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Southern Appalachian Lichens: An Indexed Bibliography

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SOUTHERN APPALACHIAN LICHENS: AN INDEXED BIBLIOGRAPHY

by Paula DePriest

NATIONAL PARK SERVICE - Southeast Region

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INTRODUCTION

This bibliography lists published and unpublished manuscripts on the lichens of the southern Appalachians, with special reference to the Great Smoky Mountains National Park. Also included are general taxonomic and nomenclatural references necessary for the study of lichens in the region. A general review of literature is presented, with an evaluation of the present status of taxonomic, floristic, phytogeographic, and ecological knowledge of lichens in the southern Appalachians. An index allows quick access to the literature citations.

METHODS

This bibliography began as a card file developed in the preparation of the author's Master's thesis (DePriest 1983). Largely, the entries were found in the extensive bibliographies of the regional floras (Dey 1975, 1977, 1978, 1979; Moore 1963) and the state checklist of Skorepa (1971). The citations derived from these works represent the information required for taxonomic and floristic investigations in this region.

Publications centering on the history of lichenology in the southern Appalachians (Armitage 1976, Dey 1975) and North America (Culberson 1961a, Thompson 1974) were used both for detailed information and for citations for the earliest lichenological reports from the region. Many of these early reports were not available to the author. In these cases, the above cited works were used for summaries.

The series "Recent Literature on Lichens," published periodically in the <u>Bryologist,</u> was an important source of additional citations. This continuing bibliography, initiated by Culberson (1951-1978) and continued by Eagan (1979-1983), collects lichenological publications appearing in American journals and some major European botanical journals. The entire 33-year run of this series was inventoried. Also, volumes covering the last 10 years of the <u>Bryologist,</u> the major publisher of American lichenological studies, as well as the regional journals, <u>Castanea</u> and <u>Rhodora</u>, were checked without any additions to the list.

Citations appearing in this bibliography were checked, when available, in the University of Tennessee, Knoxville, library. Also, the extensive personal library of Dr. Aaron J. Sharp was available for the author's use. The bibliographies of these citations provided an excellent source of new entries.

Included in the bibliography are the sources cited in the following review as well as the literature on the lichens of the southern Appalachians. The entries have been arranged alphabetically by author, and chronologically when more than one citation appears by the same author. An index at the end of the bibliography classifies the types of studies present in the bibliography. The citations are referenced by author and year.

RESULTS AND DISCUSSION

Early Collectors

The earliest collections of lichens were made in the eighteenth century exploration of the southern Appalachians commissioned by the French government. André Michaux and his son Francois visited several high mountain areas, including Grandfather Mountain and Roan Mountain of western North Carolina, in the 1780s and 1790s. Their plant collections included 14 species of lichens from "Carolina" reported by Michaux (1803). Four of these were specifically from Grandfather Mountain and several other areas, including Roan Mountain.

In the nineteenth century, two regional collectors. Henry William Ravenel and Moses Ashley Curtis, collected lichens in the southern Appalachians. These avid amateurs corresponded with Edward Tuckerman, the leading American lichenologist of that time. Collections from both were reported in Tuckerman (1858, 1860, 1862, 1888) by the collector's name and general collection location.

Ravenel was described by Culberson (1960) as a "prosperous South Carolina planter, scholar, botanist, and perennial discoverer of new species." In 1850 he reported 62 species and varieties from South Carolina and Georgia, including the uplands of the southern Appalachians. Twenty-nine of these taxa are known also in the Great Smoky Mountains (Dey 1975). Ravenel is credited with the first lichen collected from Tennessee, Cladonia carolinana Schwin ex Tuck. This specimen was sent to Tuckerman and reported in Tuckerman (1858). At the conclusion of the Civil War, Ravenel was forced for financial reasons to seek paying subscribers for his botanical collections, and substantial numbers of these collections are extant in regional herbaria.

Curtis was a circuit minister in western North Carolina. Primarily concerned with collecting fungi, he exchanged general botanical collections with both American and European botanists (Petersen 1980). In his "Botany of North Carolina" (Curtis 1867), he published a checklist of 218 species from North Carolina which was attributed to Tuckerman, much to the latter's dismay (Culberson 1961a). The list was originally prepared, with annotations, remarks, and localities, by Tuckerman in 1860. Publication was delayed by the war, and Tuckerman, in a letter to Curtis in 1866, stressed the need for revision. The list, however, appeared edited and highly mofified by Curtis. Additional remarks and locality information were deleted. Many specimens attributed to North Carolina were actually collected in South Carolina and Virginia. This publication was obscure and not noted by Zahlbruckner (1921-1940), creating some nomenclatural confusion on new names reported in the work.

Other studies in the late eighteenth century include a report on the lichens of Tennessee by W. W. Calkins (1890). While 200 species and varieties were mentioned as present in Tennessee, only 38 were actually listed. In an 1892 exploration of the Whitetop Mountain-Mount Rogers areas reported by Small and Vail (1893), 91 taxa, identified by J. W. Eckfeldt, were collected, with 21 specifically from Whitetop or Mount Rogers.

Floristic Studies

The first floristic study of the lichens of the Great Smoky Mountains National Park (GRSM) was conducted by Degelius (1941). In a two-week visit to the Great Smoky Mountains in 1939, the European lichenologists collected 206 species of crustose, foliose, and fruticose lichens. Fifteen species were described as new to science.

The study included the first observations on the zonation of the lichen flora with the altitudinal changes in the vascular plant communities. A total of 96 species (47 percent) were found exclusively in the coniferous forest, 66 (32 percent) in the deciduous forest, and the remaining 43 (27 percent) in both zones. In addition to the list of lichens, the publication included keys, collection locations, ecological notes, and occasionally discussion of diagnostic characteristics.

Moore (1963) examined herbarium and field collections to prepare a preliminary checklist of foliose and fruticose lichens of GRSM. The study documented the presence of 131 species in 30 genera of fruticose and foliose lichens and produced keys to the species, descriptions, and ecological notes.

Recent changes in species concepts and nomenclature, largely due to the development of chemical taxonomic techniques, have made this treatment seriously outdated.

Recent studies (Dey 1975, 1977, 1978, 1979) have examined the fruticose and foliose lichen flora of the high elevational areas above 1680 m (5500 ft) in the southern Appalachians. Dey emphasized species restricted to Fraser fir, which is now threatened by the balsam woolly aphid. Based on herbarium collections and specimens from collecting sites in Virginia, North Carolina, and Tennessee, 178 species were documented, with 250 species proposed as present throughout the range. Descriptions were prepared which included morphological characteristics, chemical constituents, substrate preferences, and estimates of abundance. Distributions within the major vascular plant communities were discussed, along with phytogeographic patterns in North America and throughout the world.

The author (DePriest 1983) surveyed the macrolichen flora of Unaka Mountain, a moderate elevational mountain ca. 60 miles northeast of the Great Smoky Mountains along the Unaka Range. A total of 142 species in 40 genera were reported from the elevational zone, 915 to 1596 m (3000 to 5238 ft), with descriptions, keys, and distributional information. This study incorporated a number of nomenclatural and taxonomic changes at the generic and specific level which appeared in the literature after 1975.

Regional Floras

A number of regional floras have been prepared for the southern Appalachians Areas examined include Virginia (Culberson 1965b, Forman & Sierk 1970); West Virginia (Millspaugh & Nuttall 1896, Sheldon 1939, Hale in Core 1960, Showman 1973); Kentucky (Culberson 1951, Phillips 1970); Alabama (Mohr 1901, McCollough 1962, 1964, 1967); North Carolina (Culberson 1958b, 1961a, 1966; Perry & Moore 1969); and Tennessee (Hedrick 1933, Sierk 1958b, Phillips 1963a, and Skorepa 1971, 1972).

Taxonomic Studies

In addition to floristic studies, a number of taxonomic studies and revisions have been based on southern Appalachian material. Cladonia is a well studied genus in North Carolina. An authoritative monograph by Thomson (1967b) summarizes work done earlier in the century. Species of Cladonia from Virginia have been treated by Allard and Leonard (1944), Luttrell (1954); from Kentucky, by Fulford (1938); and from Tennessee and the Great Smoky Mountains, by Mozingo (1961). Ecological studies of the C. chlorophaea group have been published by Bowler (1972) and Almeda and Dey (1973).

Species of the composite genus Parmelia have been examined for the southeast by Kurokawa (1969) and Hale (1972, 1976d). Esslinger (1972) studied the brown Parmelias which now constitute Melanelia and Neofuscelia. Dey (1981) has prepared an unpublished key to the species present in the Southeast and, during his survey of the high elevational lichen flora, described several new species and discussed rare species (Dey 1973a, 1973b, 1974b, and 1974c).

Other groups studied include Heterodermia and Anaptychia in the Carolinas (Culberson 1966); fruticose Cetraria of the Great Smoky Mountains (Mozingo 1954); Collemataceae of Tennessee (Sierk 1958; and the Physciaceae of the Carolinas in an unpublished key (Esslinger 1981). One crustose genus has been revised with an emphasis on southern Appalachian material, Petrusaria (Dibben 1975). Unpublished keys have been prepared for Ochrolechia in the southern Appalachians by Brodo (1981).

Phytogeographic Studies

Studies of the lichens of the southern Appalachians have focused on the richness of the lichen flora, which has been enhanced by elements of boreal, montaine, and southern floras. Yoshimura (1967, 1968), Culberson (1972), and Dey (1977, 1979) noted that lichen exhibit the same phytogeographic patterns as other plant groups and concluded that they were responding to the same physioecological and historical factors. However, in the lichen flora the appearance of disjunctions at the specific level, rather than at the generic or higher levels as in the vascular plants, was interpreted by Culberson (1972) as a slower rate of speciation in lichens as compared to other plant groups.

Skorepa (1972), in his checklist of Tennessee lichens, first categorized the distributions into 13 general patterns from North America. Dey (1975, 1979) found representatives of 10 of these distributions in the fruticose and foliose lichens of the high elevational areas of the southern Appalachians. Eleven distribution patterns were listed by Dey (1979) for all of North Carolina and by DePriest (1983) for the fruticose and foliose lichens of a moderate elevational zone. The most common pattern in Dey (1977) and DePriest (1983) was those species endemic to the Appalachians, with 43 species (15 percent) and 27 species (19 percent), respectively.

World distributions have been grouped into general patterns by Dey (1975, 1977) and DePriest (1983). Of six categories listed by Dey (1977), the most common was endemic to North America, represented by 43 species (15 percent) of the fruticose and foliose species, with 14 species (5 percent) narrowly restricted to the southern Appalachian Mountains. In DePriest (1983) the most common pattern of macrolichens of the moderate elevation zone was widespread, occurring on at least four continents and represented by 64 species (44 percent).

Interesting phytogeographical relationships with the eastern Asia flora have been discussed by Yoshimura (1967, 1968), Kurokawa (1972), and Sharp (1966b). Yoshimura, in examining the phytogeographic relationship of the Japanese and North American species of Cladonia, found that, out of 46 species reported for the southern Appalachians, 32 were also present in the Japanese lichen flora. This represented more common species than between any other areas considered in this study. Also, Yoshimura noted a high rate of endemism in the southern Appalachians and five vicarid species pairs between eastern North America and Japan.

The genus Gymnoderma, considered a primitive member of the Cladoniaceae, also displays the eastern Asia-southern Appalachian distributional pattern (Yoshimura 1967; Yoshimura & Sharp 1968). In the southern Appalachians one species is present, G. lineara (Evans) Yoshimura & Sharp, which is rare but widespread on vertical rock cliffs at moderate to high elevations. Two other species are endemic to southeastern Asia, G. coccocarpum and G. insularum. In recent years the distribution of this genus has become more interesting with the discovery of a fourth species, G. melacarpum Yoshimura & Kurokawa, endemic to Tasmania and Australia (Yoshimura & Kurkowa 1976).

Kurokawa (1972), in a paleofloristic comparison of Asia and eastern North American flora, examined several groups of lichens. Parmelia section Imbricaria (=Parmelina sensu Hale) is represented by 14 species in Japan and eight species in eastern North America. Of these, five occur in both floras, producing a floristic affinity value of 29, which is moderately high. One species group shows a typical disjunct distributional pattern. The apotheciate morph of this group (P. galbina), occurs in Japan and North America. The vegetative morphotypes of this group, probably derived from this fertile species, are known from only one continent each. The sorediate morph, P. metarevoluta, and the pustulate morph, P. hayachinensis, are known only from Japan, and the isidiate morph, P. obsessa, from eastern North America.

Two groups of species in Anaptychia demonstrate this pattern of a widely distributed sexual morph and a restricted asexual morph. A. palmulata, an apotheciate species, occurs in eastern Asia and eastern North America, and its isidiate morph, A. isidiza, is limited to Japan. Similarly, A. hypoleuca, a fertile species found in eastern Asia and eastern North America, has one vegetative morph, A. microphylla, an isidiate species found only in eastern Asia.

Kurokawa also examined Parmelia section Hypotrachyna (=Hypotrachyna sensu Hale) and found a low floristic affinity between eastern North America and Japan. Out of a total flora of 13 species in Japan and 10 species in eastern North America, only three occurred in both areas. The distributional pattern of this section differed from that seen in Cladonia, Anaptychia, and other Parmeliceous groups. Hypotrachyna has its center of diversity and distribution in the New World tropics.

The phytogeographical relationship between the southern Appalachians and the New World tropics has been noted by Sharp (1966a, 1966b) and Yoshimura & Sharp (1967, 1968). Six species found in the southern Appalachians have disjunct distributions in this area (Dey 1975, DePriest 1983). Three Appalachian endemics have disjunct populations in the West Indies and Mexico, Hypotrachyna croceopustulata, H. gondylophora, and Pseudevernia cladonia. All of these are abundant on Fraser fir and, more rarely, hardwoods in the spruce-fir zone of high elevational areas (Dey 1975), while occasional on other conifers and hardwoods in white pine plantations at moderate elevations (DePriest 1983). Three other species--H. thysanota, Anzia americana, and P. consocians--follow similar distributional patterns in North America but are found elsewhere only in Mexico.

Paleofloristics

Species of Hypotrachyna have been used as examples of Arcto-tertiary relics in the southern Appalachians. Of the 14 species present in the southern Appalachians, only two do not occur also in the New World tropics. H. virginica and H. showmanii are rare southern Applachian endemics (Hale 1975, 1976d). Of the remaining species, nine are endemic to the southern Appalachians in North America. The restricted distribution of H. croceopustulata, H. densirhizinata, H. gondylophora, H. producta, H. oostingii, and H. thysanota within the southern Appalachians indicates that their ranges may have been reduced and fragmented during periods of glaciation and warming (Dey 1975).

In bryophytes, Anderson and Zander (1973) concluded that the southern Appalachians served as a center of preservation of the Arcto-tertiary mixed forest. Subsequently, elements of this flora migrated from this area into land masses newly exposed by the retreat of the continental glaciers. As in the bryophytes, the Arcto-tertiary relics, unable to effectively increase their range during the post-glacial hypsithermal period, are currently represented by populations on the highest peaks or in the spruce-fir forest of the southern Appalachians (Dey 1975, 1977).

The origin of representative groups of lichens has been variously ascribed to southern and northern locations. Hale (1965), working in the Parmeliaceous genera, proposed that the ancestral species were probably nonsorediate-nonisidiate and widely distributed in the tropical regions. This was based on the high number of nonsorediate species confined to the tropical regions, often one continent, at the present time. Hale stated that the sorediate counterparts "...have developed, and most of them are much more widely distributed in temperate areas than the nonsorediate counterparts." This has been interpreted as an ecologically limited but geographically widespread fertile species, giving rise to vegetative counterparts which have a broad ecological tolerance but a limited distribution due to their recent origin.

Conversely, Kurokawa (1972) and Yoshimura (1967) have suggested that the fertile progenitors came from the north, as did the Arcto-tertiary relics. The fertile progenitors were eliminated in their northernmost distributions by glaciation and were preserved only in the southern portion of their range. As the glaciers retreated, these populations radiated from the areas of preservation, as did vegetative populations derived from the fertile populations. Because of their efficiency in vegetative propagation, these populations quickly spread away from their area of origin at a faster rate than the fertile populations. This distribution history would result in a fertile parent species which may be widespread in a worldwide sense but restricted in ecological amplitude and abundance. The vegetative morphs would be limited geographically because of their recent origin but would be broad in ecological tolerance.

Distributions

Outside of the endemics restricted to the higher elevations, little is known about the distribution of species within the southern Appalachians. Dey (1975) included the largest latitudinal range but did not compare the northern and southern peaks. Degelius (1941) was the first to compare the lichen flora of low-to-middle elevation deciduous forests with the high elevation coniferous zone. Dey (1975) discussed the lichen flora of nine community types present in this high elevation zone, above 1680 m (5500 ft) elevation, while DePriest (1983) discussed and presented in a table those of nine community types in a middle elevation zone, between 915 m (3000 ft) and 1585 m (5200 ft) elevations.

Community Studies

A limited number of community studies have been done in the southern Appalachians. Becker (1980) examined the lichen flora of a gray beech forest in the Great Smoky Mountains and found a biomass of 7 to 9 kg ha^{-1} which varied directly with the abundance of Aesculus octandra (buckeye). The annual contribution of nitrogen in the form of ammonia was 0.8 kg ha^{-1} in these beech gaps. A similar study (Becker, Reeder, & Stetler 1977) was conducted on the biomass and habitat of nitrogen fixing lichens in an oak forest of the North Carolina piedmont.

Also, in the piedmont area the lichen flora has been included in two studies of pine woodlands. Johnsen (1959) compared the terrestrial cryptogams of woodlands with and without litter. Eight lichens were included in this study. Culberson (1958b) also included lichens in his study of variation in the pine-inhabiting vegetation of North Carolina. The most luxuriant vegetation, an average of 9 lichen species per tree, was found on pines at the highest elevations, 1100 m (3609 ft). A total of 66 species were reported, including crustose species. A recent study by Fisher (1979) has suggested that Cladina rangiferina (found in this area) and C. alpestris may reduce growth of tree seedlings of jack pine and white spruce by impairing root development and ^{32}P uptake. These terrestrial lichens may greatly affect community structure.

Only one successional study has been conducted in the area. Robinson (1959) monitored the lichen succession in an abandoned field in the North Carolina Piedmont.

Substrate Specificity

A number of investigators have suggested that substrate availability is the most important factor in the distribution of lichens (Dey 1975, 1979; DePriest 1983), though the interrelated factors of altitude, climatic conditions, and community types are also important. Substrate and ecological notes for individual species have been reported in a number of articles and summarized by Moore (1963), Dey (1965, 1978, 1979), and DePriest (1983). Skorepa et al. (1979) listed and discussed the substrate preferences of the lichens of Maryland. Interesting substrate reversals are also discussed.

In the southern Appalachians the largest lichen flora is found on corticulous substrates. Dey (1979) has suggested there is a significant difference between the epiphytic flora of conifers and hardwoods. Fraser fir and red spruce epiphytes were emphasized in Dey (1975). Culberson (1958b) examined the lichen flora of various species of pines across North Carolina, while DePriest (1983) discussed the lichens of white pine plantations at moderate elevations. Hardwood-inhabiting lichens usually are found to occur on a number of species. However, Becker (1980) found the inclusion of buckeye in beech forest increased the lichen biomass and especially the frequency of blue-green algae-containing species.

The terricolous lichen flora is especially well developed in the grassy balds, ericaceous heath, and pine dominated communities of the southern Appalachians. Disturbed areas such as roadbanks and trailsides are typical locations of Baeomyces fungoides and species of Peltigera and Cladonia. The soil-inhabiting lichens of pine woodlands have been examined by Johnsen (1959).

Degelius (1941), in his study of the Great Smoky Mountains, suggested that "...the lichen flora...will prove to be rather poor. This depends principally on the great predominance of forest and the consequent inconsiderable variation in substratum, and the scarcity of naked rocks, which are so rich from the lichenologic standpoint." Rock substrates, while not extensive, are more abundant in the southern Appalachians than Degelius realized. These substrates have not been well examined, largely because of their inaccessibility. However, a number of very rare species have been collected from rock substrates. Roan

Mountain is the only North American locality for Stereocaulon ramulosum. It is known from three locations, the last of which (Sharp n.s.) was collected in 1957. The granatic rock of Grandfather Mountain is the southernmost North American locality for Xanthoparmelia incurva (Dey 1979). Hack (1965), in a geomorphological study of the Shenandoah Valley of Virginia and West Virginia, observed that different species of yellow-green lichens occurred on various sizes of scree (rock rubble). Assuming that the smaller rock fragments were of more recent origin, he suggested that the lichens could be used to approximate the age of rock surfaces in this area.

One saxicolous species, Hydrotheria venosa, occurs only on submerged rock. This aquatic lichen is known from Sevier, Blount, and Monroe Counties in the Great Smoky Mountains. Habitat notes, including physiochemical water quality notes, were published by Dennis et al. (1981).

Species Competition

Competition between saxicolous species has been examined by Lawrey (1981) and Armstrong (1982). Lawrey (1981) examined environmental conditions for two saxicolous species on two Potomac River Islands. Pseudoparmelia baltimorensis was most frequent at low light intensities while Xanthoparmelia conspersa was most frequent at high light intensities. In species poor communities, X. conspersa exhibited a niche shift toward intermediate light intensities. Lawrey concluded that this was likely the result of "reduced competitor diversity."

Armstrong (1982) also examined competition between saxicolous species. His results suggest that "the three lichens show interference by competition for space and light in the following order of competitive ability: P. conspersa > P. saxatilis > P. glabratula ssp. fuliginosa."

In a study of the Pseudoparmelia baltimorensis-caperata complex in the southeastern United States, Culberson and Culberson (1982) noted that P. baltmorensis was more common on corticolous substrates. In other parts of North America, the latter is found on both substrates. They concluded that past competitive pressure from the rock-inhabiting P. baltimorensis eliminated the rock-adapted gamodemes of P. caperata. P. baltimorensis, a North American endemic, can be distinguished from the cosmopolitan P. caperata by its production of pustules, which do not become sorediate, and trace amounts of gyrophoric acid.

Chemotoxonomic Studies

Most species in the flora have been chemiclly examined for lichen acids useful in chemotoxonomy (C. F. Culberson 1969, 1970, 1972, 1974; C. F. Culberson et al. 1977, 1981; Dey 1975). A larger number of the species, especially in *Parmelia* and *Cladonia,* require chemical analysis for identification. Some of these chemically defined species have been studied in the southern Appalachians. *Cetrelia* has four species with minor morphological variation but distinct chemical constitutents (Culberson 1958a, 1965; Culberson & Culberson 1968, 1977, 1978). The *Cetraria ciliaris* group includes three species in the southern Appalachians which differ primarily in their chemistries (Culberson & Culberson 1967). The *Cladonia chlorophaea* group has been examined by a number of workers (Culberson & Kristinson 1969, Bowler 1972, Almeda & Dey 1973, Culberson et al. 1977) and has been found to have five species, four of which occur in the southern Appalachians. Dey (1975) calculated frequencies for these species and found that *C. grayii* was the most common of the four.

Physiological Studies

In addition to natural product chemistry, two physiological studies have been conducted. Kelley and Becker (1975) examined the effects of light intensity and temperature on four nitrogen fixing lichens. Lechowicz and Adams (1979) studied the net CO_2 exchange of species of *Cladonia* endemic to the Southeast.

Lichen Growth Studies

Growth rates of lichens have been examined in three studies. Phillips (1962, 1963b) monitored the growth rate of *Parmelia isidiosa* for three years and found an average annual radial growth of 5.3 mm. However, he cautioned that foliose lichens should not be measured during or immediately after precipitation. Lawrey and Hale (1977, 1979) studied the growth rate of *Pseudoparmelia baltimorensis* on Plummers Island, Maryland. A second study at this location examined the growth response to stress induced by automobile exhaust pollution.

Pollution Effects

In the same study site, Lawrey and Hale (1981) analyzed lead levels in *Pseudoparmelia baltimorensis*, *Xanthoparmelia conspersa*, and *Cladina subtenuis*. The study illustrated that pollution by automobile exhaust has increased lead accumulation to the highest level found for foliose and fruticose lichen species outside of Pb mining areas. *C. subtenuis*, the fruticose species, had the lowest value and suggested that morphology influences lead accumulation and therefore pollution effects.

In Tennessee, two air pollution studies have been conducted. Mathis and Tomlinson (1972) monitored lichens in metropolitan Nashville along a transect formed by the Cumberland River. A depletion of lichen species was noted in the metropolitan center with a return to normal levels at the periphery. A second study was conducted by the Tennessee Valley Authority at a coal fired plant in middle Tennessee. The lichen monitoring portion of the study was carried out by well qualified lichenologists, but the results of the study are not public record.

Showman (1975, 1981) has examined the use of lichens as indicators of air quality around a coal fired generating plant in Ohio. A depletion of the lichen flora was noted in the initial study. However, with air quality improvement, recolonization of *Pseudoparmelia caperata* was observed within four years. By eight years after abatement, the species had returned to its normal distribution even in areas which were previously pollution-induced void.

The granite outcrops in Georgia have been monitored for radioactive fallout by Plummer (1967, 1968, 1969), Plummer and Helseth (1965), and Plummer and Moncrief (1964). In these studies the highest concentration of Cs, up to 300 pCs per g dry weight, was measured in *Parmelia conspersa*.

SUMMARY

The lichen flora has not been examined to the extent of the vascular flora but, as a result of a number of studies in the 1970s, our understanding of the lichens has increased tremendously. Dey's (1975, 1977, 1978, 1979) publications have been most important because they compiled and summarized information from many sources. As a result, floristically, the fruticose and foliose lichens of the Great Smoky Mountains are well known, especially at the higher elevations. Similar studies are now needed for the low to mid-elevational areas in the park, which have been long overlooked by lichenologists. Also, the different community types should be examined and floristic lists prepared.

Crustose lichens remain largely uninvestigated in this area. These lichens are very difficult to work with, and comprehensive keys and descriptions are not available for most groups. The only floristic study which included crustose species was produced in 1941 by Degelius. Since that time a number of collections have been made but are reported only in revisions and monographs. Floristic investigations of these groups are needed very much, along with compilation of existing information.

Taxonomically, our understanding of the lichen flora is very good, except in a few groups. Few taxa remain undescribed, and new names are produced largely by changes in species concepts. These changes are largely a product of modern taxonomic investigations using techniques such as thin layer chromatographic analysis of chemical constitutents. The genus _Usnea_ continues to be confusing and needs examination and revision. Because of the diversity of chemical traces in _U. confusa_, _U. mollis_, and _U. subfloridana_, these species may each represent a group of morphologically similar taxa. Conversely, species such as _U. ceratina_, _U. diplotypus_, and _U. hesperina_ are delimited by their chemical composition with little regard for their polymorphic nature. Problems also remain in the genus _Ramalina_.

In the 1970s a number of nomenclatural changes at the generic level appeared in the literature. In Dey's (1975) survey, the largest genus was _Parmelia_, with 42 species. Since that time, 10 segregates of this genus have been recognized: _Bulbothrix_, _Everniastrum_, _Hypotrachyna_, _Melanelia_, _Neofuscelia_, _Parmelia_, _Parmotrema_, _Pseudoparmelia_, _Recilina_, and _Xanthoparmelia_. Recently, _Everniastrum_ has been shown to be a nomen nudum and has been replaced by the name _Cetrariastrum_. In addition to the Parmeliaceous genera, five other generic changes have been published. _Cladina_, representing _Cladonia_ section _Cladina_, is used at the generic level. In the Physciaceae, _Phaeophyscia_, _Physciopsis_, and _Physconia_ are separated from Physcia; and in the Usneaceae, _Bryoria_ is separated from _Alectoria_. These generic concepts have resulted in nomenclatural changes in the specific epithets; for example, _Bryoria furcellata_ and _Physconia detersa_.

While these name changes have been widely accepted in the literature, many area herbaria have not been updated. Caution should be used in comparing literature before and after these changes and in using herbaria collections.

Until these specimens are reexamined and annotated, there will be considerable confusion over collections and distributions.

A number of rare species of lichens are present in the Great Smoky Mountains. These lichens should be observed closely but collected without depletion. Gymnoderma lineara, endemic to the southern Appalachians, is probably more widespread than originally thought. However, heavy collecting on Clingmans Dome may have seriously reduced its population in that area. Stereocaulon ramulosum, known from three collections on Roan Mountain, is possibly extirpated. The rock cliffs of this and adjacent mountains need to be carefully examined for this lichen. Polychidium umhausense is a rarity in herbarium collections, probably as a result of its small size and olivaceous color. A green dorsiventrally flattened lobe attached to the terete branches of this species is very rare (DePriest 1983). This species should be collected for observation and determination of its distribution in the southern Appalachians and North America.

Very few ecological studies have been conducted on lichen in this area. Information is needed on substrate preferences, microclimatic conditions, and distribution, as well as morphological variation in most groups. These studies will provide important information on niche characteristics in species and competition between species. For example, in the genus Usnea, U. strigosa and U. subfusca are well-defined chemical species. Statistical analysis of morphological variation, distributional preferences, and chemical constitutents are needed to evaluate the validity of their rank as species.

The Great Smoky Mountains National Park, as all areas in the eastern United States, has seen increases in air pollution over the past 40 years. No pollution studies of lichens have been conducted within the park or in adjacent mountainous regions. Permanent plots should be set up to determine the present lichen population and to monitor their changes as an indication of air pollution levels. Lichens sensitive to air pollution should be monitored throughout the area for changes in their population sizes and distribution. These studies are urgently needed.

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