LICHENS AND AIR QUALITY in ACADIA NATIONAL PARK

REPORT

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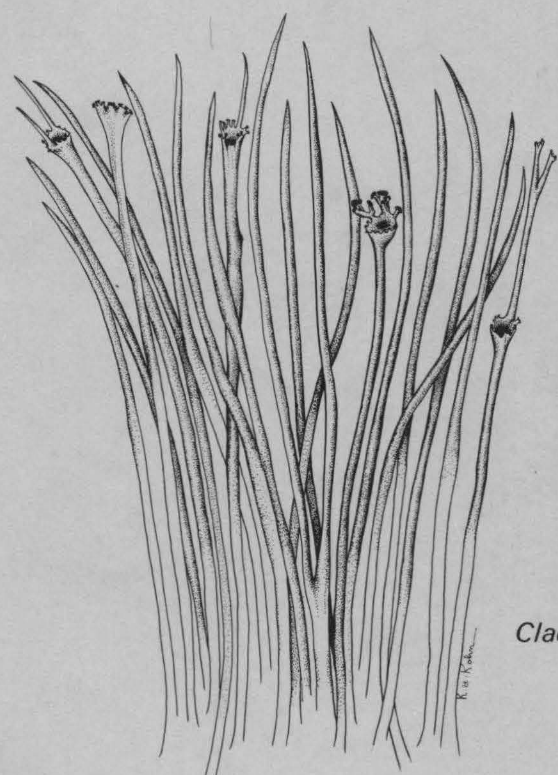

Cladonia maxima

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National Park Service
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LICHENS OF ACADIA NATIONAL PARK

PREFACE

Under a grant from the National Park Service (USDI CX 0001-2-0034) a lichen study was to be performed in Acadia National Park. 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. Much of the field work was done by Thomas Sullivan as part of his PhD dissertation. The assistance of all of these are gratefully acknowledged.

This report treats only the foliose and fruticose lichens from the 1983 collections. A supplemental report will be submitted that will include the crustose lichens and any additional species collected in 1984 when the dissertation is completed.

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.

Acadia National Park has over 38,000 acres and includes parts of Mt. Desert Island, Isle au Haut and part of the Schoodic Peninsula. The land is hilly and extends from sea level to 1530 feet on Cadillac Mountain. Parts of Mt. Desert

Island have been recently burned, especially in 1947. The park receives an average of 45 inches of rain per year and the lower elevations are frequently enclosed in fog.

Both coniferous forests and deciduous forests are present in the park. The moist valleys and some of the shores have spruce (Picea glauca and Picea rubens) and balsam fir (Abies balsamea) and the bogs have black spruce (Picea mariana), tamarack (Larix laricina) and Thuja occidentalis. Some of the moist valleys have hemlock (Tsuga canadensis) and ash (Fraxinus). Drier slopes have pines (Pinus strobus, Pinus rigida, Pinus banksiana) and oak (Quercus rubra) and beech (Fagus grandifolia) and maple (Acer saccharum). Recently burned areas have aspens (Populus tremuloides and Populus grandidentata) and white birch (Betula papyrifera) and Betula lutea.

Bare rocks are abundant along the shores and on the ridges. Many of the hills have abundant rock outcrops on the slopes and, in some cases, high rock cliffs are present.

There have been some lichenological studies done in Acadia National Park in the past which are important in indicating what the lichen flora was like in earlier times. There is one collection of Peltigera aphthosa from Mt. Desert Island in 1888 made by Redfield. The lichenologists Plitt and Riddle collected on Mt. Desert Island early in this century and Llano collected there in 1940 and 1943. Davis studied the vegetation of Maine and included some lichens from the park in his papers published in 1964. In 1972 and 1974 Egan collected

collected in the park and in 1981 Wetmore collected at one locality on Mt. Desert Island. However, none of these collectors visited more than a few localities or collected only some groups of lichens.

METHODS

Field work was done during the summer of 1983. In June I spent 9 days in the park collecting at various localities and getting the project started. Thomas Sullivan stayed on and collected at many more localities during June and July. In all 57 localities were visited and over 3366 collections were made. A complete list of collection localities is given in Appendix I. Localities for collecting were selected first to give a general coverage of the park unit, 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 mainly by Thomas Sullivan with assistance and confirmation of all species by me and 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 park and 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 available from this data base at any time on request.

LICHEN FLORA

The following list of lichens is based on my collections, those of Thomas Sullivan, historical specimens in the University of Minnesota herbarium and those reported in the literature. This report includes only the foliose and fruticose lichens but the crustose species will be treated in a supplemental report at a later date. Thomas Sullivan will also collect in the park in 1984 and any additional species will be included in the supplemental report. This list includes 148 species collected for this study and 12 additional species not found but previously reported and likely to occur in the park. In the first columns the letters indicate in what unit the species was found: D=Mt. Desert Island, S=Schoodic Peninsula, H=Isle au Haut. The next columns 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 cubuc 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.

H I Alectoria sarmentosa (Ach.) Ach. Also reported by Davis (1964b)
D Anaptychia palmulata (Michx.) Vain.
DSH S Bryoria furcellata (Fr.) Brodo & Hawksw. Also reported by Davis (1964b)
(Bryoria fuscescens (Gyeln.) Brodo & Hawksw. Reported by Brodo & Hawksworth (1977))
DSH Bryoria nadvornikiana (Gyeln.) Brodo & Hawksw. Also reported by Davis (1964b)
DSH S Bryoria trichodes (Michx.) Brodo & Hawksw. Also reported by Brodo & Hawksworth (1977)
(Candelaria concolor (Dicks.) Stein Reported by Plitt & Pessin (1924))
(Cetraria ciliaris Ach. Reported by Davis (1964b)= misidentification)
H Cetraria arenaria Kärnef.
D H Cetraria halei W. Culb. & C. Culb.
D Cetraria hepatizon (Ach.) Vain.
DS Cetraria oakesiana Tuck.
DSH I Cetraria orbata (Nyl.) Fink
D H Cetraria pinastri (Scop.) S. Gray
I (Cetraria sepincola (Ehrh.) Ach. MIN HERB)
D Cetrelia chicitae (W. Culb) W. Culb. & C. Culb.
D Cetrelia olivetorum (Nyl.) W. Culb. & C. Culb.
D Cladonia anomaea (Ach.) Ahti & P. James
DSH Cladonia arbuscula (Wallr.) Rabenh. Also reported by Davis (1964a)
DS Cladonia atlantica Evans
DSH Cladonia bacillaris (Ach.) Nyl.
DSH Cladonia boryi Tuck.
D Cladonia caespiticia (Pers.) Flörke
DSH Cladonia carassensis Vain.
(Cladonia cariosa Spreng. Reported by Riddle (1909))
(Cladonia caroliniana Schwein. ex Tuck. Reported by Davis (1964a))
DSH Cladonia cenotea (Ach.) Schaer.
D H Cladonia chlorophaea (Flörke ex Somm.) Spreng. Also reported by Davis (1964a)
D Cladonia coccifera (L.) Willd.
DSH I Cladonia coniocraea (Flörke) Spreng. Also reported by Davis (1964a)
DSH Cladonia cornuta (L.) Hoffm.
D Cladonia crispata (Ach.) Flot.

D H I Cladonia cristatella Tuck. Also reported by Plitt (1927), Davis (1964a)
D Cladonia cryptochlorophaea Asah.
S Cladonia decorticata (Flörke) Spreng.
SH Cladonia deformis (L.) Hoffm.
D Cladonia digitata (L.) Hoffm.
(Cladonia elongata (Jacq.) Hoffm. = Cladonia maxima)
D Cladonia farinacea (Vain.) Evans
D S-I Cladonia fimbriata (L.) Fr.
D H Cladonia floerkeana (Fr.) Flörke
DSH Cladonia furcata (Huds.) Schrad. Also reported by Davis (1964a)
DS Cladonia gracilis (L.) Willd. Also reported by Davis (1964a)
DSH Cladonia grayi Merr. & Sandst.
D Cladonia incrassata Flörke
DSH Cladonia maxima (Asah.) Ahti
DSH Cladonia merochlorophaea Asah.
DS Cladonia mitis Sandst.
(Cladonia ochrochlora Flörke MIN HERB: not recognized as separate species:= Cladonia coniocraea)
D Cladonia parasitica (Hoffm.) Hoffm.
DSH Cladonia pleurota (Flörke) Schaer.
DS Cladonia pyxidata (L.) Hoffm.
DSH Cladonia rangiferina (L.) Wigg. Also reported by Plitt (1927),Davis (1964a)
D H Cladonia scabriuscula (Del. ex Duby) Nyl.
DSH Cladonia squamosa (Scop.) Hoffm. Also reported by Davis (1964a)
DSH Cladonia stellaris (Opiz) Pouz. & Vezda
DSH Cladonia strepsilis (Ach.) Vain.
SH Cladonia sulphurina (Michx.) Fr.
DSH Cladonia terrae-novae Ahti
DSH Cladonia turgida (Ehrh.) Hoffm. Also reported by Davis (1964a)
DSH Cladonia uncialis (L.) Wigg. Also reported by Davis (1964a)
D Cladonia verticillata (Hoffm.) Schaer.
D Collema subflaccidum Degel.
D Cornicularia aculeata (Schreb.) Ach.
D Dermatocarpon weberi (Ach.) Mann
DSH I Evernia mesomorpha Nyl. Also reported by Davis (1964b)
D H Heterodermia obscurata (Nyl.) Trev.
D Heterodermia speciosa (Wulf.) Trev.
D Heterodermia squamulosa (Degel.) W. Culb.
(Hypogymnia enteromorpha (Ach.) Nyl. Reported by Davis (1964b):= Hypogymnia krogii)
DSH Hypogymnia krogii Ohls.
DSH I Hypogymnia physodes (L.) W. Wats. Also reported by Plitt & Pessin (1924), Berry (1941), Davis (1964a)
DSH S Hypogymnia tubulosa (Schaer.) Hav.
DSH Lasallia papulosa (Ach.) Llano Also reported by Llano (1950)
DSH Lasallia pensylvanica (Hoffm.) Llano also reported by

Llano (1950)
DSH Leptogium cyanescens (Ach.) Körb.
(Leptogium tremelloides (L.) S. Gray Reported by Plitt & Pessin (1924): misidentification)
DSH S Lobaria pulmonaria (L.) Hoffm. Also reported by Plitt & Pessin (1924), Davis (1964b)
DSH Lobaria quercizans Michx. Also reported by Jordan (1973)
D H Lobaria scrobiculata (Scop.) DC.
D Menegazzia terebrata (Hoffm.) Mass.
H I Nephroma laevigatum Ach. Also reported by Wetmore (1960)
D Nephroma parile (Ach.) Ach.
D Pannaria rubiginosa (Thunb. ex Ach.) Del.
D Parmelia arnoldii Du Rietz
DSH I Parmelia caperata (L.) Ach. Also reported by Plitt & Pessin (1924), Davis (1964b)
DSH Parmelia centrifuga (L.) Ach.
D H Parmelia conspersa (Ach.) Ach. Also reported by Plitt (1927), Berry (1941)
DSH Parmelia crinita Ach. Also reported by Davis (1964b), Hale (1965)
D Parmelia cumberlandia (Gyeln.) Hale
DS Parmelia disjuncta Erichs.
D Parmelia galbina Ach. Also reported by Plitt & Pessin (1924)
D H I Parmelia glabratula Lamy
D Parmelia halei Ahti
D Parmelia hypopsila Müll. Arg.
DS Parmelia omphalodes (L.) Ach.
DSH Parmelia panniformis (Nyl.) Vain.
DSH S Parmelia perlata (Huds.) Ach.
D Parmelia plittii Gyeln.
DSH I Parmelia rudecta Ach. Also reported by Plitt & Pessin (1924), Davis (1964b)
DSH I Parmelia saxatilis (L.) Ach. Also reported by Plitt & Pessin (1924), Berry (1941), Davis (1964b)
D Parmelia sorediosa Almb.
DSH Parmelia squarrosa Hale
DS Parmelia stygia (L.) Ach.
I-T (Parmelia subargentifera Nyl. Reported by Plitt & Pessin (1924)
DSH S Parmelia subaurifera Nyl.
DS I Parmelia subrudecta Nyl.
DSH I-T Parmelia sulcata Tayl. Also reported by Plitt & Pessin (1924)
DSH Parmelia taractica Kremp.
D Parmeliella triptophylla (Ach.) Müll. Arg.
DSH I Parmeliopsis aleurites (Ach.) Nyl.
D H I Parmeliopsis ambigua (Wulf.) Nyl.
D I Parmeliopsis hyperopta (Ach.) Arn.
H Peltigera aphthosa (L.) Willd. Also reported by Thomson (1950)
D H Peltigera canina var. praetextata (Flörke in Somm.) Hue
(Peltigera polydactyla (Neck.) Hoffm. Reported by Thomson (1950))

D Peltigera horizontalis-polydactyla

H Peltigera polydactyla (Neck.) Hoffm. Also reported by Thomson (1950)

D Phaeophyscia pusilloides (Zahlbr.) Essl.

D Phaeophyscia rubropulchra (Degel.) Essl. Also reported by Thomson (1963)

D H I Physcia adscendens (Th. Fr.) Oliv. Also reported by Thomson (1963)

D I Physcia aipolia (Ehrh.) Hampe Also reported by Thomson (1963)

D I Physcia millegrana Degel.

D I Physcia stellaris (L.) Nyl. Also reported by Plitt & Pessin (1924), Thomson (1963)

(Physcia subtilis Degel. Reported by Thomson (1963))

D H I Physcia tenella (Scop.) DC.

D H I Physconia detersa (Nyl.) Poelt

(Pilophorus cereolus (Ach.) Th. Fr. Reported by Yoshimura & Sharp (1968))

DSH I Platismatia glauca (L.) W. Culb. & C. Culb. Also reported by Davis (1964b), Culberson & Culberson (1968)

DSH Platismatia tuckermanii (Oakes) W. Culb. & C. Culb. Also reported by Davis (1964b), Culberson & Culberson (1968)

D Pseudevernia cladonia (Tuck.) Hale & W. Culb. Also reported by Davis (1964b)

D Pseudevernia consocians (Vain.) Hale & W. Culb. Also reported by Davis (1964b)

D H Pseudocyphellaria crocata (L.) Vain.

DSH Pycnothelia papillaria (Ehrh.) Duf.

DSH Pyxine sorediata (Ach.) Mont.

D S Ramalina americana Hale

(Ramalina calicaris var. canaliculata Fr. Reported by Plitt & Pessin (1924): misidentification)

D H I Ramalina dilacerata (Hoffm.) Hoffm.

DSH S Ramalina farinacea (L.) Ach. Also reported by Plitt & Pessin (1924)

D Ramalina intermedia (Del. ex Nyl.) Nyl.

DSH Ramalina roesleri (Hochst.) Nyl. Also reported by Davis (1964b)

D Stereocaulon dactylophyllum Flörke Also reported by Riddle (1910)

(Stereocaulon paschale (L.) Hoffm. Reported by Riddle (1910))

D Stereocaulon pileatum Ach. Also reported by Riddle (1910)

DSH Stereocaulon saxatile Magn.

D H Stereocaulon tomentosum Fr. Also reported by Riddle (1910)

DSH Umbilicaria deusta (L.) Baumg. Also reported by Llano (1950)

D Umbilicaria mammulata (Ach.) Tuck. Also reported by Llano (1950)

DSH Umbilicaria muehlenbergii (Ach.) Tuck. Also reported by Llano (1950)

SH Umbilicaria polyphylla (L.) Baumg.

D   Umbilicaria torrefacta (Lightf.) Schrad.
         (Umbilicaria vellea (L.) Ach. MIN HERB)
D   S Usnea ceratina Ach.
DSH   S Usnea filipendula Stirt. Also reported by Davis (1964b)
         (Usnea florida (L.) Wigg. Reported by Plitt & Pessin (1924): misidentification)
D H   Usnea fulvoreagens (Räs.) Räs.
D   S-I Usnea hirta (L.) Wigg. Also reported by Plitt & Pessin (1924)
  H   Usnea longissima Ach.
DSH   Usnea merrillii Mot.
D   Usnea mutabilis Stirt. Also reported by Davis (1964b)
         (Usnea rubicunda Stirt. Reported by Davis (1964b): misidentification)
D   Usnea strigosa (Ach.) A. Eat. Also reported by Davis (1964b)
DSH S-I Usnea subfloridana Stirt. Also reported by Davis (1964b)
DSH   Usnea trichodea Ach. Also reported by Davis (1964b)
D   Xanthoria elegans (Link) Th. Fr.
DSH   Xanthoria parietina (L.) Th. Fr. Also reported by Plitt & Pessin (1924)
DS   I Xanthoria polycarpa (Ehrh.) Oliv.

DISCUSSION OF LICHEN FLORA

The lichen flora is quite rich due to the varied habitats and the moist conditions caused by fog. Some of the species are characteristic of the Appalachians (e.g., *Pycnothelia papillaria*) but most of the species are the common boreal and north temperate species (e.g., *Lobaria*, *Nephroma*, *Bryoria*, *Usnea*). Rare species in the park include *Cetraria arenaria*, *Cetraria sepincola*, *Cladonia parasitica*, *Dermatocarpon weberi*, *Menegazzia terebrata*, *Parmelia arnoldii*, *Parmelia galbina*, *Parmelia hypopsila*, *Peltigera* species, *Ramalina americana*, *Ramalina intermedia*, and *Usnea longissima*.

There are numerous lichens in the park that are very sensitive to sulfur dioxide according to the list presented in Wetmore, 1983. Species in the most sensitive category are usually absent when sulfur dioxide levels are above 50ug per cubic meter average annual concentrations. The species that occur in the park in this category are as follows. The S-I category is between Sensitive and Intermediate.

S <u>Bryoria</u> <u>furcellata</u> (Fr.) Brodo & Hawksw.
S <u>Bryoria</u> <u>trichodes</u> (Michx.) Brodo & Hawksw.
S-I <u>Cladonia</u> <u>fimbriata</u> (L.) Fr.
S <u>Hypogymnia</u> <u>tubulosa</u> (Schaer.) Hav.
S <u>Lobaria</u> <u>pulmonaria</u> (L.) Hoffm.
S <u>Parmelia</u> <u>perlata</u> (Huds.) Ach.
S <u>Parmelia</u> <u>subaurifera</u> Nyl.
S <u>Ramalina</u> <u>americana</u> Hale
S <u>Ramalina</u> <u>farinacea</u> (L.) Ach.
S <u>Usnea</u> <u>ceratina</u> Ach.
S <u>Usnea</u> <u>filipendula</u> Stirt.
S-I <u>Usnea</u> <u>hirta</u> (L.) Wigg.
S-I <u>Usnea</u> <u>subfloridana</u> Stirt.

The distributions of these species are mapped (Fig. 1-13). Although some of these species are not found at all localities, there is no indication that the voids in the distributions are due to poor air quality. Some of the localities where collections were made do not have suitable habitats for some of these species.

There were no cases where lichens sensitive to sulfur dioxide were observed to be damaged or killed. All species normally found fertile were also fertile in the park. These observations indicate that there is no air quality degradation in the park due to sulfur dioxide that causes observable damage to 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 <u>Umbilicaria</u> do show damage from acid precipitation by dying at the margins. Some of these lichens frequently were seen in the park with dead margins and this may be due to acid rain.

CHEMICAL 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 et al, 1981). Elevated but sublethal levels of sulfur or other elements might indicate incipient damaging conditions.

Lichens were collected for elemental analysis at several localities in the park. In some cases not all species were present in quantities needed for the analysis. Evernia mesomorpha in particular was not abundant at most localities.

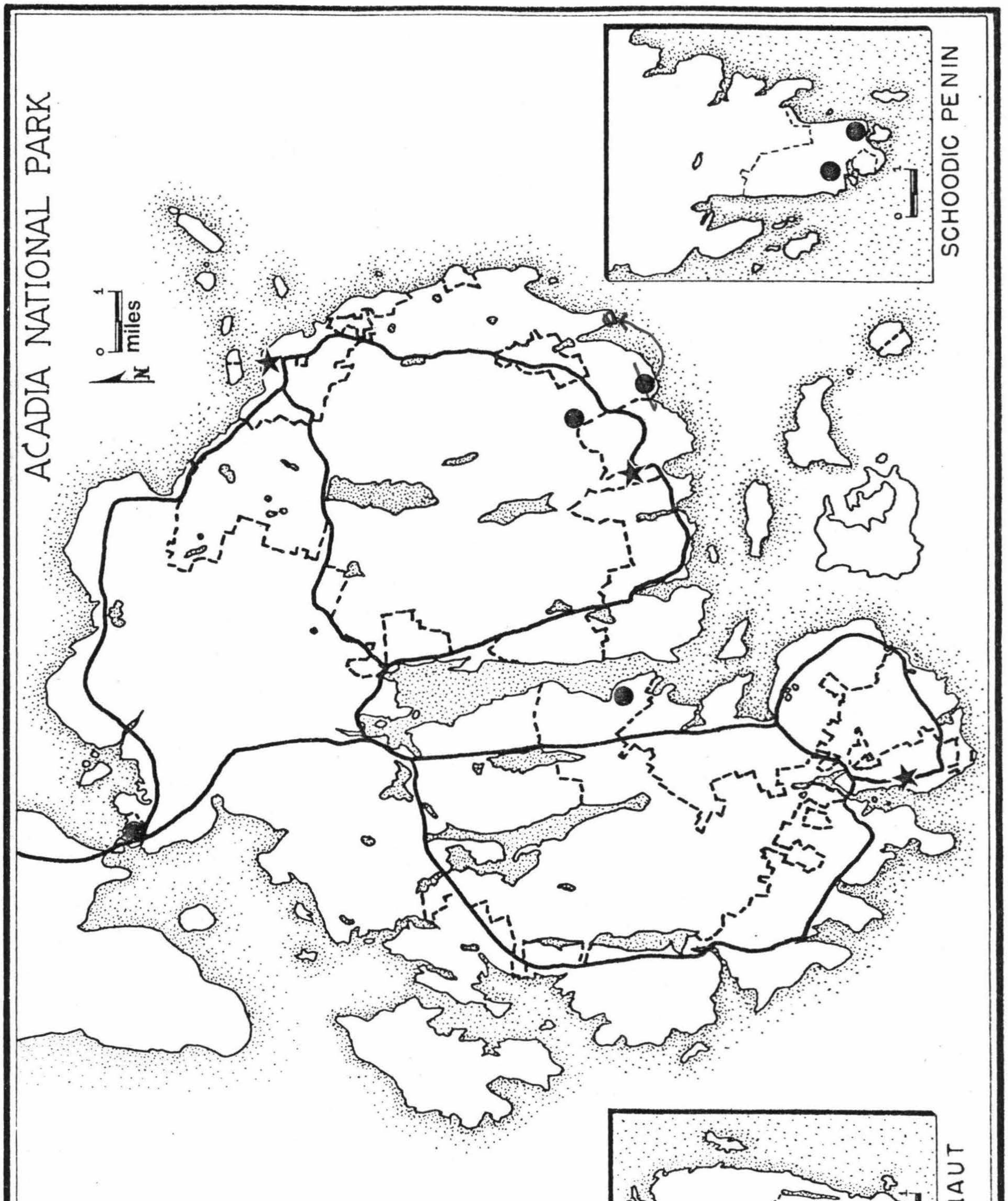
METHODS

Lichen samples of several species were collected in plastic bags at various localities in different parts of the park for laboratory analysis. Species collected and the substrates were Cladonia rangigerina (soil), Evernia mesomorpha (trees), Hypogymnia physodes (trees), Platismatia glauca (trees), and Lasallia papulosa (rocks). These species were selected because they are relatively easy to clean and other authors have used them and so there is some information in the literature for comparison.

The five localities were selected to represent the geographical extremes of the park. One locality was at the northern end of Mt. Desert Island 0.3 miles south of Thompson

Island. At the southeastern end of Mt. Desert Island most species were collected on a point between Otter Point and Seal Harbor (labeled Otter Point in tables) but one species was collected about 2 miles inland northeast of Day Mountain. Another locality was in south-central Mt. Desert Island at Flying Mountain. On Isle au Haut Hypogymnia and Platismatia were collected at Moore Harbor and Cladonia and Lasallia were collected at Western Head. On the Schoodic Peninsula most species were collected northeast of West Pond Cove but Lasallia was collected at The Anvil. Ten to 20 grams of each species were collected at each locality.

Lichens were air dried and cleaned of all bark and soil 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 boron 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 Centigrade for 10-12 hrs. Crucibles were covered during the ashing as a precaution against contamination. The



Locations of collections for chemical analysis 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 arranged by species. Table 2 gives the means and standard deviations for each set of replicates. In cases when values were obtained at or below the detection limits these values have been adjusted before statistical analysis. If only one value is below the detection limit the value is included at 0.7 of the detection limit. If more than one reading is below the detection limit no statistical analysis has been done on that element at that locality.

All of the levels found in the Acadia lichens are within typical limits. From these tables it can be seen that there is no consistent correlation between element levels and location in the park. Although any one species may have significantly higher levels of an element at one locality, other species may have higher levels at another locality so there is no overall correlation between high element levels and any one locality. The sulfur levels in lichens tested range from 330 to 1450 ppm for all samples and these values are near background levels as cited by Solberg (1967) Erdman & Gough (1977), Nieboer et al (1977) and Puckett & Finegan (1980). Levels may be as low as 200-300 in the arctic (Tomassini et al, 1976) while levels in polluted areas are 4300-5200 ppm (Seaward, 1973) or higher. Different species may accumulate different amounts of elements

Table 1. Chemical analysis of Acadia lichens
Values in ppm of thallus

Species	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Pb	Ni	Cr	Cd	S	Locality
C. rangiferina	344	1222	186	390	84	91	108.5	5.2	12.5	1.4	0.9	6.5	<0.3	0.2	0.2	330	Isle au Haut
C. rangiferina	383	1362	193	421	87	97	130.4	5.6	13.8	1.5	1.0	6.8	0.3	0.3	0.1	500	Isle au Haut
C. rangiferina	362	1301	210	424	90	100	131.3	6.0	13.4	1.5	1.0	7.5	0.4	0.2	0.3	480	Isle au Haut
C. rangiferina	594	2356	249	333	66	71	117.8	30.5	17.9	2.1	1.6	3.5	0.6	0.2	0.1	590	Schoodic Pen.
C. rangiferina	557	2235	261	329	68	73	116.3	30.4	17.3	2.1	1.5	3.5	0.9	0.2	0.2	520	Schoodic Pen.
C. rangiferina	562	2188	259	320	78	86	121.7	29.3	17.3	2.2	1.7	4.0	0.9	0.3	0.3	540	Schoodic Pen.
C. rangiferina	649	2523	186	321	97	86	72.9	27.6	17.2	2.0	1.1	7.2	<0.3	0.2	0.1	620	Flying Mt.
C. rangiferina	548	2241	203	310	112	108	69.3	27.9	16.2	1.9	1.1	8.4	0.6	0.2	0.1	610	Flying Mt.
C. rangiferina	563	2317	203	308	101	96	63.9	27.9	16.5	1.9	1.1	9.5	0.5	0.2	0.2	600	Flying Mt.
C. rangiferina	386	1506	224	423	81	75	185.6	18.7	14.4	1.4	0.9	7.7	1.0	0.2	0.3	500	Otter Point
C. rangiferina	449	1687	238	452	75	70	186.6	19.8	15.1	1.5	0.9	6.1	1.1	0.4	0.2	460	Otter Point
C. rangiferina	385	1548	250	417	80	74	208.9	20.4	14.2	1.4	0.9	6.7	0.5	0.2	0.3	475	Otter Point
C. rangiferina	358	1502	268	288	135	130	60.1	15.1	14.5	1.5	0.9	10.9	0.5	0.3	0.2	340	Thompson Isl.
C. rangiferina	366	1481	285	288	139	132	61.9	15.4	14.7	1.5	0.9	10.9	0.5	0.3	0.2	340	Thompson Isl.
C. rangiferina	397	1532	270	283	145	140	60.9	15.0	14.8	1.5	1.0	11.2	0.7	0.4	0.3	420	Thompson Isl.
H. physodes	408	2481	8395	1053	175	152	136.0	175.6	46.7	2.8	1.6	33.8	1.5	0.4	0.6	590	Isle au Haut
H. physodes	415	2495	6335	1068	168	145	146.9	173.0	47.7	3.0	1.6	29.6	1.5	0.4	0.6	640	Isle au Haut
H. physodes	428	2513	6783	1054	174	155	149.5	188.2	47.7	2.8	1.7	28.9	1.4	0.5	0.8	570	Isle au Haut
H. physodes	622	2681	6916	1373	237	278	316.6	137.3	44.4	2.8	2.2	34.5	1.5	0.6	0.5	540	Schoodic Pen.
H. physodes	650	2736	8360	1409	228	256	322.1	153.3	45.3	2.8	2.1	34.4	1.5	0.6	0.6	480	Schoodic Pen.
H. physodes	689	2784	7298	1438	226	255	319.6	155.4	45.8	2.8	2.1	32.6	1.5	0.5	0.5	580	Schoodic Pen.
H. physodes	496	2902	7720	936	167	157	81.6	156.1	68.2	3.0	1.3	38.1	2.3	0.4	0.7	580	Flying Mt.
H. physodes	527	3048	7249	933	162	156	72.3	183.7	66.9	3.1	1.3	35.1	2.2	0.4	0.6	650	Flying Mt.
H. physodes	542	2966	8761	902	158	145	79.6	180.1	64.1	3.0	1.4	34.0	2.2	0.4	0.8	620	Flying Mt.
H. physodes	755	3123	6639	1395	215	211	473.9	77.0	52.8	3.2	3.1	42.8	1.2	0.5	0.4	620	Otter Point
H. physodes	741	3145	7926	1418	218	216	462.6	84.2	51.2	3.1	3.1	45.9	1.2	0.6	0.3	690	Otter Point
H. physodes	779	3059	7848	1394	218	210	474.4	86.6	53.6	3.2	3.1	43.5	0.9	1.0	0.5	690	Otter Point
H. physodes	591	2814	7613	878	185	194	136.2	169.4	63.7	2.7	2.0	38.9	2.0	0.5	0.4	570	Thompson Isl.
H. physodes	697	3072	6098	917	178	187	152.3	125.8	60.5	2.8	2.3	34.1	1.6	0.5	0.3	630	Thompson Isl.
H. physodes	654	2946	6673	920	190	202	142.6	126.1	59.4	3.0	2.6	40.3	1.9	0.5	0.4	680	Thompson Isl.
L. papulosa	875	4167	92	528	123	168	108.1	5.8	148.4	2.1	2.1	16.3	0.9	0.3	0.3	1290	Isle au Haut
L. papulosa	1075	4368	123	507	152	236	94.5	6.3	167.1	2.5	1.9	24.4	0.8	0.4	0.3	1210	Isle au Haut
L. papulosa	610	4162	102	505	163	241	91.5	6.3	164.9	2.7	2.0	29.4	1.1	0.5	0.3	1260	Isle au Haut
L. papulosa	335	3087	59	313	127	122	116.5	7.0	112.7	2.4	1.8	18.0	0.9	0.4	0.3	1150	Schoodic Pen.
L. papulosa	488	3394	63	335	105	122	137.1	6.7	156.0	2.2	2.1	12.9	0.6	0.3	0.4	1340	Schoodic Pen.
L. papulosa	323	3114	59	318	107	135	141.6	6.6	111.6	2.5	1.9	22.4	0.5	0.2	0.5	1230	Schoodic Pen.
L. papulosa	445	3499	72	318	183	190	48.6	13.3	196.9	3.0	1.6	28.6	0.9	0.3	0.6	1410	Flying Mt.
L. papulosa	373	3061	54	261	229	212	47.5	9.7	130.1	2.5	1.6	13.6	0.8	0.3	0.4	1250	Flying Mt.
L. papulosa	417	3032	52	261	213	205	52.0	8.6	154.2	2.4	1.7	11.5	0.6	0.3	0.4	1450	Flying Mt.
L. papulosa	398	3328	93	360	119	163	44.3	10.5	148.3	2.7	1.2	33.5	0.7	0.3	0.3	1150	Otter Point
L. papulosa	562	4345	169	375	121	196	50.3	15.9	190.7	2.8	1.4	27.5	0.8	0.3	0.3	1060	Otter Point
L. papulosa	523	4149	116	454	135	159	48.0	16.4	196.3	3.3	1.4	38.4	1.2	0.4	0.3	1170	Otter Point
P. glauca	496	2126	523	420	99	89	99.5	61.9	25.0	2.3	2.2	10.7	0.8	0.4	0.2	590	Isle au Haut
P. glauca	486	2070	503	412	93	86	93.4	59.0	24.1	2.3	2.2	11.2	0.9	0.4	0.2	605	Isle au Haut
P. glauca	437	1916	518	409	93	85	96.4	59.3	23.5	2.1	2.1	12.0	0.7	0.3	0.2	560	Isle au Haut
P. glauca	482	1983	390	461	231	230	190.2	37.0	18.2	2.1	2.5	12.2	0.8	0.6	0.2	600	Schoodic Pen.
P. glauca	443	1896	391	463	236	238	180.2	33.9	18.5	2.2	2.6	13.7	1.2	0.7	0.3	590	Schoodic Pen.
P. glauca	480	1963	388	468	230	231	185.0	33.8	17.5	2.1	2.5	11.8	0.9	0.6	0.2	500	Schoodic Pen.
P. glauca	429	2169	548	372	168	173	64.9	61.7	25.2	3.0	1.6	18.3	1.2	1.5	0.2	700	Flying Mt.
P. glauca	429	2200	524	374	146	149	65.5	59.0	24.6	2.8	1.5	16.3	0.8	0.5	0.2	750	Flying Mt.
P. glauca	462	2259	545	375	146	150	69.3	60.9	25.8	2.9	1.6	14.9	0.8	0.5	0.3	820	Flying Mt.
P. glauca	376	1811	556	553	166	164	218.6	26.8	22.4	2.6	2.4	20.0	0.9	0.5	0.3	690	Otter Point
P. glauca	367	1777	514	554	173	171	206.8	27.9	21.3	2.7	2.3	20.5	0.8	0.6	0.2	700	Otter Point
P. glauca	356	1649	534	512	173	171	194.9	26.6	20.6	2.4	2.3	19.4	0.8	0.5	0.1	730	Otter Point
P. glauca	532	2217	665	405	171	180	98.7	32.3	29.7	2.2	2.6	12.8	0.6	0.6	0.1	710	Thompson Isl.
P. glauca	511	2132	727	420	192	208	106.4	35.5	30.7	2.3	2.9	13.3	1.0	0.6	0.1	720	Thompson Isl.
P. glauca	508	2160	654	407	178	191	102.2	34.8	28.7	2.2	2.6	13.7	0.9	0.6	0.3	650	Thompson Isl.
E. mesomorpha	649	2242	422	391	227	285	147.5	22.4	39.8	2.7	4.9	19.6	1.4	0.9	0.3	850	Thompson Isl.
E. mesomorpha	542	2003	307	339	216	262	122.8	15.7	33.7	2.4	4.5	19.9	1.2	0.8	0.3	920	Thompson Isl.
E. mesomorpha	610	2092	314	358	228	286	151.5	15.6	31.5	2.5	5.6	21.1	1.4	0.8	0.5	900	Thompson Isl.

Table 2. Acadia Chemical Analysis Summary
Values in ppm of thallus

	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Pb	Ni	Cr	Cd	S	Locality
Cladonia rangiferina																	
Mean	363	1295	197	412	87	96	123.4	5.6	13.2	1.4	1.0	6.9	0.3*	0.2	0.2	437	Isle au Haut
Std. dev.	19	70	12	19	3	5	12.9	0.4	0.7	0.1	0.1	0.5	0.1*	0.1	0.1	93	Isle au Haut
Mean	571	2260	256	327	71	76	118.6	30.1	17.5	2.1	1.6	3.7	0.8	0.2	0.2	550	Schoodic Pen.
Std. dev.	20	86	6	7	7	8	2.8	0.7	0.3	0.1	0.1	0.3	0.2	<.1	0.1	36	Schoodic Pen.
Mean	587	2360	197	313	103	97	68.7	27.8	16.6	1.9	1.1	8.4	0.4*	0.2	0.1	610	Flying Mt.
Std. dev.	54	146	10	7	8	11	4.6	0.2	0.5	0.1	<.1	1.1	0.2*	<.1	<.1	10	Flying Mt.
Mean	406	1580	237	431	78	73	193.7	19.6	14.5	1.5	0.9	6.8	0.9	0.2	0.2	478	Otter Point
Std. dev.	37	95	13	19	3	3	13.2	0.9	0.4	<.1	<.1	0.8	0.3	0.1	<.1	20	Otter Point
Mean	374	1505	274	287	140	134	60.9	15.2	14.7	1.5	0.9	11.0	0.6	0.3	0.2	367	Thompson Isl.
Std. dev.	20	26	9	3	5	5	0.9	0.2	0.1	<.1	<.1	0.2	0.1	<.1	0.1	46	Thompson Isl.
Hypogymnia physodes																	
Mean	417	2496	7171	1058	172	151	144.1	178.9	47.3	2.9	1.6	30.8	1.4	0.4	0.7	600	Isle au Haut
Std. dev.	10	16	1083	8	4	5	7.1	8.2	0.6	0.1	0.1	2.7	0.1	0.1	0.1	36	Isle au Haut
Mean	654	2734	7525	1407	230	263	319.5	148.7	45.2	2.8	2.1	33.8	1.5	0.6	0.5	533	Schoodic Pen.
Std. dev.	34	52	748	32	6	13	2.8	9.9	0.7	<.1	<.1	1.1	<.1	0.1	0.1	50	Schoodic Pen.
Mean	522	2972	7910	924	163	153	77.8	173.3	66.4	3.0	1.3	35.7	2.2	0.4	0.7	617	Flying Mt.
Std. dev.	23	73	774	19	5	7	4.9	15.0	2.1	0.1	<.1	2.1	0.1	<.1	0.1	35	Flying Mt.
Mean	758	3109	7471	1403	217	212	470.3	82.6	52.5	3.2	3.1	44.1	1.1	0.7	0.4	667	Otter Point
Std. dev.	19	45	721	14	1	4	6.6	5.0	1.2	0.1	<.1	1.6	0.2	0.3	0.1	40	Otter Point
Mean	647	2944	6795	905	184	194	143.7	140.4	61.2	2.8	2.3	37.8	1.8	0.5	0.4	627	Thompson Isl.
Std. dev.	54	129	765	24	6	7	8.1	25.1	2.2	0.2	0.3	3.3	0.2	<.1	0.1	55	Thompson Isl.
Lasallia papulosa																	
Mean	853	4232	106	513	146	215	98.0	6.1	160.1	2.5	2.0	23.4	0.9	0.4	0.3	1253	Isle au Haut
Std. dev.	233	118	16	13	21	41	8.8	0.3	10.2	0.3	0.1	6.7	0.2	0.1	<.1	40	Isle au Haut
Mean	382	3198	60	322	113	126	131.7	6.8	126.8	2.4	1.9	17.8	0.7	0.3	0.4	1240	Schoodic Pen.
Std. dev.	92	170	2	12	12	7	13.4	0.2	25.3	0.1	0.2	4.8	0.2	0.1	0.1	95	Schoodic Pen.
Mean	412	3197	59	280	209	202	49.4	10.5	160.4	2.7	1.6	17.9	0.8	0.3	0.5	1370	Flying Mt.
Std. dev.	36	262	11	33	23	11	2.4	2.5	33.8	0.3	0.1	9.3	0.2	<.1	0.1	106	Flying Mt.
Mean	495	3940	126	396	125	173	47.5	14.2	178.4	2.9	1.3	33.1	0.9	0.3	0.3	1127	Otter Point
Std. dev.	85	540	39	50	9	20	3.0	3.3	26.2	0.3	0.1	5.4	0.2	0.1	<.1	59	Otter Point
Platismatia glauca																	
Mean	473	2037	515	414	95	87	96.5	60.1	24.2	2.2	2.2	11.3	0.8	0.4	0.2	585	Isle au Haut
Std. dev.	32	109	10	6	4	2	3.1	1.6	0.8	0.1	<.1	0.7	0.1	<.1	<.1	23	Isle au Haut
Mean	468	1947	390	464	232	233	185.1	34.9	18.1	2.1	2.5	12.6	1.0	0.7	0.2	563	Schoodic Pen.
Std. dev.	22	45	2	3	3	4	5.0	1.8	0.5	0.1	<.1	1.0	0.2	0.1	<.1	55	Schoodic Pen.
Mean	440	2209	539	374	153	157	66.5	60.6	25.2	2.9	1.6	16.5	0.9	0.9	0.2	757	Flying Mt.
Std. dev.	19	46	13	1	13	14	2.4	1.4	0.6	0.1	<.1	1.7	0.2	0.6	0.1	60	Flying Mt.
Mean	366	1746	535	539	171	169	206.7	27.1	21.4	2.6	2.3	20.0	0.8	0.5	0.2	707	Otter Point
Std. dev.	10	85	21	24	4	4	11.9	0.7	0.9	0.1	0.1	0.6	0.1	<.1	0.1	21	Otter Point
Mean	517	2170	682	411	181	193	102.4	34.2	29.7	2.2	2.7	13.3	0.8	0.6	0.2	693	Thompson Isl.
Std. dev.	13	43	39	8	11	14	3.9	1.7	1.0	0.1	0.1	0.5	0.2	<.1	0.1	38	Thompson Isl.
Evernia mesomorpha																	
Mean	601	2112	348	363	223	277	140.6	17.9	35.0	2.5	5.0	20.2	1.3	0.8	0.4	890	Thompson Isl.
Std. dev.	54	121	65	26	6	14	15.5	3.9	4.3	0.2	0.5	0.8	0.1	0.1	0.1	36	Thompson Isl.

*= one value at or below detection limit; included as 0.7 of detection limit

and this is evident when comparing sulfur levels of the different species. Cladonia rangiferina has the lowest levels and Lasallia papulosa has the highest levels. Even when taking these differences into account there is no clear trend in accumulated levels of sulfur.

There seem to be no important differences or correlations between collections sites and the chemical levels. There appears to be no reason to suspect man made air pollution in the park based on these chemical analyses. All levels are within normal ranges and there are no localities with significantly higher levels of elements characteristic of air pollution.

CONCLUSIONS

There is no indication that the lichens of Acadia National Park are being damaged by air quality. The lichen flora is diverse with many species present in all sections of the park. Many species in the group most sensitive to sulfur dioxide are present and their distribution in the park does not show any significant voids that are not due to normal ecological conditions. There is no evidence of damaged or dead lichens in any area. The elemental analyses do not show abnormal accumulations of polluting elements at any locality.

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APPENDIX I

Collection Localities

Collection numbers 45645-46564 are those of Clifford Wetmore and the numbers from, 400-2846 are those of Thomas Sullivan. All collections are listed in ascending order by collection number and date of collection.

Hancock County

45645-45729 400-466 Mt. Desert Isl. NW end of Upper Hadlock Pond on E slope of Norumbega Mountain. In spruce forest on steep slope with rock cliffs. Some *Thuja*, maple and balsam fir. 16 June 1983.

45730-45782 467-479 Mt. Desert Isl. Around peak of Cadillac Mt. On rock outcrops and in stunted spruce forest. 17 June 1983.

45783-45827 480-481 Mt. Desert Isl. Otter Point SE of Bar Harbor. In old spruce forest near shore. 17 June 1983

45828-45890 482-492 Mt. Desert Isl. Bog 1.5 mi E of Seal Cove. Along edge of bog with spruce, *Thuja*, and maples. 18 June 1983.

45891-45951 493-498 Mt. Desert Isl. Great Hill just W of Bar Harbor. On burned hillside with big tooth aspen, rock outcrops and some oak. 18 June 1983.

45952-46010 499-506 Mt. Desert Isl. On NW slope of St. Sauveur Mt. (2.5 mi N of Southwest Harbor). On hillside and ridge with pines and few scattered maple and *Thuja*. 19 June 1983.

46011-46068 507-510 Mt. Desert Isl. Bass Harbor Head along shore E of lighthouse. On shore rocks and in spruce woods near shore. 19 June 1983.

46069-46129 511- Mt. Desert Isl. East shore of Bubble Pond on W slope of Cadillac Mt. On steep slope with scattered *Thuja* and rock outcrops and some hardwoods. 20 June 1983.

521

46130- Mt. Desert Isl. South end of Eagle Lake. In old
46203 hemlock forest and along stream with maple and ash.
522- 20 June 1983.
531

46204- Mt. Desert Isl. Point between Seal Harbor and Otter
46249 Point. Rocky shore and in spruce and balsam fir woods
532- near shore. 21 June 1983. chem
539

46250- Mt. Desert Isl. Southeast side of The Triad, N of
46315 Seal Harbor. In mixed mature forest of maple, birch,
540- beech and spruce. 21 June 1983.
549

46316- Mt. Desert Isl. Sargent Mt. Pond just S of Sargent
46378 Mt. Around lake in bog with maple and spruce and on
550- nearby rock ledges. 22 June 1983.
551

46379- Mt. Desert Isl. West side of Ship Harbor (S of
46440 Southwest Harbor). Along ocean shore and in spruce
552- woods. 23 June 1983.
558

46441- Mt. Desert Isl. Southeast edge of Big Heath (S of
46472 Southwest Harbor). At wet edge of bog in spruce and
559- tamarack. 23 June 1983.
560

46473- Mt. Desert Isl. Northeast side of Dorr Mt. S of Bar
46520 Harbor. On lower slopes in area with old hemlock, oak,
maple only lightly burned by 1947 fire. 24 June 1983.

46521- Mt. Desert Isl. Oak Hill Cliff SE of Bar Harbor. On
46564 top of small hill with young oak, white birch and big
561- tooth aspen. Burned by 1947 fire. 24 June 1983.
566

567- Mt. Desert Isl. .3 mi S of Thompson Island. Along
641 shore and in spruce woods. 25 June 1983. chem

642- Mt. Desert Isl. E of Pretty Marsh Picnic Area, N
701 of Hodgdon Pond. Along stream with spruce and Thuja to
higher rocky slope of spruce and balsam fir. 26 June 1983.

702- Mt. Desert Isl. N side of Beech Mt. (2 mi NW of
755 Southwest Harbor, ME). In spruce, maple, birch woods
with rock outcrops. 27 June 1983.

756- Mt. Desert Isl. E of Ripple Pond & 1 mi SW of
800 Somesville. Mostly young maple and spruce with some

birch. 27 June 1983.

801- Mt. Desert Isl. NW slope of Norumbega Mt. (2 mi N
866 of Northeast Harbor). In maple, spruce woods with some *Thuja*, pitch pine and rock outcrops. 28 June 1983.

867- Mt. Desert Isl. 1.0 mi S of Mansell Mt. (1.7 mi NW
919 of Southwest Harbor). In maple, spruce and *Thuja* woods 29 June 1983.

920- Mt. Desert Isl. Between Seal Harbor and Otter Point
921 SE of Bar Harbor. In old spruce woods near shore. 29 June 1983.

922- Mt. Desert Isl. South end of Kebo Mt. In oak, maple,
985 birch and some pitch pine woods at rock outcrops. 1 July 1983.

986- Mt. Desert Isl. S of Dorr Pt. W of Sols Cliff (1.0
1041 mi S of Bar Harbor). In oak, maple, aspen woods with some mature white pine and pitch pine on rock outcrops. 1 July 1983.

1042 Mt. Desert Isl. S of Pine Hill, N of Seal Cove
1117 Pond. Mature *Thuja*, maple woods with some birch and spruce. 2 July 1983.

1118 Mt. Desert Isl. N of Bald Mt, SE of Seal Cove Pond.
1159 Maple, birch and spruce woods. In swampy area along stream as well as drier uplands. 2 July 1983.

1160 Mt. Desert Isl. S of Upper Hadlock Pond. In maple,
1222 spruce and *Thuja* woods with some balsam fir, birch and aspen. 3 July 1983.

1223- Mt. Desert Isl. S end of Huguenot Head and Champlain
1284 Mt. along rock boulders at base and saddle between. In maple, birch, oak and pitch pine woods. 5 July 1983.

1285- Mt. Desert Isl. E of Great Meadow Marsh (1 mi S of
1322 Bar Harbor). At base of cliff in maple, birch, oak woods & along rock outcrops with oak and pitch pine. 5 July 1983.

1323- Schoodic Peninsula. Schoodic Head. In jack pine and
1372 spruce woods with rock outcrops. 7 July 1983.

1373- Schoodic Peninsula. SE end of Big Moose Island. In
1411 spruce & jack pine woods with some rock outcrops. 7 July 1983.

1412- Mt. Desert Isl. Along Duck Brook N of Great Hill (NW
1467 of Bar Harbor). In burn area of mixed hardwoods with

spruce, hemlock and Thuja and rock outcrops. 8 July 1983.

1468-1533 Mt. Desert Isl. Great Head (4 mi S of Bar Harbor, ME). Along rock outcrops & along shore with spruce, poplar, maple, birch and alder. 8 July 1983.

1534-1600 Mt. Desert Isl. Man of War Brook between Acadia & St. Sauveur Mts. (2 mi N of Southwest Harbor). In Thuja, maple and spruce woods and along stream. 10 July 1983.

Knox County

1601-1641 Isle au Haut. Shark's Point. Along rocky shore and in spruce woods with some maples along road. 11 July 1983.

1642-1698 Isle au Haut. Along Bowditch Trail W of Jerusalem Mt. In spruce & maple woods with some rock outcrops and around bog area. 12 July 1983.

1699-1754 Isle au Haut. Jerusalem and Bowditch Mts. In spruce woods with some maple and birch and along rock outcrops. 12 July 1983.

1755-1811 Isle au Haut. SE end of Moore Harbor (S of Eli Creek). In spruce, maple & birch woods and along shore on rocks and bank. 13 July 1983. chem

1812-1862 Isle au Haut. SW of Duck Harbor Mt. along Western Head Trail. In spruce woods with some maple & birch. Some rock outcrops and bog area. 14 July 1983.

1863-1926 Isle au Haut. Western Head along Western Head & Cliff Trails. In spruce woods with some maple and birch and along shore and shore cliffs and bog area. 14 July 1983. chem

1927-1988 Isle au Haut. N of Merchants Cove. In spruce-maple woods with some birch including a bog. 15 July 1983.

1989-2025 Isle au Haut. NE of Wentworth Mt. Edge of swamp with Thuja, maple and spruce. 15 July 1983.

2026-2083 Isle au Haut. Moore Harbor NE of Deep Cove. In maple & spruce woods with some Thuja and birch and along shore bank. 16 July 1983.

(2084 not from park: Knox Co, Me. Deer Isle. Old Settlers Cemetery on tombstone. 16 July 1983.)

Hancock County

2085- Mt. Desert Isl. NE of Aunt Betty Pond (W of park
2156 headquarters) along carriage trail. In conifer and mixed hardwoods with some rock outcrops. 19 July 1983.

2157- Mt. Desert Isl. NW of Lake Wood. In mixed hardwood and
2236 conifer forest. 20 July 1983.

2237- Schoodic Peninsula. S of Frazer Pt. between Moore
2276 Rd. and power line cut. In spruce and Thuja woods with some maple and birch. 21 July 1983.

2277- Schoodic Peninsula. NE of West Pond Cove (W of
2321 Schoodic Head). In spruce woods. 21 July 1983. Chem

2322- Schoodic Peninsula. The Anvil. In spruce woods with
2379 jack pine at top of rock outcrops. Some hardwoods at base. 21 July 1983. Chem

2380- Mt. Desert Isl. Flying Mt. In spruce & Thuja woods
2475 with pitch pine at top of rock outcrops and some maple and white pine. 23 July 1983. Chem

2476- Mt. Desert Isl. Western Mt. at Little Notch and
2530 Knight Nubble. In valley of spruce with birch, maple, Thuja and pitch pine at rock outcrops. 23 July 1983.

2531- Mt. Desert Isl. E of Bass Harbor Marsh (SW of Hio
2585 Hill). In spruce woods with some maple and Thuja. In marsh area as well as on higher ground. 24 July 1983.

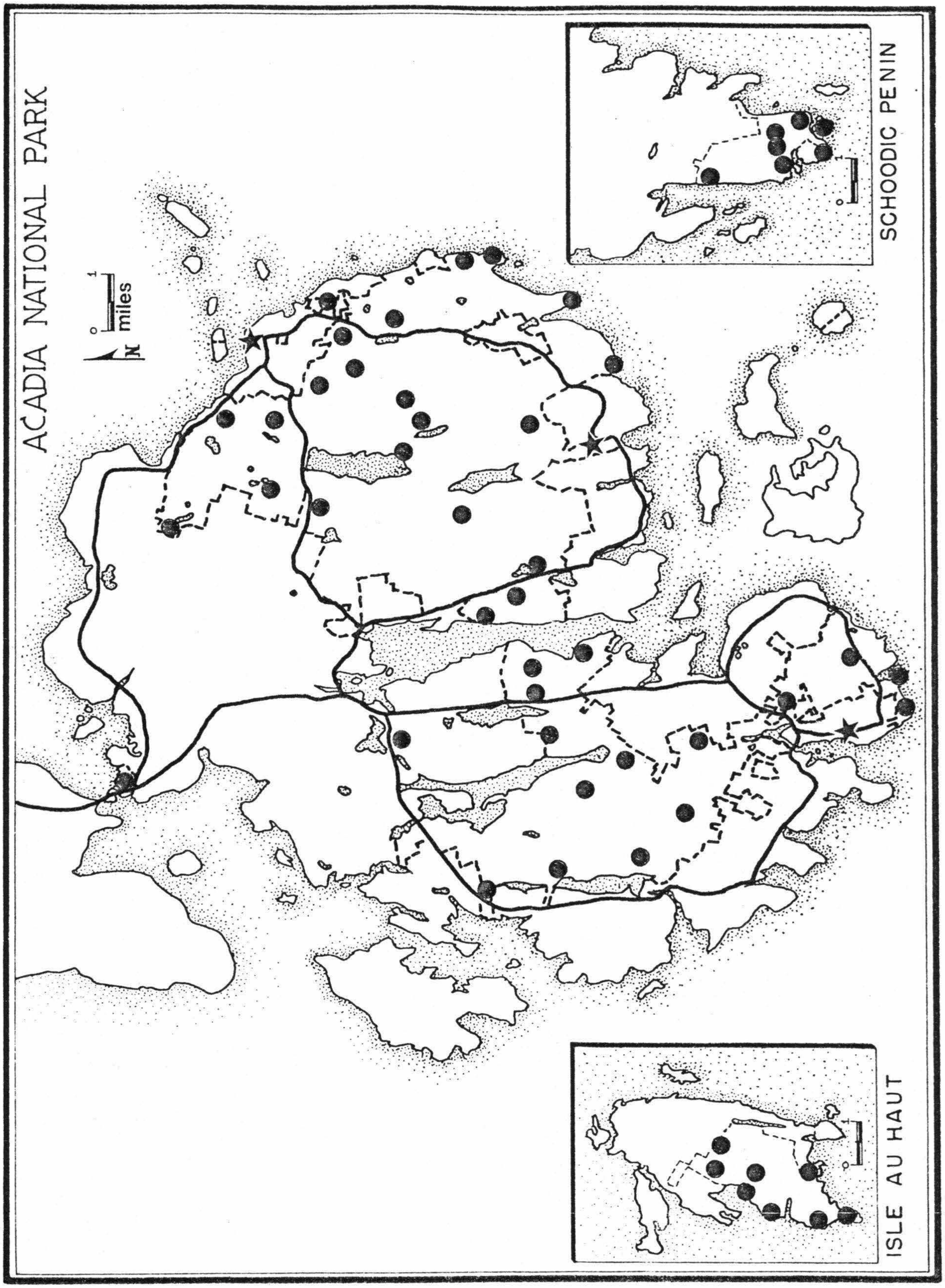
2586- Mt. Desert Isl. 1.5 mi W of Southwest Harbor (W of
2645 Freeman Ridge). In mature spruce woods with some Thuja and maple. 24 July 1983.

2646 Mt. Desert Isl. Big Heath bog at SE edge. 24 July 1983.

2647- Schoodic Peninsula. W of Schoodic Head in spruce &
2694 Thuja woods with some maple and birch. 25 July 1983.

2695- Little Moose Island off Schoodic Peninsula. N-NE
2758 side of island in spruce woods with alder. 25 July 1983.

2759- Mt. Desert Isl. McFarland Mt. at S end of Breakneck
2846 Ponds. In maple, birch, spruce and Thuja woods and rock outcrops. 26 July 1983



Collection localities in 1983

APPENDIX II

Species Sensitive to Sulfur Dioxide

Based on the list of lichens with known sulfur dioxide sensitivety compiled from the literature, the following species in Acadia National Park 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.

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

Fig. 1 S *Bryoria furcellata* (Fr.) Brodo & Hawksw.
Fig. 2 S *Bryoria trichodes* (Michx.) Brodo & Hawksw.
Fig. 3 S-I *Cladonia fimbriata* (L.) Fr.
Fig. 4 S *Hypogymnia tubulosa* (Schaer.) Hav.
Fig. 5 S *Lobaria pulmonaria* (L.) Hoffm.
Fig. 6 S *Parmelia perlata* (Huds.) Ach.
Fig. 7 S *Parmelia subaurifera* Nyl.
Fig. 8 S *Ramalina americana* Hale
Fig. 9 S *Ramalina farinacea* (L.) Ach.
Fig. 10 S *Usnea ceratina* Ach.
Fig. 11 S *Usnea filipendula* Stirt.
Fig. 12 S-I *Usnea hirta* (L.) Wigg.
Fig. 13 S-I *Usnea subfloridana* Stirt.

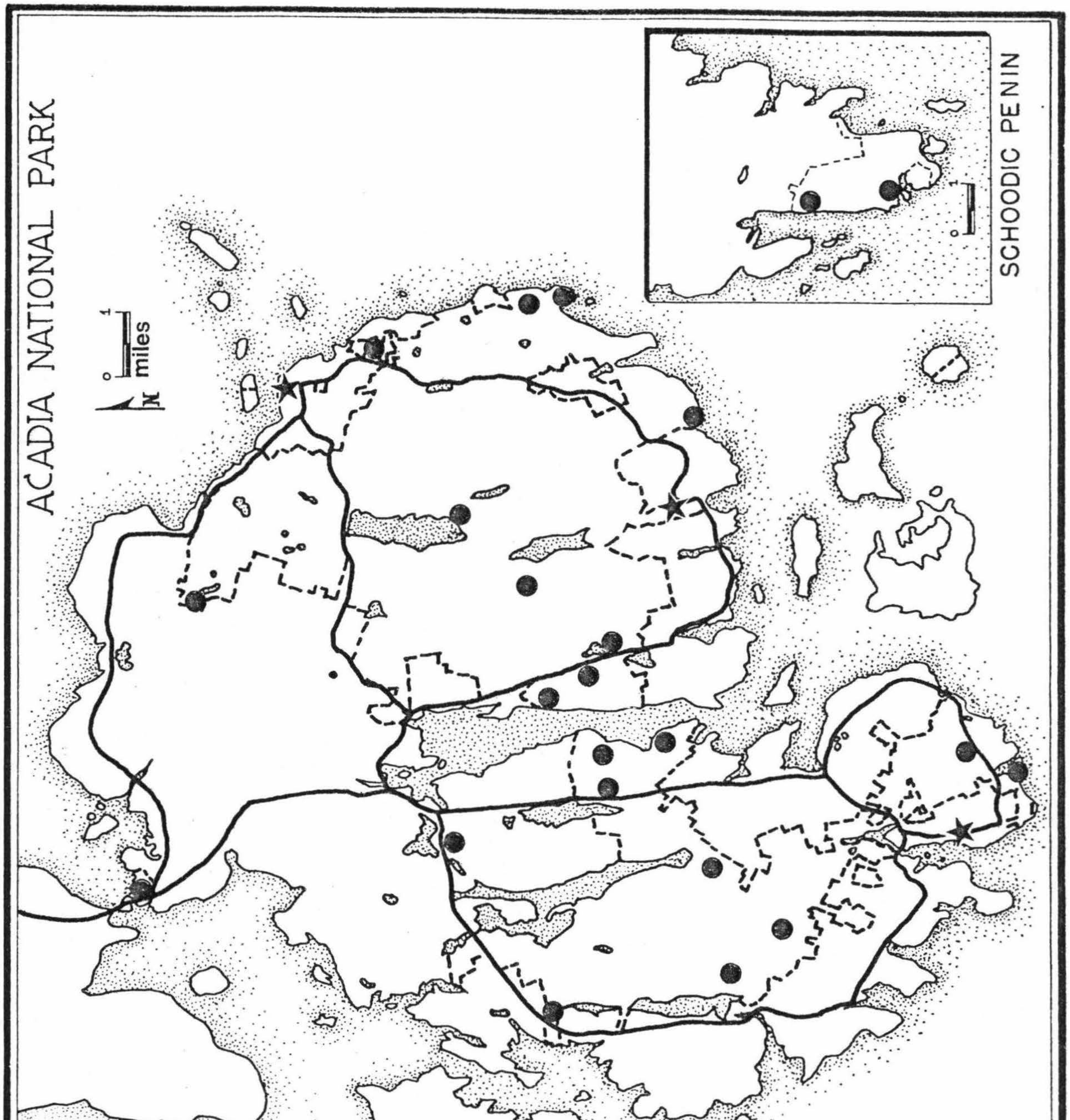


Fig. 1. *Bryoria furcellata*

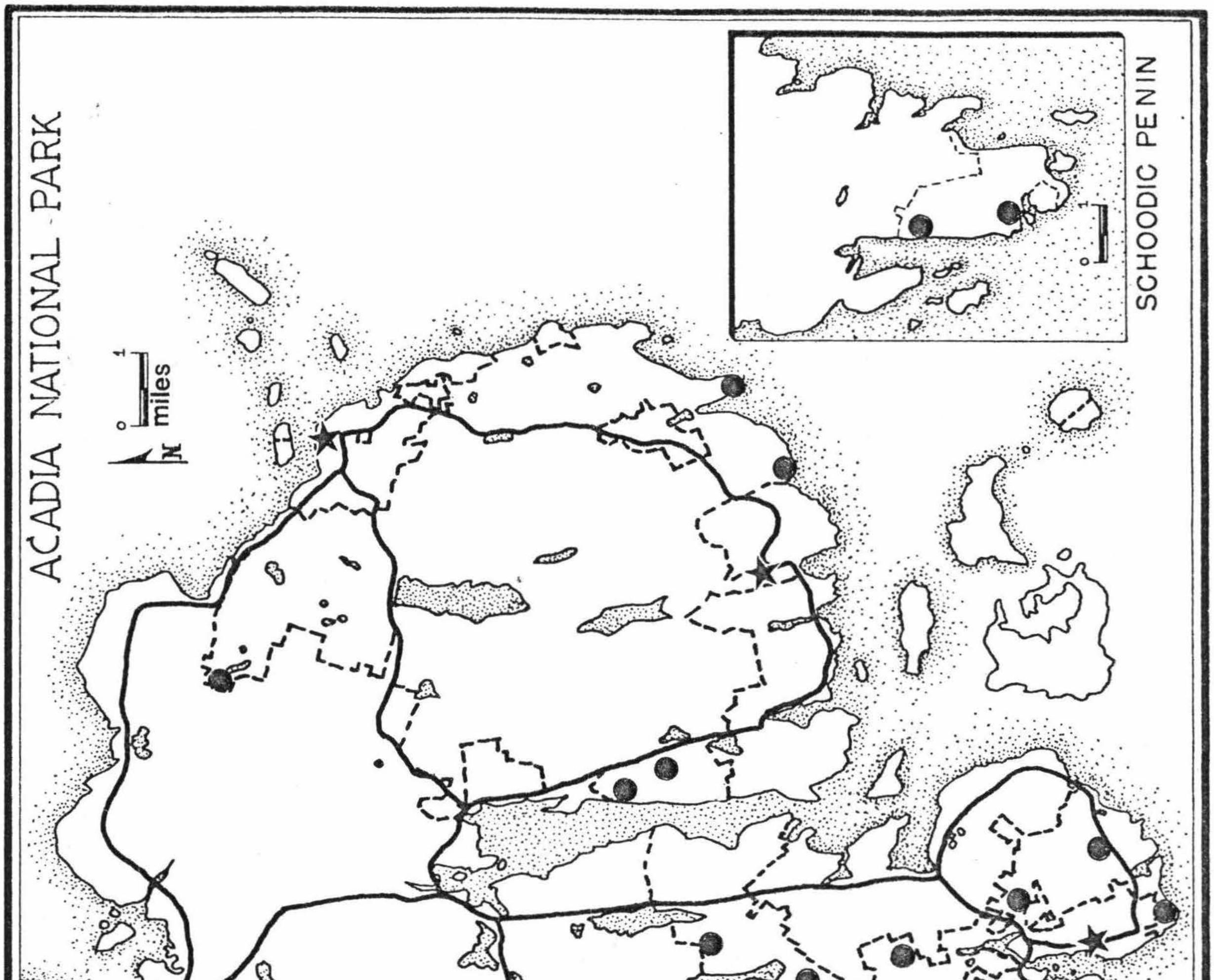


Fig. 2. Bryoria trichodes

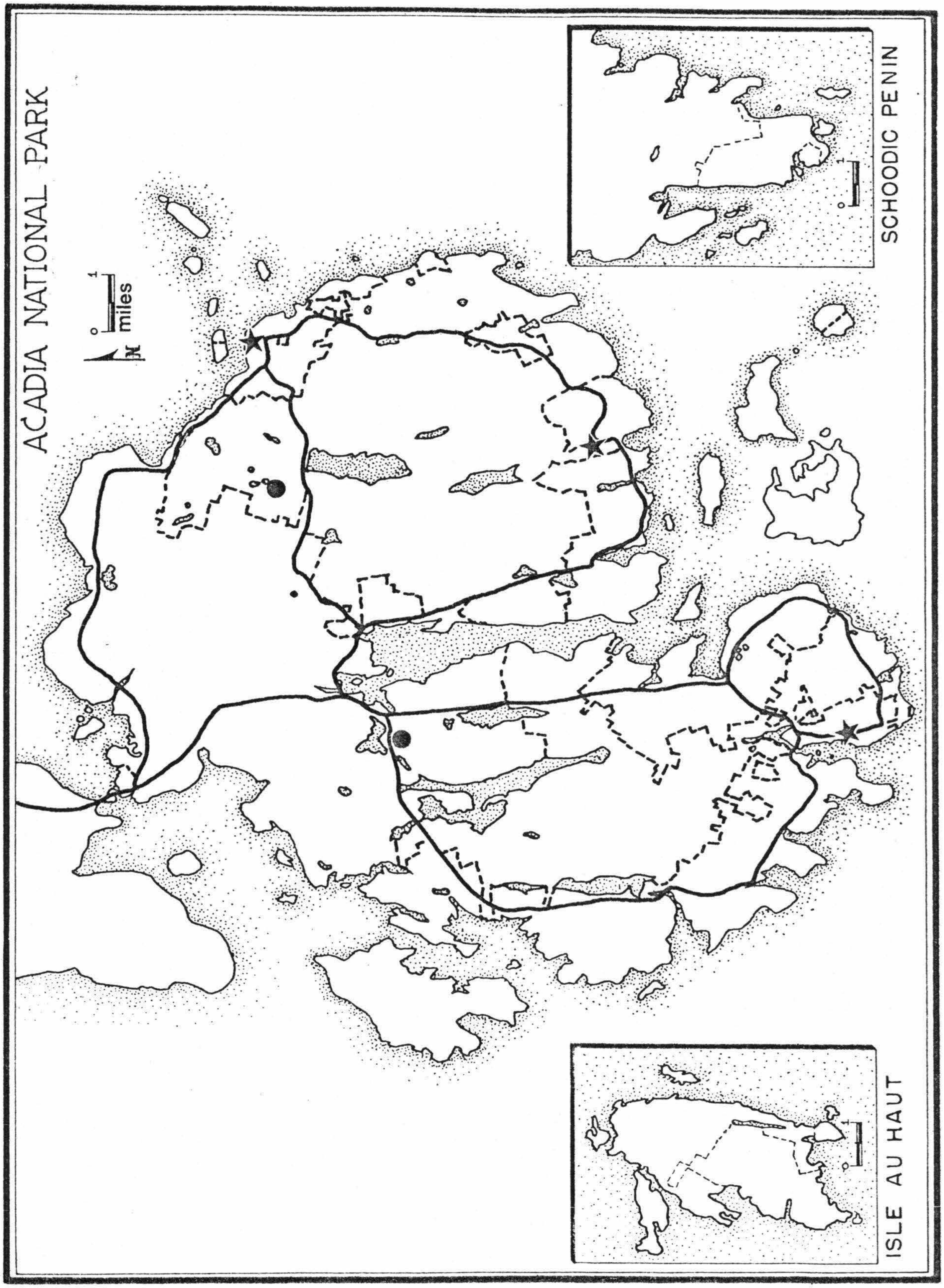


Fig. 3. Cladonia fimbriata

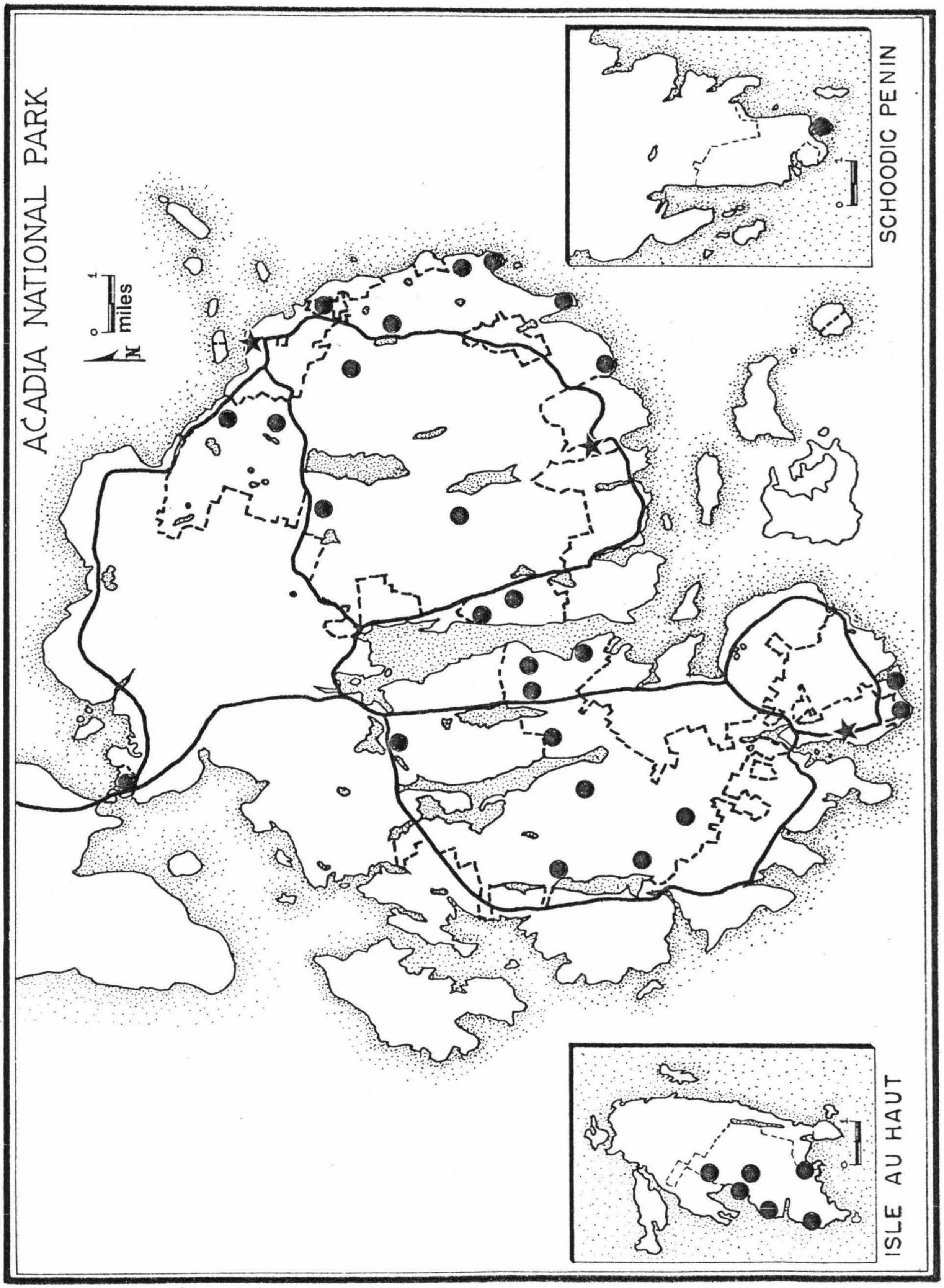


Fig. 4. Hypogymnia tubulosa

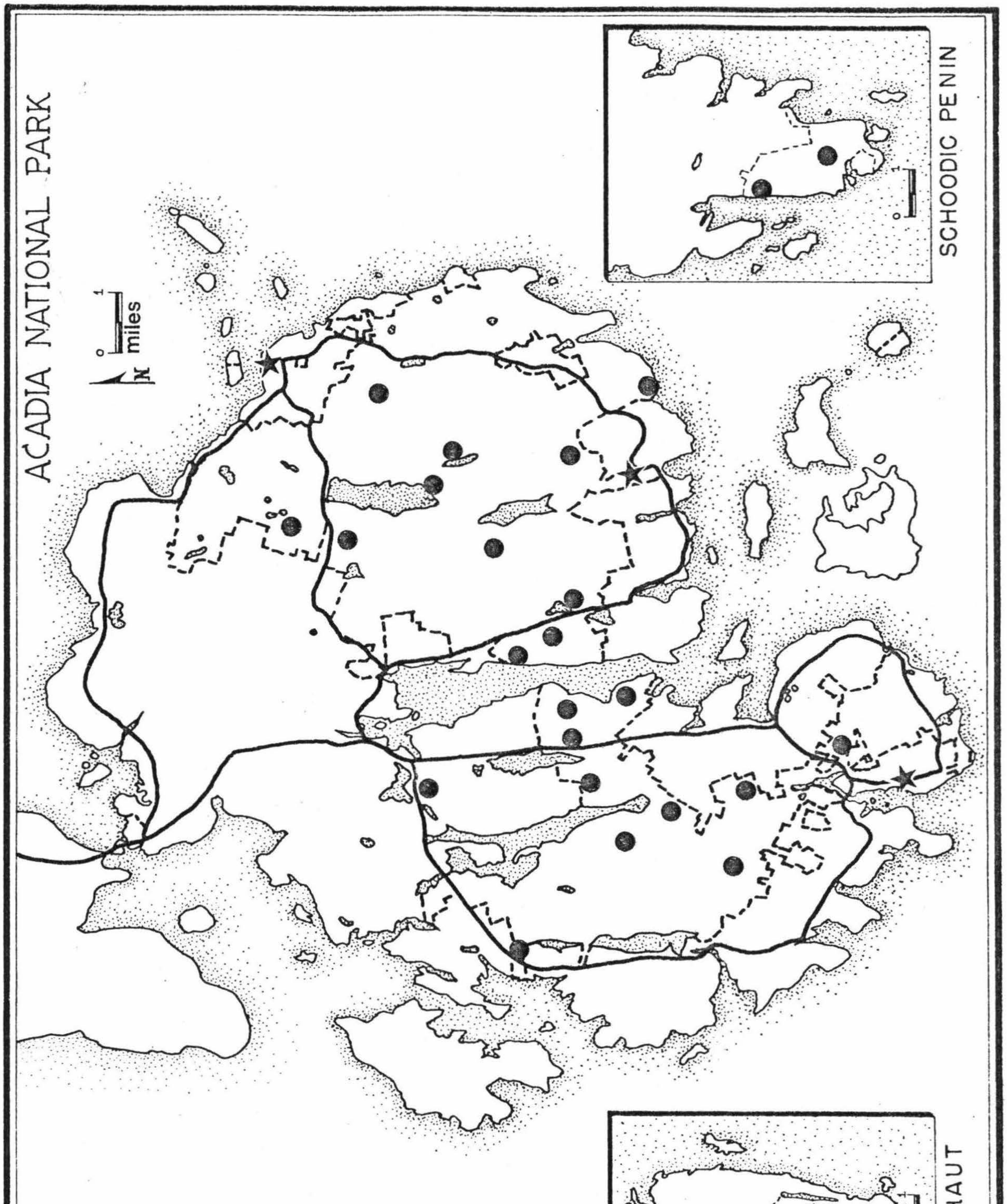


Fig. 5. Lobaria pulmonaria

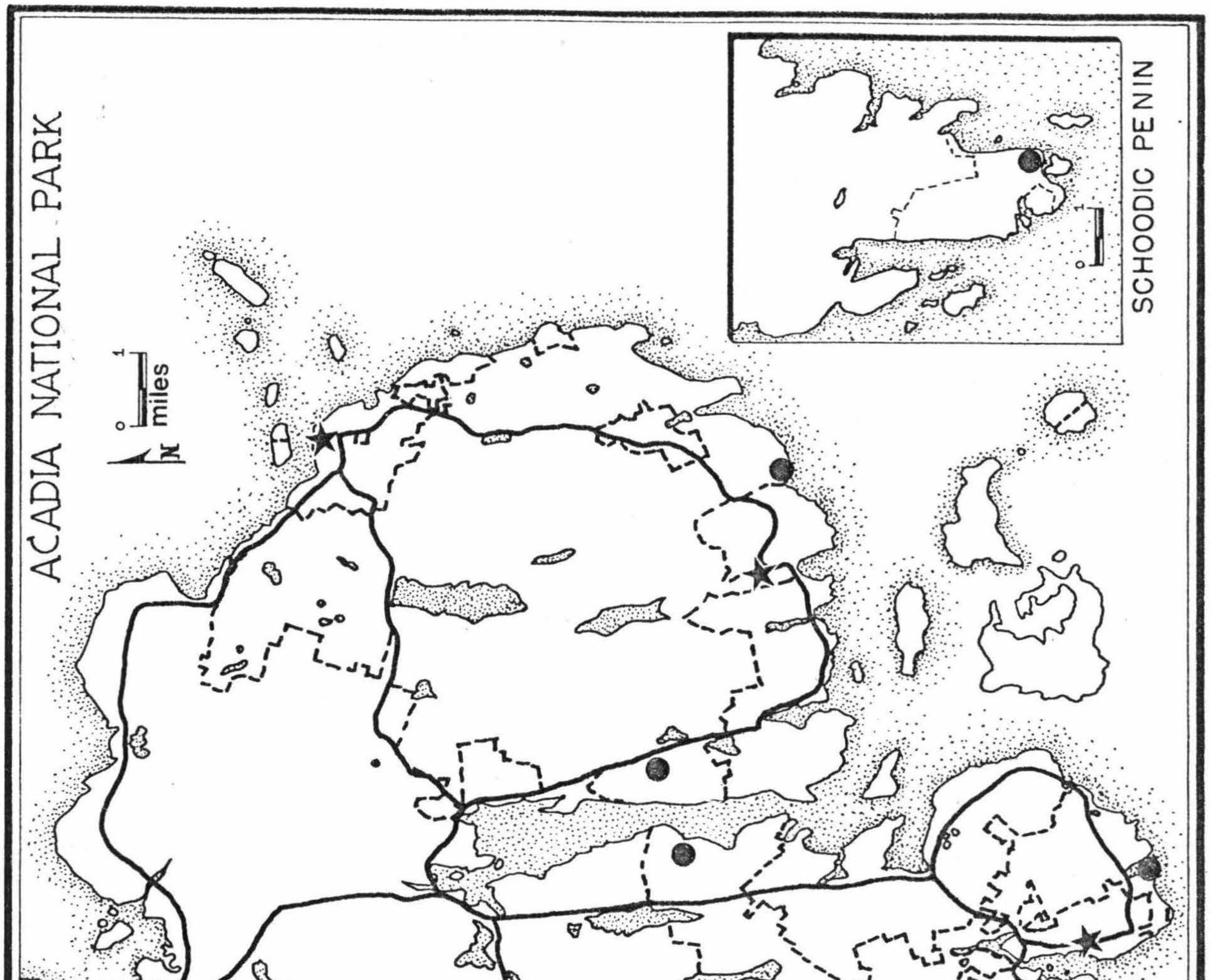


Fig. 6. Parmelia perlata

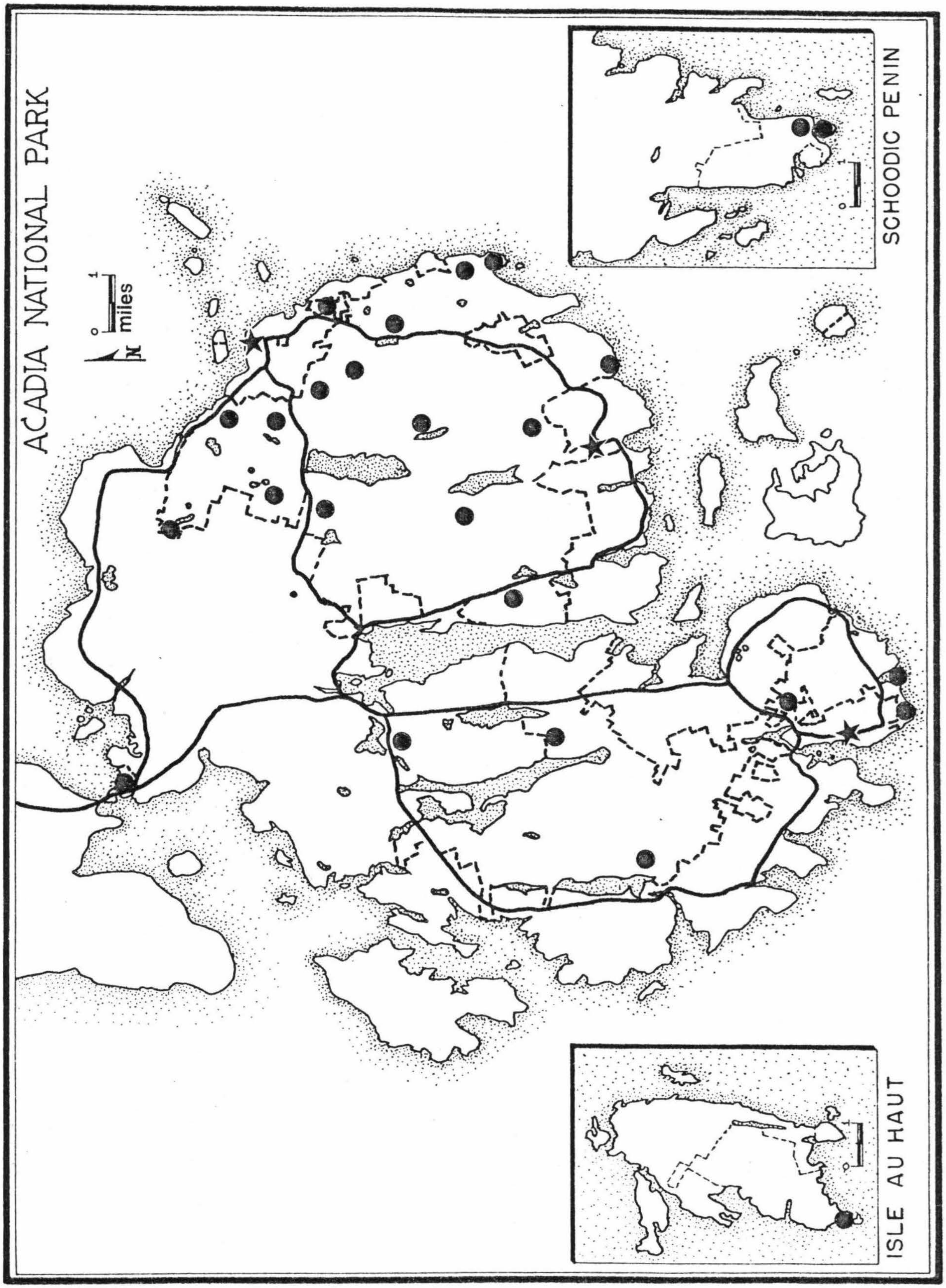


Fig. 7. Parmelia subaurifera

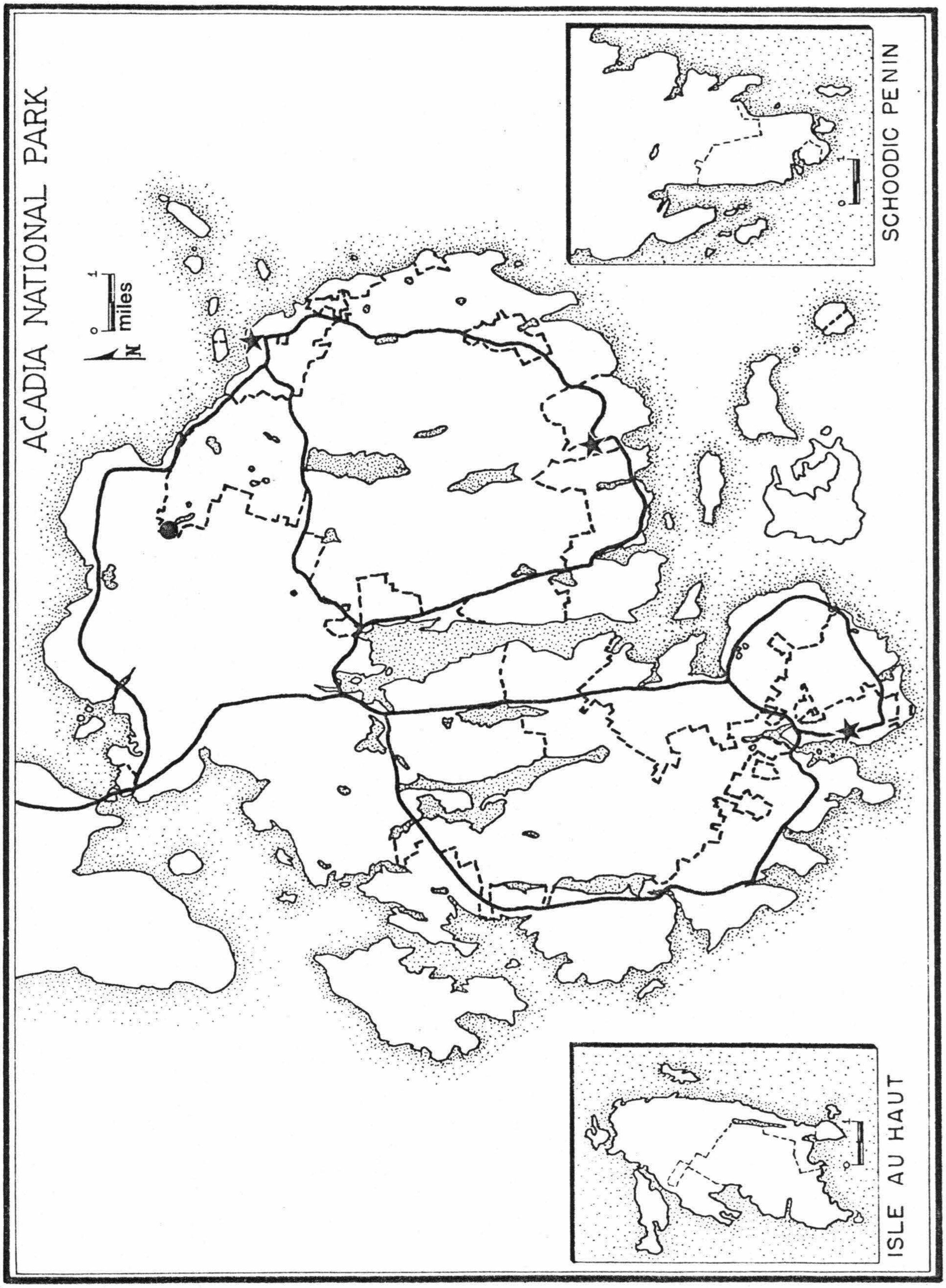


Fig. 8. <u>Ramalina</u> <u>americana</u>

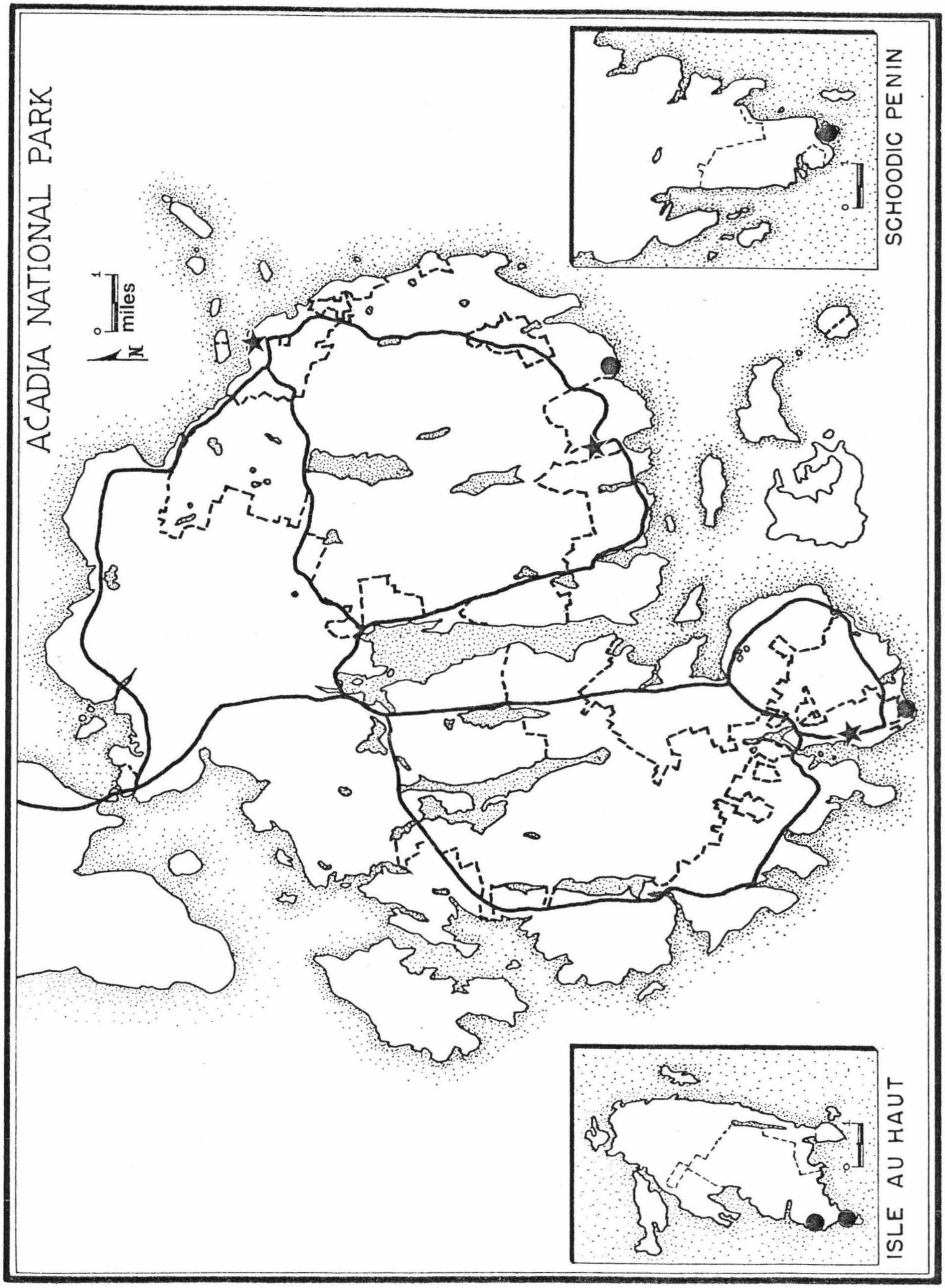


Fig. 9. Ramalina farinacea

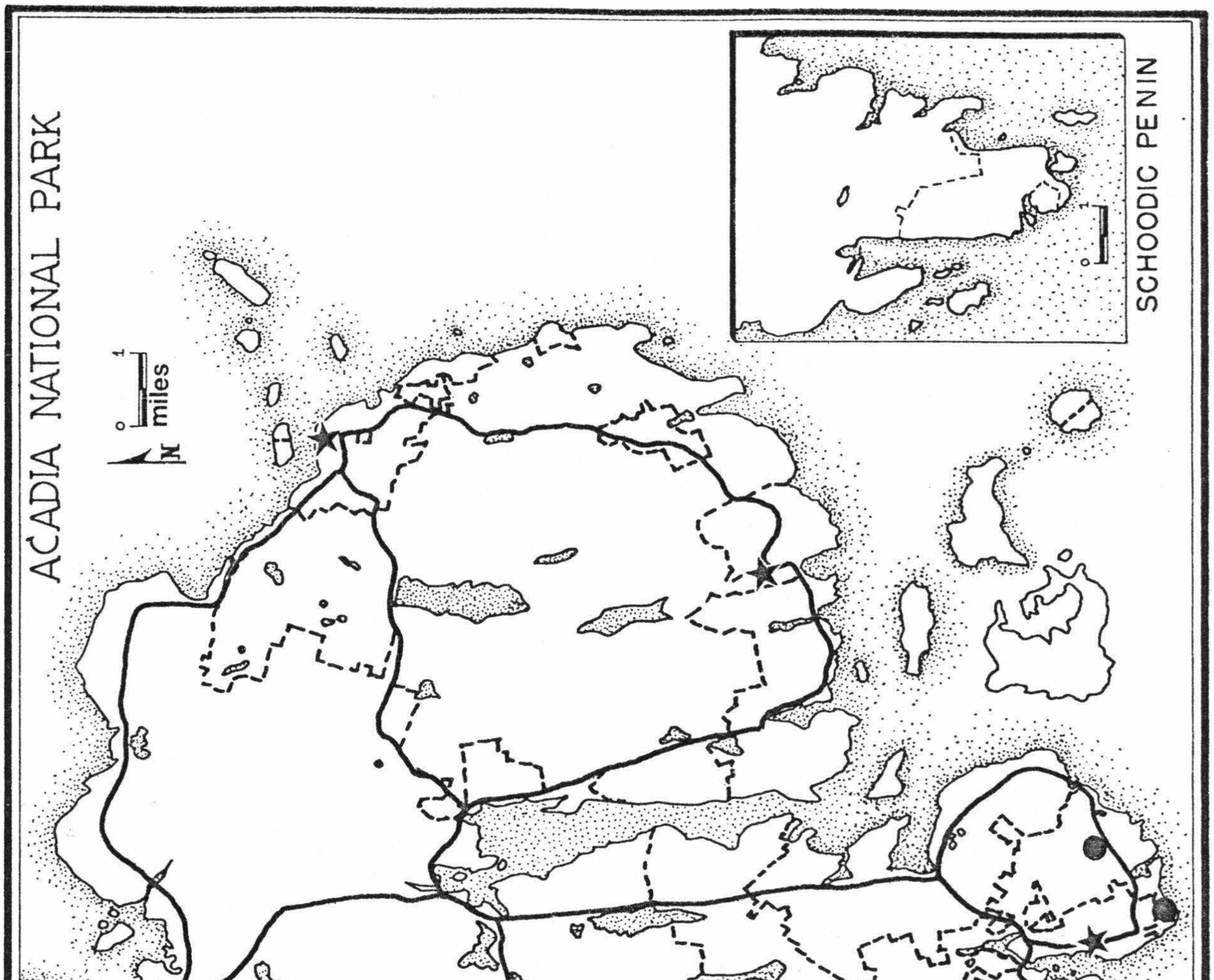


Fig. 10. <u>Usnea ceratina</u>

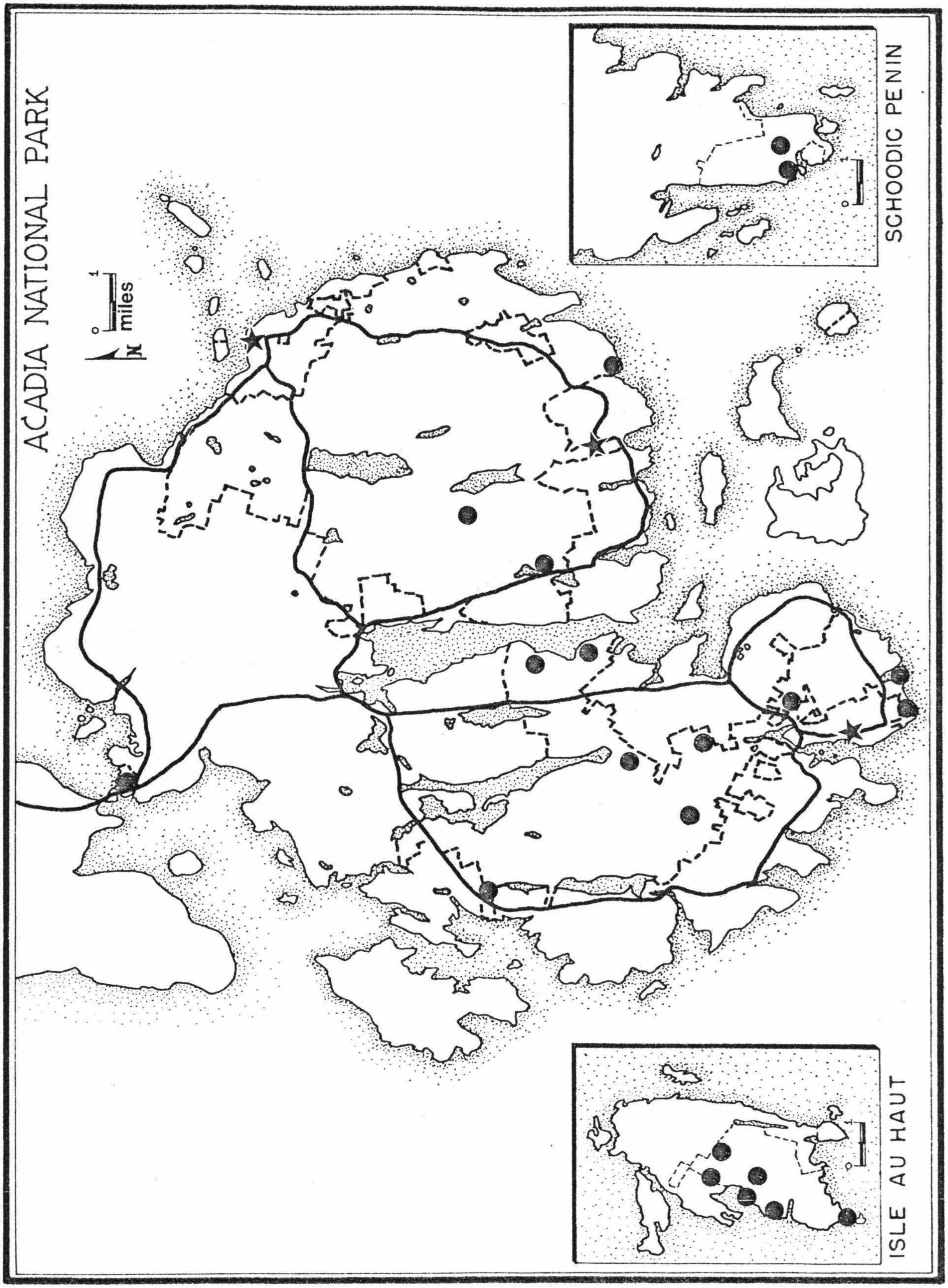


Fig. 11. Usnea filipendula

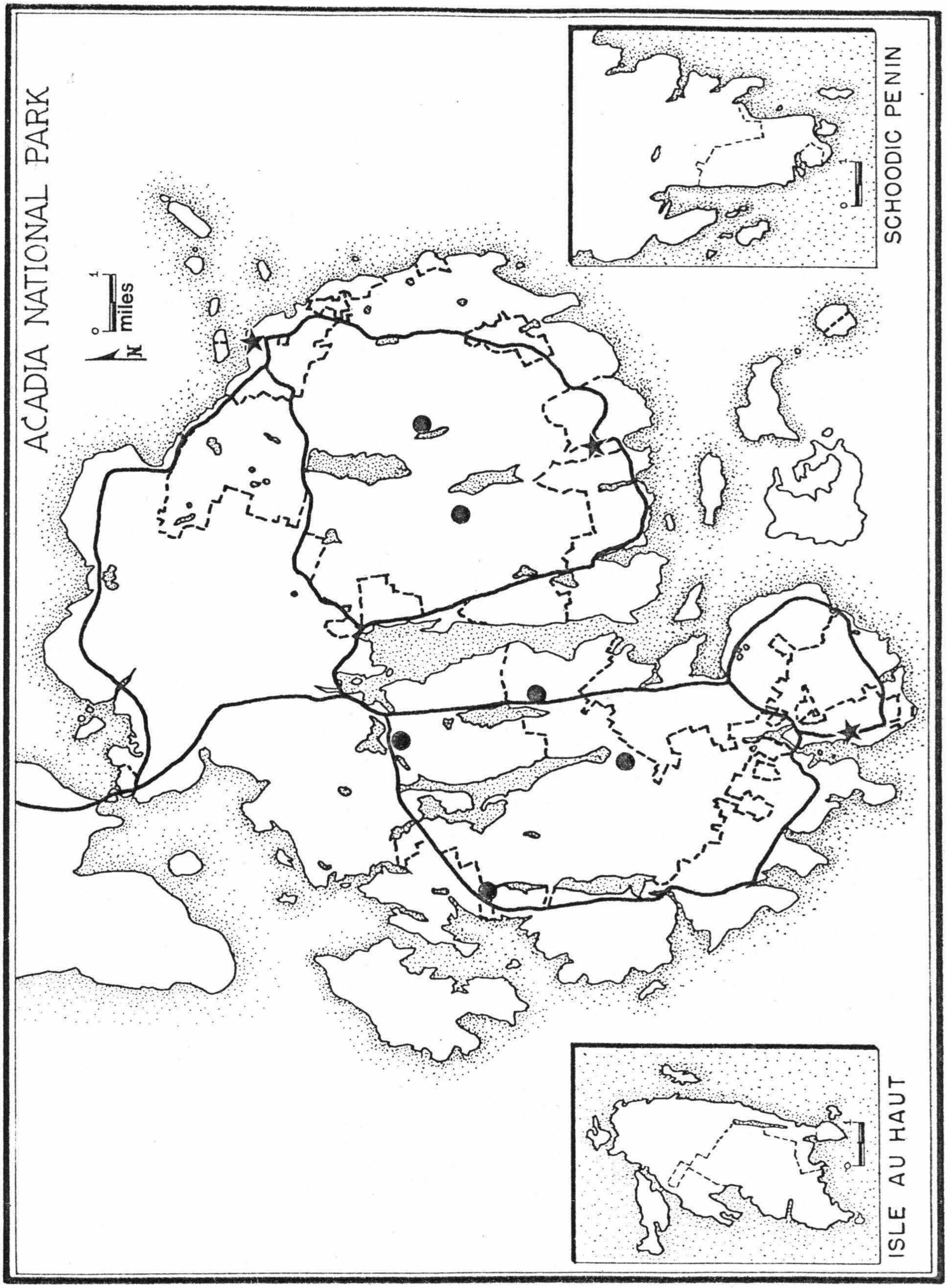


Fig. 12. *Usnea hirta*

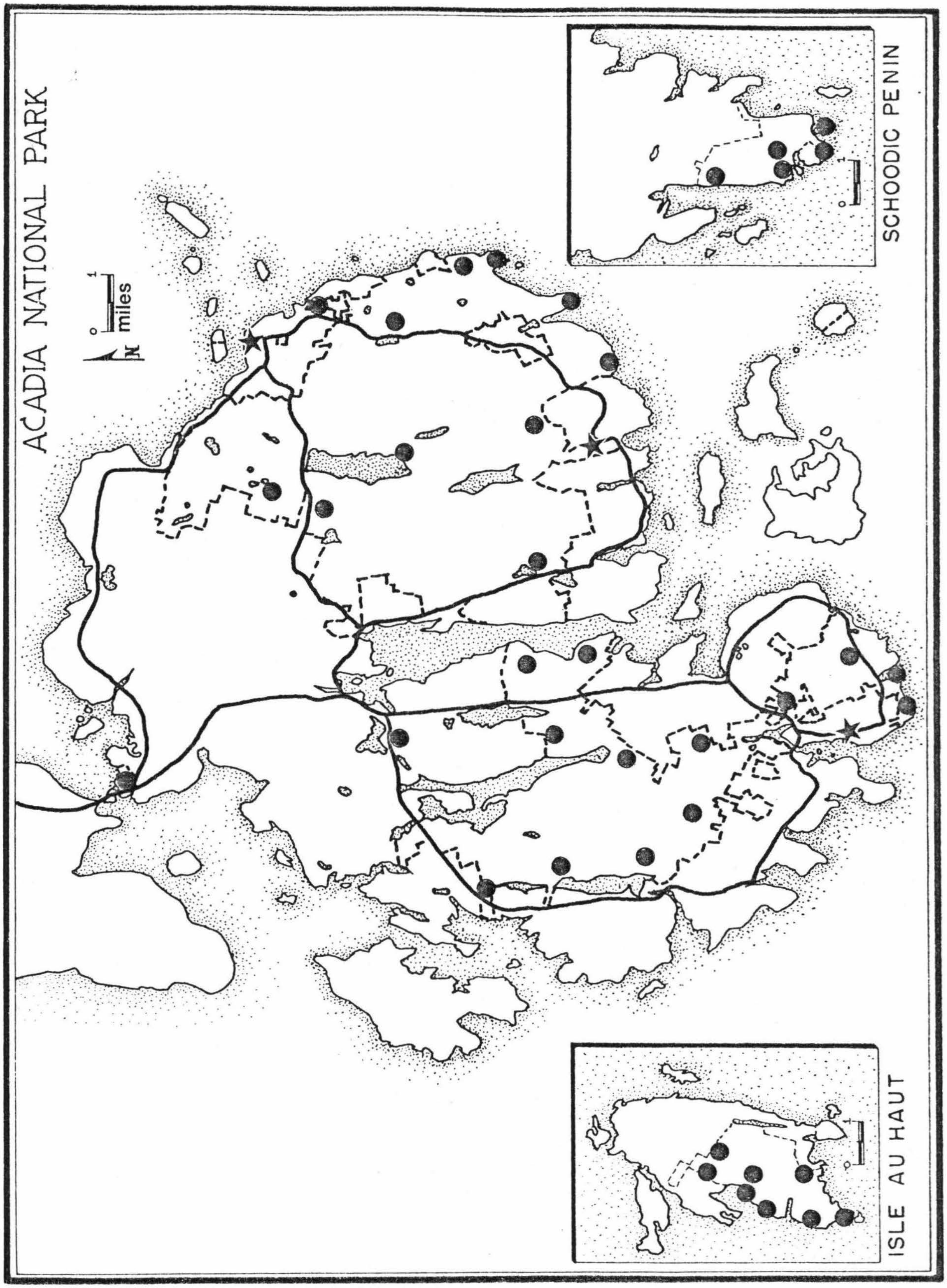


Fig. 13. Usnea subfloridana