen, 1895b, 1912, Wolfe, 1940, Taylor, 1967

I *Physcia stellaris (L.) Nyl. Claassen, 1895b, 1912, Wolfe, 1940, Taylor, 1967

I Physconia detersa (Nyl.) Poelt Taylor, 1967 Rare

I *Physconia distorta (With.) Laund. Claassen, 1895b

Placynthiella icmalea (Ach.) Coppins & James Rare

*Placynthium nigrum (Huds.) S. Gray Claassen, 1912, Wolfe, 1940

*Placynthiella uliginosa Claassen, 1912, Wolfe, 1940

*Platismatia tuckermanii (Oakes) W. Culb. & C. Culb. Claassen, 1912, Wolfe, 1940, Taylor, 1967

Porpidia albocaerulescens (Wulf.) Hert. & Knoph Claassen, 1895b, 1903, 1912, Wolfe, 1940

Porpidia crustulata (Ach.) Hert. & Knoph

*Porpidia macrocarpa (DC.) Hert. & Schwab Claassen, 1912, Claassen, 1917, Wolfe, 1940

Psorotichia schaereri (Mass.) Arn. Rare

I *Pyrenula nitida (Weig.) Ach. Claassen, 1912, Wolfe, 1940

S *Ramalina americana Hale Taylor, 1968

S *Ramalina calicaris (L.) Fr. Claassen, 1895b, 1912, Wolfe, 1940

*Ramalina complanata (Sw.) Ach. Taylor, 1968

S *Ramalina farinacea (L.) Ach. Claassen, 1912, Wolfe, 1940, Taylor, 1968
S *Ramalina fraxinea (L.) Ach. Claassen, 1912, Wolfe, 1940
*Ramalina intermedia (Del. ex Nyl.) Nyl. Taylor, 1968
S *Ramalina pollinaria (Westr.) Ach. Taylor, 1968
*Rhizocarpon concentricum (Dav.) Beltr. Claassen, 1912, Wolfe, 1940
I *Rinodina exigua (Ach.) S. Gray Claassen, 1912, Wolfe, 1940
*[Rinodina sophodes Claassen, 1912, Wolfe, 1940, misident.]
*Sarcogyne simplex (Dav.) Nyl. Wolfe, 1940
*Stereocaulon dactylophyllum Flörke Claassen, 1912, Wolfe, 1940
*Stereocaulon saxatile Magn. Taylor, 1968
*Stereocaulon tomentosum Fr. Taylor, 1968
Thelidium parvulum Arn. Rare
*Tomasellia sparsella (Nyl.) R. Harris Claassen, 1912
Trapelia coarctata (Sm.) Choisy in Werner Claassen, 1912, Wolfe, 1940 Rare
Trapelia involuta (Tayl. in Mack.) Hert.
Trapelia placodioides Coppins & James Rare
*Trypethelium virens Tuck. ex Michx. in Darl. Claassen, 1912, Wolfe, 1940
*[Usnea barbata Claassen, 1895b, Wolfe, 1940, misident.]
S-I *Usnea hirta (L.) Web. in Wigg. Claassen, 1912
*Verrucaria fuscella (Turn.) Winch Claassen, 1912, Wolfe, 1940
Verrucaria muralis Ach. Claassen, 1912 Rare
*Verrucaria nigrescens Pers. Claassen, 1912, Wolfe, 1940
Verrucaria rupestris Schrad. Claassen, 1898, Wolfe, 1940
*Verrucaria viridula (Schrad.) Ach. Claassen, 1912
S-I *Xanthoria fallax (Hepp in Arn.) Arn. Claassen, 1912, Wolfe, 1940
I *Xanthoria polycarpa (Hoffm.) Rieber Claassen, 1912, Claassen, 1917, Wolfe, 1940, Taylor, 1967

DISCUSSION OF FLORA

The lichen floras of the northern hardwood forests in the southern Great Lakes Area probably never were very rich when compared to some other areas of the country. In many of these forests there is too much shade for good lichen growth. Open roadsides and farmyards always have more lichens that the interior of the woods. However, there are some localities, such as Stumpy Basin, with microhabitats suitable for the lichens that should have many more lichens than are present. A

total of 172 species were reported for Summit and Cuyahoga Counties in the literature up to 1917. Of these 139 species were not found in this study (81%). This list of species includes 34 new records for the region. Adding the new records to the list of historical species produces a potential lichen flora of 205 species. The most common species are Arthonia caesia, Bacidia chlorococca, Parmelia sulcata and Physcia millegrana. All of the previously reported species most sensitive to sulfur dioxide are gone along with several in the S-I and Intermediate categories. All of the 16 species with blue green algae formerly know for the area are gone but I found one species with blue green algae not previously reported for the region. Many of the species still present are rare. There are 38 species found only once or twice in the whole park.

Appendix III lists lichens present by localities. The localities are arranged from north to south. There are very few lichens at the northern end of the park but this may be due to lack of suitable habitats or other factors. There seems to be no clear trend in numbers of sensitive species according to the arrangement by localities in Appendix III. There are also more species in O'Neil Woods that at any other locality, including Stumpy Basin.

There were several cases where lichens sensitive to sulfur dioxide were observed to be damaged or killed. The species present are small and sometimes have distorted growth. Some species, especially Arthonia caesia, normally found

fertile were frequently sterile in the park.

These observations indicate that there is air quality degradation in the park that has eliminated most of the lichen flora.

Since lichens are not known to be sensitive to acid precipitation, no conclusions can be drawn about this environmental contaminant. However, preliminary reports indicate that some species of Umbilicaria do show damage from acid precipitation by dying at the margins. No specimens of this genus were seen in the park.

Another way of analyzing the lichen flora of an area is to study the distributions of the sensitive species within the park to look for voids in the distributions that might be caused by air pollution. Showman (1975) has described and used this technique in assessing sulfur dioxide levels around a power plant in Ohio. Only the very common species have meaning with such a technique since the rare species may be absent due to other factors.

All but one of the lichens in the most sensitive category in the list presented in Wetmore (1983) are gone from the present flora and only a few species present are in the S-I category and most of these are not very common. Parmelia subaurifera is listed in the S category in Wetmore (1983) but probably belongs in the S-I category. Species in the most sensitive category are usually absent when sulfur dioxide levels are above 50ug per cubic meter average annual concentrations. The S-I category is between Sensitive and

Intermediate. The species in the S and S-I categories that occur in the park are as follows.

S Parmelia subaurifera (one collection)
S-I Candelaria concolor

These species occur too infrequently in the park to provide useful information with this technique but they are mapped to show their present occurrence (Fig. 2-3).

ELEMENTAL ANALYSIS

An important method of assessing the effects of air quality is by examining the elemental content of the lichens (Nieboer et al, 1972, 1977, 1978; Erdman & Gough, 1977; Puckett & Finegan, 1980; Nash & Sommerfeld, 1981). Elevated but sublethal levels of sulfur or other elements might indicate incipient damaging conditions.

One species of lichen was collected for elemental analysis at two localities in the park.

METHODS

Lichen samples of Parmelia rudecta were collected in spunbound olefin sample bags at two localities in different parts of the park for laboratory analysis. This was the only species abundant enough to use and relatively easily cleaned and was collected from hardwood trees. It was found in abundance at only two localities: Furnace Run near Richfield in the middle part of the park, and in O'Neil Woods at the southern end of the park. These localities are indicated on the map of collection localities (Fig. 1). Ten to 20 grams were collected at each locality for analysis.

Lichens were air dried and cleaned of all bark under a dissecting microscope but thalli were not washed. Three samples of each collection were submitted for analysis. Analysis was done for sulfur and multi-element analysis by the Research Analytical Laboratory at the University of Minnesota. In the sulfur analysis a ground and pelleted 100-150 mg sample was prepared for total sulfur by dry combustion and measurement of evolved sulfur dioxide on a LECO Sulfur Determinator, model no. SC-132, by infra red absorption. Multi-element determination for Ca, Mg, Na, K, P, Fe, Mn, Al, Cu, Zn, Cd, Cr, Ni, Pb, and B were determined simultaneously by Inductively Coupled Plasma (ICP) Atomic Emission Spectrometry. For the ICP one gram of dried plant material was dry ashed in a 20 ml high form silica crucible at 485 degrees Celsius for 10-12 hrs. Crucibles were covered during the ashing as a precaution against contamination. The dry ash was boiled in 2N HCl to improve the recovery of Fe, Al and Cr and followed by transfer of the supernatant to 7 ml plastic disposable tubes for direct determination by ICP.

RESULTS AND DISCUSSION

Table 1 gives the results of the analyses for all replicates. All reported values are above the lower detection limits of the instruments. All of the levels found in the Cuyahoga Valley lichens are within typical limits for similar lichens although there are no literature reports on analyses of this species. The sulfur levels in lichens tested range from 1320 to 2420 ppm for all samples and these values are

Table 1. Analysis of *Parmelia rudecta* from Cuyahoga Valley
Values in ppm of thallus

P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Pb	Ni	Cr	Cd	S	Locality
1388	4253	34809	540	196	257	9.8	17.0	28.9	4.0	1.7	54.7	1.1	0.7	0.7	1320	Furnace Run
1257	3972	37241	522	205	273	11.7	17.1	29.6	3.9	1.7	56.6	1.2	0.7	0.6	1340	Furnace Run
1298	4011	39090	519	192	265	7.4	16.8	29.1	3.8	1.5	55.1	1.0	0.7	0.7	1400	Furnace Run
1011	2847	4417	414	304	423	17.0	78.7	51.5	4.9	4.1	9.9	1.2	1.5	0.1	2380	O'Neil Woods
1039	2866	3894	417	287	385	18.8	77.6	50.2	4.9	4.0	10.5	1.3	1.4	0.1	2380	O'Neil Woods
1046	2966	4721	421	285	373	16.2	80.1	49.7	4.9	4.0	10.9	1.2	1.4	0.2	2420	O'Neil Woods

Summary of analysis of *Parmelia rudecta* from Cuyahoga Valley
Values in ppm of thallus

	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Pb	Ni	Cr	Cd	S	Locality
Mean	1315	4078	37047	527	198	265	9.6	16.9	29.2	3.9	1.6	55.5	1.1	0.7	0.7	1353	Furnace Run
Std. dev.	67	152	2147	11	6	8	2.2	0.1	0.4	0.1	0.1	1.0	0.1	.0	0.1	42	Furnace Run
Mean	1032	2893	4344	418	292	394	17.3	78.8	50.5	4.9	4.0	10.4	1.2	1.4	0.2	2393	O'Neil Woods
Std. dev.	18	64	418	3	10	26	1.3	1.3	1.0	.0	0.1	0.5	0.1	0.1	0.1	23	O'Neil Woods

near background levels for other species as cited by Solberg (1967) Erdman & Gough (1977), Nieboer et al (1977) and Puckett & Finegan (1980). There are no literature reports on elemental levels of Parmelia rudecta. Different species may accumulate different amounts of elements so valid comparisons with other species cannot be made. The sulfur levels in Parmelia are much higher at O'Neil Woods than at Furnace Run.

Of the other elements, Ca and Pb are much higher at Furnace Run and Na, Mn and Zn are much higher at O'Neil Woods. The Furnace Run locality was along a little-used dirt road about a half mile from the main highway but down a small valley from the highway and some automobile fumes may drift down this valley. The O'Neil Woods collection shows higher levels of typical industrial pollutants. This lichen was completely absent from the northern localities near Cleveland so it is not possible to say whether pollution levels are higher in the southern or northern extremes of the park based on this analysis. It may be that levels near Cleveland are higher and have eliminated this species there.

CONCLUSIONS

The present lichen flora of Cuyahoga Valley is severely damaged by air pollution. Only about 19% of the species reported in the literature for these two counties are still present. All of the species most sensitive to sulfur dioxide are gone and several in the less sensitive categories also. Some of the species present are small or show distorted growth or are sterile. There is no clear gradient in species

abundance from north to south. The elemental analyses show higher levels of industrial pollutants in the southern end of the park but no analysis was possible at the northern end of the park.

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APPENDIX I

Collection Localities

Collection numbers are those of Clifford Wetmore. All collections are listed in ascending order by collection number and date of collection.

54055-54067 Cuyahoga Co., One mile SW of Jaite and headquarters area on Snowville Road. In hardwood forest and small stream valley with maple, beech and oak. 11 July 1985.

54068-54071 Cuyahoga Co., One mile N of Boston on Stanford Road. Around old home and on hill in dense hardwoods. 11 July 1985.

54072-54078 Summit Co., South of Brandywine Road and W of old railroad grade. In dense hardwood forest along stream. 11 July 1985.

54079-54092 Summit Co., Deep Lock Quarry at S edge of Peninsula. In hardwood forest around old quarry. 13 July 1985.

54093-54101 Summit Co., Along Boston Mill Road SW of Boston near interstate and turnpike. On S facing slope in hardwoods with some small openings. 13 July 1985.

54102-54117 Summit Co., Near railroad and Boston Mill Road on E side of park. In open area with scattered rocks, ash and cottonwood. 13 July 1985.

54118-54130 Summit Co., One mile SE on Wetmore Road S of Peninsula. Around old farmyard. 13 July 1985.

54131-54146 Summit Co., O'Neil Woods in SW corner of park. Along small stream in mixed hardwoods. 16 July 1985. chem
41° 09' 52" N 81° 35' 27" W 780 ft

54147-54161 Summit Co., 1.5 miles WNW of Northampton Center. Around old homestead in open abandoned fields. 16 July 1985.

54162-54174 Summit Co., On Northampton Road 1.25 miles N of Steels Corners Road. At pipeline station in clearing and in oak woods. 16 July 1985.

54175-54180 Summit Co., Northampton Center in SE corner of park. In open fields and along gulch in woods. 16 July 1985.

54181-54184 Summit Co., At north edge of Ira along canal by river. Hardwoods and brush along towpath. 17 July 1985.

54185- Summit Co., 1.5 miles W of Everett north of Everett
54195 Road. Along abandoned road on ridge in hardwoods and pines. 17 July 1985.

54196- Summit Co., Major farm at bend in Major Road (2 mi WSW
54204 of Peninsula). In old pasture with very old big trees in open woods. 17 July 1985.

54205- Summit Co., On Major Road 1 mile SW of Peninsula.
54213 Around small pond with open fields and some trees. 17 July 1985.

54214- Summit Co., Furnace Run at north side of interstate (I-271) E
54226 of Richfield. On roadbank and in woods. 18 July 1985. chem
41° 14' 17" N 81° 36' 29" W 850 ft

54227- Summit Co., Northern end of Furnace Run near picnic
54233 ground N of Richfield. Open trees around meadow. 18 July 1985.

54234- Summit Co., Boston Ledges near highway 303 and 8 (2
54244 miles E of Peninsula). Along deep gully with stream in dense hardwoods. 19 July 1985.

54245- Summit Co., Happy Days Camp ledges (2 miles E of
54253 Peninsula). Around sandstone ledges among hemlock and hardwoods. 19 July 1985.

54254- Summit Co., 1 mile SW of Everett. In old gravel pit
54262 overgrown with weeds and brush. 19 July 1985.

54263- Cuyahoga Co., Half mile S of Brecksville near
54272 maintenance buildings. In valley and clearings near road. 21 July 1985.

54273- Summit Co., 2 miles SE of Brecksville along Cuyahoga
54287 River. In trees at old homestead and along canal and lock with cottonwoods, aspen and boxelder. 21 July 1985.

54288- Cuyahoga Co., 2 miles SE of Independence at sewage
54295 disposal plant along river. On cottonwoods and along railroad bank. 21 July 1985.

54296- Cuyahoga Co., Eastern edge of Valley View. In deep
54308 gulch down from old railroad grade with hemlock, oak and sassafras. 21 July 1985.

54309- Cuyahoga Co., SE of Independence at N end of Riverview
54314 Road. On E facing hillside in hardwoods and in river bottom with cottonwood and boxelder. 22 July 1985.

54315- Cuyahoga Co., SE of Independence around gravel pit.
54322 Disturbed area between railroad and river. 22 July 1985.

54323 Cuyahoga Co., S edge of Maple Heights at Dunham Road S of Tinkers Creek near golf course. Around old homestead with much brush. 22 July 1985.

54324-54326 Cuyahoga Co., S edge of Maple Heights on Tinkers Creek Road E of Dunham Road. On stone wall near road. 22 July 1985.

54327-54334 Cuyahoga Co., S of Bedford at picnic ground on park drive. Dense hardwoods but open areas around parking lot. 22 July 1985.

54335-54343 Summit Co., West of bend in Major Road 2 miles SW of Peninsula. In gullies along stream back of Major Farm with beech, maple and oak. 23 July 1985.

54344-54358 Summit Co., Stumpy Basin N of Peninsula. In open floodplain with ash, elm and sycamore. 23 July 1985.

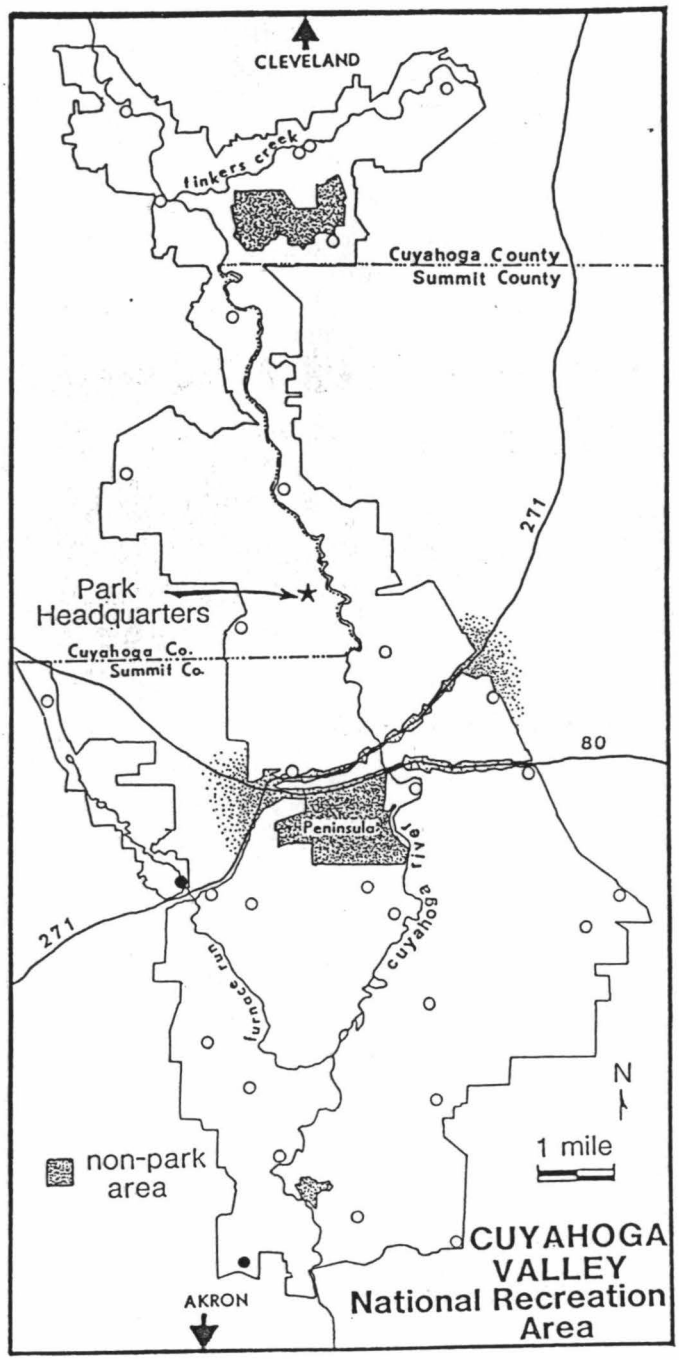

Fig. 1. Open circles are collection localities, solid circles are elemental analysis localities.

APPENDIX II

Species Sensitive to Sulfur Dioxide

Based on the list of lichens with known sulfur dioxide sensitivity compiled from the literature, the following species in Cuyahoga Valley fall within the Sensitive and Sensitive/Intermediate categories as listed by Wetmore, 1983. Sensitive species (S) are those present only under 50ug sulfur dioxide per cubic meter (average annual). The intermediate category includes species present between 50ug and 100ug. The S-I group falls between the Sensitive and Intermediate categories. Open circles are localities where the species was not found and solid circles are where it was found.

Note: Refer to text for interpretation of these maps and precautions concerning absence in parts of the park.

Fig. 2 S *Parmelia subaurifera* Nyl.
Fig. 3 S-I *Candelaria concolor* (Dicks.) B. Stein.

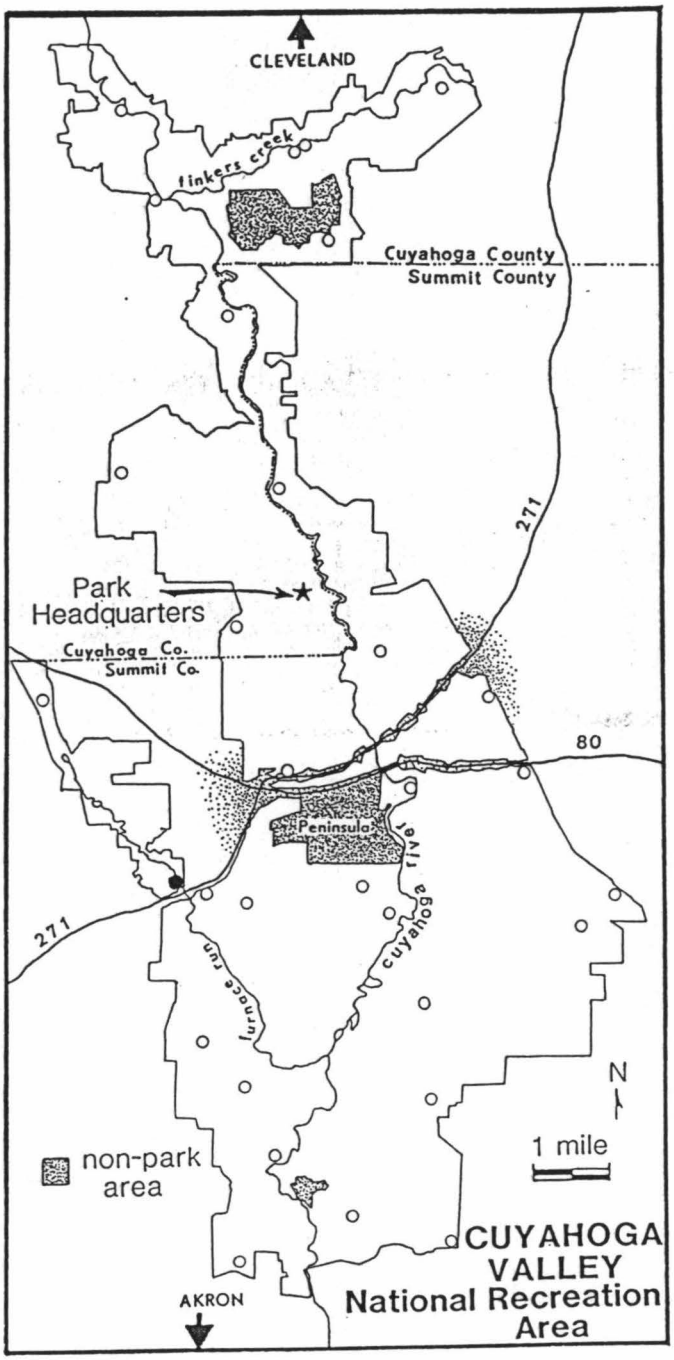

Fig. 2. Parmelia subaurifera

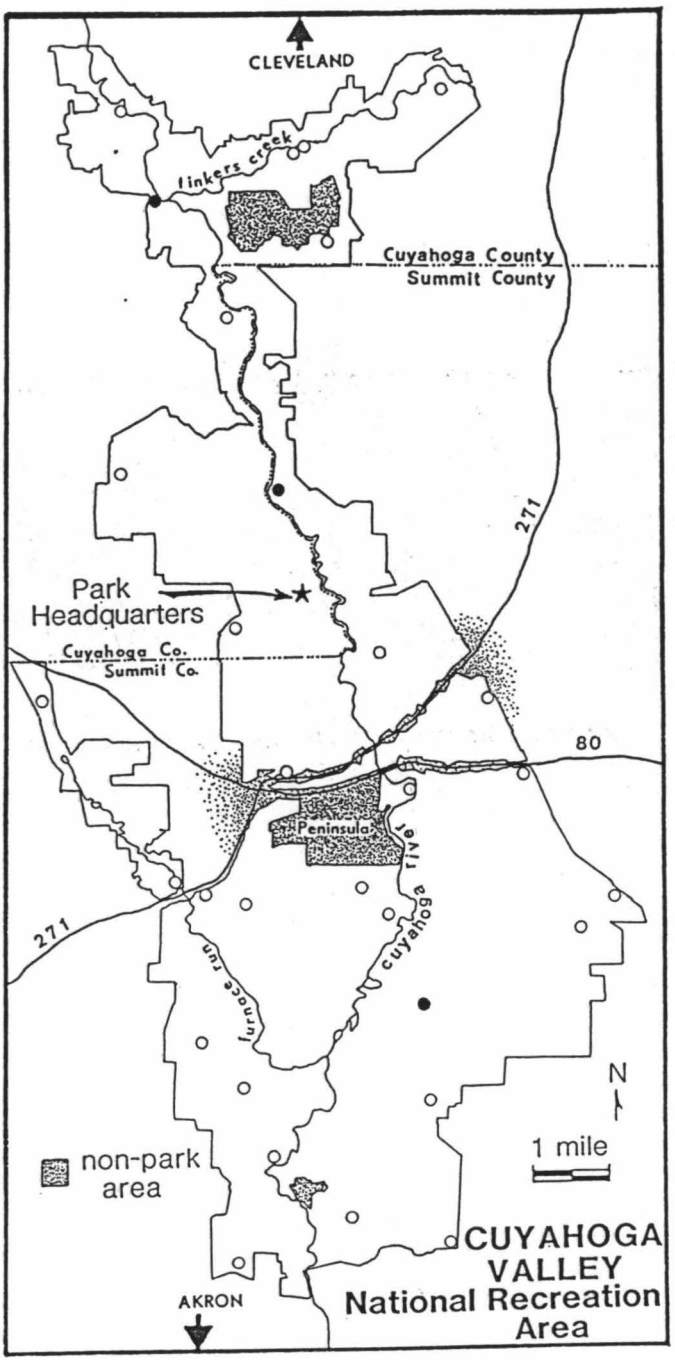

Fig. 3. Candelaria concolor

APPENDIX III

Species lists for each locality in Cuyahoga Valley NRA. Localities are arranged from north to south with species found only once or twice marked by *.

Summary of localities with numbers of species in each sensitivity category.

		Species	S	S-I	I	I-T	T
1	Independence, SE of	8			1	1	
2	Bedford, S of, picnic area	8			1	1	
3	Maple Hts., Tinkers Cr. Rd	2					
4	Maple Hts., Tinkers Creek	1					
5	Independence, Riverview Rd	6		1	2		
6	Valley View, E edge of	11			1		
7	Independence, 2 mi SE	7			2	1	
8	Brecksville, S of	9			1		2
9	Brecksville, 2 mi SE of	13		1	3	1	
10	1 mi SW of Jaite	11			2		
11	1 mi N of Boston	4			1		
12	Furnace Run N of Richfield	6			3		
13	S of Brandywine Road	7			1	1	
14	Boston Mill Rd SW of Boston	8			2		
15	Railroad & Boston Mill Road	14			4	1	
16	Stumpy Basin N of Peninsula	11			5	1	
17	Furnace Run E of Richfield	13	1		2	1	
18	Peninsula, SW of, Major Rd	9			4	1	
19	Major farm on Major Road	9			4	1	
20	Peninsula, Major Rd 1 mi SW	8			3	1	
21	Boston Ledges	8			3		
22	Peninsula, Deep Lock Quarry	12			4	1	
23	Happy Days Camp ledges	8			1		
24	Wetmore road S of Peninsula	13		1	7	1	1
25	Everett, 1.5 mi W of	10			5	1	
26	Everett, 1 mi SW of	7			1	1	
27	Northampton Road	10			4	1	
28	Ira	4			1	1	
29	Northampton Center, WNW of	12			4		
30	Northampton Center	5			2		
31	O'Neil Woods	16			6	1	
	Total possible		1	1	9	1	2

Complete species lists by localities
*=Rare

1 Independence, SE of 8 species
Caloplaca feracissima
I *Cladonia cristatella*
Cladonia peziziformis
T *Lecanora dispersa*

Lecidea erratica
*Thelidium parvulum
*Trapelia coarctata
Verrucaria rupestris

2 Bedford, S of, picnic area 8 species
Arthonia caesia
Cladonia bacillaris
Cladonia caespiticia
Lepraria finkii
I-T Parmelia sulcata
Phaeophyscia rubropulchra
I Physcia millegrana
Porpidia albocaerulescens

3 Maple Hts., Tinkers Creek Road 2 species
*Bacidia sabuletorum
Lepraria finkii

4 Maple Hts., Tinkers Creek 1 species
Arthonia caesia

5 Independence, Riverview Road 6 species
I *Anisomeridium biforme
Arthonia caesia
S-I Candelaria concolor
Lepraria finkii
Phaeophyscia pusilloides
I Physcia millegrana

6 Valley View, E edge of 11 species
*Bacidia sabuletorum
Cladonia bacillaris
I Cladonia cristatella
Cladonia grayi
*Cladonia strepsilis
*Endocarpon pusillum
Lepraria finkii
Phaeophyscia adiastola
Porpidia crustulata
*Psorotichia schaereri
Verrucaria rupestris

7 Independence, 2 mi SE 7 species
Arthonia caesia
I Cladonia coniocraea
Cladonia peziziformis
Lecidea cyrtidia
*Parmelia flaventior
I-T Parmelia sulcata
I Physcia millegrana

8 Brecksville, S of 9 species
Arthonia caesia

I Bacidia chlorococca
T *Buellia punctata
Caloplaca feracissima
T Lecanora dispersa
Lecidea cyrtidia
Lepraria finkii
Phaeophyscia pusilloides
Porpidia crustulata

9 Brecksville, 2 mi SE of 13 species
Arthonia caesia
I Bacidia chlorococca
*Bacidia trachona
*Caloplaca citrina
S-I Candelaria concolor
Candelariella efflorescens
I Lecidea scalaris
Lepraria finkii
I-T Parmelia sulcata
Phaeophyscia adiastola
Phaeophyscia pusilloides
Phaeophyscia rubropulchra
I Physcia millegrana

10 1 mi SW of Jaite 11 species
*Caloplaca sideritis
Cladonia bacillaris
I Cladonia coniocraea
*Cladonia furcata
*Hymenelia lacustris
*Lecanora polytropa
Lepraria finkii
*Micarea melaena
I Parmelia rudecta
Phaeophyscia rubropulchra
Porpidia albocaerulescens

11 1 mi N of Boston 4 species
Arthonia caesia
Lepraria finkii
Phaeophyscia pusilloides
Physcia millegrana

12 Furnace Run N of Richfield 6 species
Arthonia caesia
I Bacidia chlorococca
Cladonia bacillaris
Cladonia caespiticia
I Lecidea scalaris
I Physcia millegrana

13 S of Brandywine Road 7 species
Arthonia caesia
Cladonia bacillaris

I Cladonia cristatella
*Cladonia cylindrica
I-T Parmelia sulcata
Phaeophyscia rubropulchra
Porpidia crustulata

14 Boston Mill Road SW of Boston 8 species
Cladonia bacillaris
I Cladonia coniocraea
I Cladonia cristatella
*Cladonia cylindrica
Cladonia grayi
Cladonia polycarpoides
Lecidea cyrtidia
Trapelia involuta

15 Railroad & Boston Mill Road 14 species
Arthonia caesia
I Bacidia chlorococca
*Cladina rangiferina
Cladonia bacillaris
*Cladonia coccifera
I Cladonia coniocraea
Cladonia cornuta
I Cladonia cristatella
Cladonia grayi
Cladonia polycarpoides
Lecidea erratica
*Lecidea granulosa
I-T Parmelia sulcata
I Physcia millegrana

16 Stumpy Basin N of Peninsula 11 species
I Arthonia caesia
Cladonia bacillaris
I Lecidea scalaris
Lepraria finkii
*Parmelia aurulenta
I Parmelia caperata
I Parmelia rudecta
I *Parmelia subrudecta
I-T Parmelia sulcata
Phaeophyscia adiastola
Physcia millegrana

17 Furnace Run E of Richfield 13 species
Arthonia caesia
Candelariella efflorescens
Cladonia polycarpoides
*Cladonia rei
Lecidea cyrtidia
Lecidea erratica
I Parmelia rudecta
S *Parmelia subaurifera

I-T Parmelia sulcata
I Physcia millegrana
Porpidia crustulata
Trapelia involuta
Verrucaria rupestris

18 Peninsula, SW of, Major Road 9 species
Arthonia caesia
I Bacidia chlorococca
I Cladonia coniocraea
*Cladonia ramulosa
I Lecidea scalaris
I-T Parmelia sulcata
Phaeophyscia adiastola
I Physcia millegrana
Porpidia crustulata

19 Major farm on Major Road 9 species
Cladonia bacillaris
I Cladonia cristatella
*Lecidea aeruginosa
*Lecidea granulosa
I Lecidea scalaris
I Parmelia rudecta
I-T Parmelia sulcata
I Physcia millegrana
*Placynthiella icmalea

20 Peninsula, Major Road 1 mi SW 8 species
Arthonia caesia
I *Bacidia chlorococca
Cladonia chlorophaea
I Cladonia coniocraea
I Cladonia cristatella
Cladonia polycarpoides
*Cladonia verticillata
I-T Parmelia sulcata

21 Boston Ledges 8 species
I Cladonia coniocraea
I Cladonia cristatella
Cladonia grayi
*Lepraria neglecta
*Peltigera evansiana
I Physcia millegrana
Porpidia crustulata
*Trapelia placodioides

22 Peninsula, Deep Lock Quarry 12 species
I *Anisomeridium biforme
Arthonia caesia
I Bacidia chlorococca
I Cladonia coniocraea
Cladonia grayi

Cladonia polycarpoides
*Lecidea aeruginosa
Lepraria finkii
I-T Parmelia sulcata
Phaeophyscia rubropulchra
I Physcia millegrana
Porpidia crustulata

23 Happy Days Camp Ledges 8 species
Arthonia caesia
Cladonia bacillaris
Cladonia caespiticia
I Cladonia coniocraea
*Cladonia ramulosa
*Cladonia squamosa
Lepraria finkii
Porpidia albocaerulescens

24 Wetmore Road S of Peninsula 13 species
Arthonia caesia
I Bacidia chlorococca
Caloplaca feracissima
S-I Candelaria concolor
I Cladonia coniocraea
T Lecanora dispersa
I Lecidea scalaris
I Parmelia caperata
I Parmelia rudecta
I-T Parmelia sulcata
I Physcia millegrana
I *Physconia detersa
*Verrucaria muralis

25 Everett, 1.5 mi W of 10 species
I Bacidia chlorococca
Cladonia bacillaris
*Cladonia chlorophaea
I Cladonia coniocraea
Cladonia polycarpoides
I Lecidea scalaris
I Parmelia rudecta
I-T Parmelia sulcata
Phaeophyscia rubropulchra
I Physcia millegrana

26 Everett, 1 mi SW of 7 species
Arthonia caesia
I Cladonia cristatella
Cladonia peziziformis
Cladonia polycarpoides
Lecidea erratica
I-T Parmelia sulcata
Trapelia involuta

27 Northampton Road 10 species
Arthonia caesia
I Bacidia chlorococca
Cladonia bacillaris
I Cladonia cristatella
Cladonia grayi
Cladonia polycarpoides
I *Parmelia subrudecta
I-T Parmelia sulcata
I Physcia millegrana
*Placynthiella icmalea

28 Ira 4 species
Arthonia caesia
I Bacidia chlorococca
Parmelia sulcata
Phaeophyscia adiastola

29 Northampton Center, WNW of 12 species
*Acarospora immersa
Arthonia caesia
Cladonia bacillaris
I Bacidia chlorococca
I Cladonia coniocraea
I Cladonia cristatella
Cladonia grayi
Cladonia peziziformis
Cladonia polycarpoides
*Cladonia robbinsii
I Physcia millegrana
Verrucaria rupestris

30 Northampton Center 5 species
Arthonia caesia
I Bacidia chlorococca
I Cladonia cristatella
Cladonia grayi
Cladonia peziziformis

31 O'Neil Woods 16 species
Arthonia caesia
I Bacidia chlorococca
Candelariella efflorescens
Cladonia bacillaris
I Cladonia coniocraea
*Cladonia furcata
Cladonia grayi
Lecidea cyrtidia
I Lecidea scalaris
Lepraria finkii
I Parmelia caperata
I Parmelia rudecta
I-T Parmelia sulcata
Phaeophyscia rubropulchra

I *Physcia millegrana*
**Trapelia coarctata*