THE ECOLOGY OF CORTICOLOUS LICHEN COMMUNITIES AT VARIOUS ALTITUDES ON SALT POND MOUNTAIN, GILES COUNTY, VIRGINIA

by

Margaret Proffitt Morris

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APPROVED:

Orson K. Miller, Jr., Chairman

R. A. Paterson

Judith Croxdale

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INTRODUCTION

Recent reports have indicated that the presence and cover of corticolous (bark inhabiting) lichens are adversely affected by certain air pollutants. The deleterious effects of atmospheric SO_2 have been extensively documented in numerous publications, among them; Rao and LeBlanc (1967), Ferry et al (1973), and Showman (1975). These findings have prompted a growing interest in lichen ecology. The fact that lichen distribution can be used as a natural gauge to assess the intensity of certain air pollutants (LeBlanc and Rao, 1973), points to the need for examining corticolous lichen ecology in undisturbed and unindustrialized sites. These studies are needed to provide the baseline data necessary to determine the features of a disturbed corticolous lichen community.

Since the classic studies of Culberson (1955a) and Hale (1955), vertical distribution, exposure, and substrate preferences of corticolous lichens have been examined in the field by numerous authors. However, no attempts have been made to study these aspects of lichen ecology in the southern or eastern regions of the United States.

The area around Salt Pond Mountain in southwestern Virginia is often noted for its abundant lichen flora, and, therefore, is well suited for an investigation of lichen community structure. Salt Pond Mountain is located within the Jefferson National Forest in Giles County, Virginia, near the Craig County line. Research efforts centered at Mountain Lake Biological Station of the University of Virginia, which is located on Salt Pond Mountain, have led to an excellent understanding of the flora and fauna of Giles County. However, previous lichenological studies in the county have been limited to cataloguing the fruiticose and foliose species found in the vicinity of Mountain Lake (Culberson, 1965).

The elevation gradient exhibited by Salt Pond Mountain suggested the inclusion of altitude as an aspect of lichen ecology. The impact of an elevation gradient on corticolous lichen distribution has been studied only in the Colorado Rocky Mountains (Gough, 1975). Elevational trends in the Appalachians, however, were recognized by Degelius (1941, in Dey, 1976), who listed lichens of the Smokey Mountains.

To meet the present needs for lichen ecology studies in this region, this investigation was designed with the following objectives:

1. To evaluate the impact of an elevation gradient of 610m on the abundance and species composition of an undisturbed corticolous lichen community.

2. To develop information on the undisturbed community structure of corticolous lichens on selected tree species on Salt Pond Mountain, Virginia.

REVIEW OF LITERATURE

Numerous studies have been made of the environmental influences on lichen cover and species distribution. This section will discuss the importance of macroclimate, the microclimatic influences of water, light, and temperature, and field investigations of the effects of environmental gradients on lichen communities.

Macroclimatic Influences

The research of Culberson (1955a, 1955b) and Hale (1955) on the corticolous cryptogams of Wisconsin demonstrated that macroclimate is the most important environmental influence on lichen distribution. Their data show that many corticolous cryptogams are restricted to the moist climate of Wisconsin's northern floristic province, while those that are common in the drier southern floristic province are not similarly restricted to the southern province. Other corticolous cryptogams are found equally in all parts of the state. As suitable corticolous substrate is present in both provinces, it was concluded that the climatic moisture gradient was controlling corticolous cryptogamic distribution. Barkman (1958) did not consider this result surprising, as a tree is a relatively dry habitat, and it would be only natural that a wetter climate would be more favorable.

Other research has also indicated that climate, particularly precipitation, is the most influential determinant of corticolous lichen community composition. Jonescu (1970) compared three locations in West-Central Canada, and concluded that low annual precipitation limited the lichen population both in terms of numbers of species and species frequency. After examining the lichen flora of North Central Oklahoma, Adams and Risser (1971a) confirmed that there is a positive correlation between total number of species and annual precipitation. Kershaw and Harris (1971b) found that the percent thallus saturation of Pseudoparmelia caperata that results in the optimal net assimilation rate (NAR) was positively correlated with rainfall.

Microclimatic Influences

Meterological data, however, indicate only general weather patterns, and do not necessarily reflect the environmental conditions of a plant's habitat or its microclimate (Biel, 1961). As Haynes and Morgan-Huws (1970) explain, the environment of a lichen is more comparable to that of its substrate's surface than to the atmosphere. Therefore, microclimatic effects must also be analyzed in order to interpret lichen distribution patterns with accuracy. Hoffman and Kazmierski (1969) report that epiphytes are influenced by microclimatic differences not discerned by vascular plants.

Moisture and light. If macroclimate is constant, then, microclimate is the controlling influence (Yarranton, 1972). Local availability of moisture and light is critical to supply lichen photosynthetic needs. However, in nature, moisture and light intensity are antagonistic. Barkman's observation (1958) that the richest lichen flora occurs where there is a balance of these two requirements is confirmed by Brodo's work (1961a). He compared the corticolous lichen flora among forest stands on Long Island, New York, and found the greatest abundance of lichen flora where both moisture and light were ample.

Lichen NAR research supports Farrar's (1973) observation that the influence of moisture is dominant over the influence of light intensity. Kershaw and Rouse (1971) found that net photosynthesis, thus the effect of light intensity, is limited if thallus water content is above or below its optimal saturation level.

Temperature. Temperature effects on lichens should also be considered. In the laboratory, temperatures above 20°C were found to increase fungal respiration rates, thus lowering net photosynthesis (Kershaw, 1972). Harris (1971b) confirmed this adverse effect of high temperatures using lichen specimens that were tested in the laboratory immediately after field collection. Hinds (1970) found that a temperature and humidity gradient limited lichen distribution in the field. The combination of temperature and moisture effects would account for the common observation that the most luxurious lichen flora occurs on cool, misty, tropical mountains.

Variation of microclimatic elements. Most authors agree with Kershaw and Harris (1971a), though, that moisture availability and light intensity are the microclimatic elements most important to lichens. However, until recently the requirement for these has been misunderstood. Pearson and Lawrence (1965) first suggested that the fluctuation of environmental conditions is the key. Pearson (1969) subsequently determined that lichens in the field thrive best when periods of dryness alternate with periods of high humidity, rather than when optimal humidity is sustained. Studies involving maintenance of intact lichens in growth chambers (Pearson, 1970) showed that variation of humidity, light, and temperature for 3-5 months yielded normal appearing lichens with normal photosynthetic patterns. Lichens maintained under sustained optimal climatic conditions were abnormal in both appearance and photosynthetic pattern. Pearson (1970) speculated that both lichen symbionts need to be suppressed from time to time to prevent the lichen from becoming a mass of algae or mold. The "varying climate" cultural technique Ahmadjian and Heikkila (1970) used in achieving the first relichenization of a separated phycobiont and mycobiont (of *Endocarpon pusillum*) supports this speculation.

Assessment of total available moisture. It is important to note that moisture assessment in ecological studies of lichens is typically confined to measurement of precipitation. Yet, other sources of moisture such as dew and fog (the "horizontal precipitation" of Stocker (1927) in Barkman, 1958), may have an effect equal to, or greater than precipitation. "Foggy nights or a foggy day keep bark more moist than a hard rain once a week" (Billings and Drew, 1938), and permit greater light transmission than rain clouds. Pearson and Lawrence's suggestion (1965) that corticolous moss cover may be used as an indicator of total available moisture is particularly interesting, as direct measurement of both horizontal and vertical precipitation is difficult. Others (Hale, 1955; Culberson, 1955a; Hoffman and Kazmierski, 1969; Stringer and Stringer, 1974) have also observed a direct correlation between moss cover and available moisture, but no direct correlation between lichen cover and moisture. Billings and Drew (1938) and Patterson (1940) found that bryophytes extend higher on the trunk at mesic sites. These reports imply that moss cover could be used as a reliable gauge of moisture availability, as Pearson and Lawrence (1965) suggest.

Field Studies of Environmental Influences

Aspect. As the culture of entire lichens is a rare achievement (Ahmadjian and Heikkila, 1970), carefully designed field studies are required in order to examine precise effects of environmental gradients on corticolous lichens. One method employed is to test the effect that aspect (compass direction) has on the corticolous lichen community. All who have tested horizontal distribution of corticolous lichens (Kalgutkar and Bird, 1969; Jonescu, 1970; Yarranton, 1972; Sheard and Jonescu, 1974; Gough, 1975) have concluded that the north face is the most favorable to both lichen species frequency and lichen cover, while the south face is the most adverse. Exceptions occur if a prevailing wind biases the sample by directing rainfall to a specific quadrant. The lichen communities of the east and west facing quadrants are similar to each other, and resemble those of the northern quadrant more than those of the southern quadrant. It was concluded that these findings reflect the reduced moisture stress that results from the decreased intensity of northern radiation, and the enhanced moisture stress that results from the intense radiation encountered on southern exposures. Yarranton (1972) reports that this response to aspect remains statistically unchanged as one progresses vertically up a tree trunk.

Vertical level. Although response to aspect remains stable with variation in vertical level, vertical level changes are reflected in a lichen community. Differential vertical distribution of lichen species was first observed by Hale (1952). Subsequent work by Hale (1955, 1965), and others (Culberson, 1955a; Hosakawa and Odani, 1957; Brodo, 1961b; Kershaw, 1964; Pearson and Lawrence, 1965; Kalgutkar and Bird, 1969; Hoffman and Kazmierski, 1969; Kershaw and Harris, 1971a; Harris, 1971a; Hoffman, 1971; Harris, 1972) has confirmed that lichen species sort out vertically along a tree trunk according to their environmental needs.

Barkman (1958) considered moisture, light, and substrate characteristics to be the factors that determine the vertical distribution of corticolous cryptogams. Recent research indicates that available moisture is the factor that is primarily responsible for differential vertical distribution. An early experiment (Hosakawa and Odani, 1957) was conducted utilizing lichens contained in flasks at various heights along a tree trunk. The results revealed that the lower level of humidity encountered at a height above a lichen's original location prevented the lichen from reaching its compensation point, or the point at which photosynthetic production compensates for respiration loss. Thus a lichen's viability above its original height was reduced. The same trend was noted by Brodo (1961b) when Cladonia chlorophaea transplanted from the tree base to the 1.3 m level died within 4 months. The recent computer simulation of the vertical distribution of Pseudoparmelia caperata cover by Kershaw and Harris (1971a) and Harris (1972) showed that the vertical distribution of this species is strongly correlated with the vertical change in evaporation gradient. They also found that the evaporation gradient effect dominates the influence of radiation.

These experiments support the extensive field observations of Culberson (1955a) and Hale (1955). In their now classic investigations of the distribution of corticolous cryptogams in Wisconsin, they both found that lichen species occur with differing frequencies at the base and 1.3 m levels, and that most lichen species occur more frequently at the 1.3 m level. In other field research, Hoffman (1971) determined that the greatest number of lichen species occur when moisture conditions are of an intermediate nature. He further noted that in a mesic habitat, the number of lichen species decreases vertically, while under intermediate moisture conditions there is no predictable vertical pattern. Harris (1971a) found that vertical zonation is not necessarily reflected by changes in species presence, though it is reflected by changes in species abundance.

Field studies in Minnesota also show that lichen cover differs according to vertical level, with cover increasing with increasing height above ground level (Pearson and Lawrence, 1965). Biomass analysis of corticolous fruticose and foliose lichens in Nova Scotia, Canada yielded similar results (Wein and Speer, 1975). Corticolus lichen biomass was reduced on the lowest meter of the trunk, thereafter it increased with height.

Altitude. Ecological and climatic gradients due to altitude have also been recognized, though rarely studied. As Kuchler (1967) states, "an increase in altitude implies a decrease in temperature, an increase in relative humidity, frequently an increase in cloudiness and precipitation, and an increase in isolation and wind velocity", though the increased isolation and wind may reduce humidity above a certain altitude.

Reports relating lichens to elevation gradients seem conflicting. Wetmore (1968) concluded that few corticolous lichen distribution differences in the Black Hills of South Dakota and Wyoming are due principally to elevation. Elevational zonation was observed, however, by Degelius (1941 in Dey, 1976) who listed lichen species according to their prevalence at certain elevations. Dey (1976), who composed species lists of the corticolous lichens of the high southern Appalachians (over 1650m), concluded that differences in fruticose and foliose lichen distribution in this setting are due primarily to climatic differences found along an elevational gradient. Wetmore may consider apparent differences in lichen distribution in the Black Hills more properly attributed to moisture, light, and temperature gradients than a multifaceted factor such as elevation.

Gough (1975) has conducted the only published effort to precisely measure elevational distribution of lichens. He found that the epiphytic species composition of the trunk and branch communities remained unchanged with changing elevation, but the frequency and coverage of the dominant lichens did vary. He suggested that the most limiting factor in epiphyte distribution in the Colorado Rockies is the high winds and consequent low level of available moisture on the higher elevations of this range.

Forest composition. Although climate and microclimate are clearly the most important influences on corticolous lichen communities, there are other important features of environment. Forest composition and density influence the ability of a forest to modify climate (Hale, 1955; Brodo, 1961a; Wetmore, 1968; Adams and Risser, 1971a; Pike et al, 1975).

The profuse radiation in a pine-oak forest (Brodo, 1961a) or the reduced light intensity in a climax maple woods (Hale, 1955) will prevent the establishment of specific lichens, even if their preferred substrate is well represented in the forest.

Substrate. Although less important than forest composition, the physical traits of the host substrate bark are also influential in determining corticolous lichen community composition (Culberson, 1955a, 1955b; Hale, 1952, 1955; Adams and Risser, 1971b). Tree age, beyond the initial stages, is considered unimportant except as a function of height (Yarranton, 1972), since the mean number of lichen species does not vary among trees greater than 10 cm diameter at breast height. Although the relative influence of each factor is not clear, important bark characteristics include water holding capacity (Beals, 1965; Kalgutkar and Bird, 1969), pH (Beals, 1965), and texture or degree of roughness (Stringer and Stringer, 1974). Lichen substrate specificity depends on the best tolerated range of bark characteristics. The prevalence of this distinctive range of factors determines the frequency of lichen species within a forest. It is interesting to note that most cryptogamic epiphytes are most frequent in *Quercus* dominated forest stands (Hale, 1955). The epiphytic communities on *Q. rubra* have been observed to vary in correlation with environment (Hale, 1955).

Lichen reactions. Lichens do not react as a group to environmental gradients. Preferences for different amounts of moisture have been demonstrated at both the growth form and species levels. Jesberger and Sheard (1973) have found that slow growing crustose lichens are negatively associated with moisture, while the more rapid growing foliose lichens are positively associated with moisture. Fruticose lichens have an intermediate reaction to moisture. Individual lichen species' varied responses to moisture gradient have been recorded in the field by numerous authors, among them Hale (1955, 1965), Culberson (1955a) and Hoffman and Kazmierski (1960). Kershaw (1972) made the interesting discovery that the optimum rate of net photosynthesis is determined by species specific saturation levels.

Studies in the Southern Appalachians

The lichen flora of the southern Appalachians is rich (Culberson, 1965), but lichenological studies in this region have been confined to species lists or chemotaxonomy. Other than the dissertation work of Dey (1975), which describes the distribution patterns of fruticose and foliose lichens in the highest mountains of the southern Appalachians (above 1,676m) there has been no effort to analyze the ecology of lichen communities in this area. The rapid climatic changes which accompany an elevational rise of 610m, the relatively undisturbed *Quercus*-dominated forest, and the well-developed lichen flora of Salt Pond Mountain presented a location well-suited for the first large scale elevation-based lichen ecology study east of the Rocky Mountains, and the first attempt to quantitatively measure the distribution patterns of the lichens of the southern Appalachians.

SITE DESCRIPTION

The flora in Giles County, Virginia, is generally undisturbed, as the county is largely forested and relatively unindustrialized. Approximately 70 percent of the county is commercial woodland, 30 percent of which is within the Jefferson National Forest (Knight and McClure, 1967). As of 1976, there were only 13 industrial concerns located in the county, whose activities included limestone and gypsum mining, mining equipment production, clothing manufacture, and generation of electricity through burning coal. The rural nature of Giles County is also indicated by its population density of 46.1 persons per square mile (based on the 1970 census).

Neighboring Craig County, with a population density of only 10.1 persons per square mile (based on the 1970 census), is forested to an even greater extent than Giles County. Slightly more than 75 percent of Craig County is commercial forest, over 60 percent of which is Jefferson National Forest (Knight and McClure, 1967). Craig County's industry as of 1976 consisted of three manufacturing concerns, which produce clothing, furniture, and high grade sand.

The southeast facing slope of Salt Pond Mountain ($37^{o}24'$ lat., $80^{o}29'$ long.) was chosen as the research site (Figure 1). Its elevation increases 610m (2000 ft.) within a distance of approximately 4.0km (2.5 mi.). This typifies the Ridge and Valley Province of these Appalachian Highlands, "where narrow ridges are separated by valleys one to two thousand feet deep" (Thorne and Cooperrider, 1960). The incline is continuous, uninterrupted by water bodies, cliffs, or open meadows. The second growth mixed oak forest dates from 1890 (Blacksburg District Ranger, Jeff. Nat. For., pers. comm.), with no recorded fires or lumbering activity since that time. The flora of the slope corresponds to the open, sandy oak-pine woods habitat type described by Cooperrider and Thorne (1964) in the Flora of Giles Co. II, and the generalized chestnut oak forest of Cooper and Hardin (1967), in which *Quercus prinus* and *Q. rubra* are co-dominant and *Q. velutina*, *Q. alba*, and *Acer rubrum* are the main associates, with *Pinus rigida* and ericaceous shrubs on the drier sites. The arboreal and shrub species found on the research site are indicated by elevation in Table 1.

This location has several advantages. At the summit of Salt Pond Mountain, approximately 8 km from this site, is Mountain Lake, the area covered by Culberson's (1965) checklist. The entire slope is accessible via the Appalachian Trail, which transects the slope. The forest appears relatively undisturbed despite the presence of the trail. Also, weather data are available from Mountain Lake Biological Station, elevation 1140 m, situated approximately 5 km from one entrance to the Appalachian Trail.

Lichen development is favored by the climate, which is cooler than that found in much of Virginia. Mean January temperatures (1972-76) on Salt Pond Mountain range from a maximum of 4.2°C to a minimum of -5.8°C, while the mean July temperatures range from a maximum of 23.4° C to a minimum of 13.0°C. Mean annual precipitation (1972-76) is 141.6cm, with higher monthly averages May through July. Snow is frequently present on the ground during the winter months, with a mean maximum depth (1972-76) of 43.9cm. Prevailing winds are west to northwest in the winter, and west to southwest in the summer (Dr. Craig, Geology Dept. VPI & SU, pers. comm.).

METHODS

Study Sites

Ten sites were selected on the southeast-facing slope of Salt Pond Mountain, Giles County, Virginia at altitudinal intervals of 61 meters, starting at an elevation of 625m. These sites and the elevation gradient are shown in Figure 1. The elevation of each site was determined by an aneroid barometer surveying altimeter (Weather Measure Corp.) accurate to 6.1m. This instrument was calibrated at an U.S. Geological Survey bench mark at the base of the mountain. The accuracy of the elevational determinations was established by six trails, on three days when barometric pressure was relatively constant.

Substrate Selection

The epiphytic lichen flora of *Quercus rubra* L. (Northern red oak) was chosen for study except at elevation site 6, where *Q. rubra* does not occur (Table 1). The epiphytic flora of *Q. velutina* Lam. (black oak), which has bark characteristics similar to *Q. rubra* (Hale, 1955), was sampled at that location. The epiphytic flora of *Q. velutina* was sampled also at elevation sites 5 and 7, to determine if *Q. velutina* data could be used as a substitute at site 6.

At each elevation site, four sample trees of one species (eight of two species at sites 5 and 7) were selected to the northeast of the Appalachian Trail (Fig. 1) in a line approximately perpendicular to the trail. This transect line began at least 6.1m from the trail, to limit the effects of edge lighting and human disturbance. These trees were a minimum of 4.5m apart, 14cm at breast height (BH) (1.37m), living, upright, and free of wounds. The level of epiphytic presence was not noted when the sample trees were selected.

To ascertain the uniformity of the forest at each elevation site, the number and diameter at BH of all trees (DBH $\geq$ 10cm) and Q. rubra (DBH $\geq$ 10cm) was recorded within a 20m by 5m plot. To prevent prejudicing the data, this plot was established along the transect line with the second sample tree included at the western edge of the plot. The basal area per hectare at each elevation site was calculated from these measurements. Basal areas and mean diameter of sample trees are found in Table 2. The presence of all arboreal and shrub species found at each elevation site was noted (Table 1).

Measurement of Epiphytes

A ruled, clear plastic grid, 35 x 35cm, was placed on each sample tree, centered at North on the horizontal axis and at 0.5m, 1.37m (BH), and 3.0m above ground level on the vertical axis, also referred to as the basal, middle, and top vertical levels, respectively. The basal vertical level was centered slightly above the ground to limit the sample to truly corticolous species. The top vertical level was below the initiation of branching in most cases.

The cover of each fruticose and foliose lichen species was measured by counting the number of grid squares that each covered. The fruticose species were moistened slightly and flattened if necessary. Dead (bleached) lichen cover was not counted, although living (nonbleached) portions of dead lichens were counted. A species list is located in

Appendix A. All species were identified in the field using current checklists and keys (Appendix B). When positive field identification was not possible, specimens were labeled and re-examined in the laboratory. Voucher specimens for all major species were placed in the VPI & SU herbarium. There was no attempt made to identify crustose species. However, total crustose cover was calculated by subtracting the total covers of the fruticose and foliose species from the total lichen cover. To provide a gauge of the moisture locally available (Pearson and Lawrence, 1965), the moss cover of each quadrat was visually estimated using the grid.

The following measurements were made July through October, 1976, on Q. rubra and Q. velutina at each elevation site and vertical level:

1. Lichen and moss percentage cover.
2. Crustose, foliose, and fruticose percentage of lichen cover.
3. Total and mean number of foliose and fruticose species.

Analysis

The following analyses were carried out:

1. For each foliose and fruticose species, the following were determined:

   a. percentage cover (species cover/lichen cover),

   b. absolute frequency (number of samples which contain a species/number of samples),

   c. relative frequency (number of samples which contain a species/total number of all species occurrences in all samples), and

   d. modified importance value (percentage cover + relative frequency).

2. Nested analysis of variance on *Q. rubra* data with altitude and trees within altitude as the independent variables, and lichen cover, moss cover, crustose lichen cover, foliose lichen cover, fruticose lichen cover, and number of lichen species as dependent variables.

3. Constancy (number of specified samples which contain a species/ number of specific samples (Hale, 1955)) of each lichen species on *Q. rubra* and *Q. velutina* by elevation, tree, and occurrence at a vertical level.

4. Mean number of lichen species, lichen cover, crustose lichen cover, foliose lichen cover, fruticose lichen cover, and moss cover on *Q. rubra* and *Q. velutina* over the study area and by vertical level over the study area. To compare the values at the three vertical levels, the means were normalized by dividing the smallest of the three values into the others.

5. Elevation and vertical level preference of lichen species present on at least 20 percent of the sample *Q. rubra* through a prominence index (percentage cover + absolute frequency).

6. Similarity of each pair of elevation sites by Kulczynski's coefficient of community (Culberson, 1955a; Brodo, 1961a; Kalgutkar and Bird, 1969; Adams and Risser, 1971a), which is the formula $\frac{2w}{a+b} \times 100$; where "a" is the sum of the values for one stand, "b" is the sum of values for another stand, and "w" is the sum of values shared by both stands. The lower value, in each case, is the maximum shared. The values used are the modified importance values.

RESULTS

There are 38 corticolous foliose and fruticose lichen species representing 19 genera on _Q. rubra_ on the southeast slope of Salt Pond Mountain. Most species were found at all three vertical levels examined, and all species found were on the previous checklist (Culberson, 1965). Four species, _Pseudoparmelia caperata_, _Parmelia rudecta_, _P. squarrosa_, and _Parmotrema reticulatum_, form 39 percent of the lichen cover and 65 percent of the foliose lichen cover on _Q. rubra_ (Appendices E and G). The dominant lichen species of this slope is _P. caperata_, which occurs on 100 percent of the sample trees and alone forms 19 percent of the lichen cover and 32 percent of the foliose lichen cover.

Lichen Species Numbers Analysis

Analysis of variance shows that there is no significant difference in the number of lichen species among altitudes or among trees within altitudes (Table 3). The mean number of species per sample on _Q. rubra_ and on _Q. velutina_ also does not vary appreciably (Appendix C).

The mean number of foliose species found at an elevation site on _Q. rubra_ is 18.4 (Table 4). There is little variation from this mean with altitude, when either the total tree sample or each vertical level is examined, as shown in Figure 2. The normalized vertical level means (Table 4) indicate that there are slightly more foliose species at the middle and top levels. The number of foliose species found on _Q. velutina_ is similar to that on _Q. rubra_ (Figure 2) (Table 4).

The mean number of fruticose species found at an elevation site on *Q. rubra* is 4.2 (Table 4). There is a trend for the number of fruticose species to decrease with altitude. This trend is particularly apparent on the total tree sample and the basal and middle levels (Figure 2). The largest number of fruticose species occurs over-all at the top vertical level, followed in order by that at the middle and basal levels (Table 4). The number of fruticose species on *Q. velutina* appears similar to that on *Q. rubra* (Figure 2) (Table 4) at comparable elevations.

Lichen and Moss Cover Analysis

Analysis of variance of lichen and moss cover indicates that both vary significantly among altitudes (Table 3). Unlike moss cover, lichen cover does not vary significantly among trees within altitudes. The mean lichen cover found on *Q. rubra* at an elevation site is 24.6 percent (Table 4). Both lichen and moss cover increase with altitude, though at different rates, as seen on all samples in Figure 3. The increase in lichen cover with altitude is greatest at the top vertical level and least at the basal level. The increase in moss cover is substantial at all vertical levels at the two highest elevation sites. There is an over-all trend for lichen cover to be greatest at the top level and least at the basal level, while moss cover exhibits the opposite trend (Table 4). Lichen and moss cover on *Q. velutina* is comparable to that of *Q. rubra* at the same elevations, although there is a tendency for *Q. velutina* to have a higher moss cover at the basal level (Figure 3).

Crustose and foliose lichen cover varies significantly with altitude, but fruticose lichen cover does not (Table 3). However, the cover of all three growth forms demonstrates insignificant variance among trees within altitudes (Table 3). Foliose lichens are the dominant growth form, representing 59.5 percent of the lichen cover on this mountain slope, while crustose lichens represent 39.7 percent and fruticose lichens represent only 0.9 percent of the lichen cover (Table 4). Although the covers of crustose and foliose lichens do not exhibit any altitudinal trends, fruticose lichen cover is greatest at the lowest elevations (Figure 3). Neither crustose nor foliose lichen cover demonstrates distinct vertical zonation, although crustose cover increases and foliose cover decreases slightly at the base (Table 4). However, fruticose lichen cover is greatest at the top vertical level (Figure 3) (Table 4). Lichen growth forms on *Q. velutina* tend to follow the lichen growth form patterns of *Q. rubra.*

Lichen Species Analysis

Analysis of species constancy on *Q. rubra* reveals several trends (Table 5). The foliose species *Cetraria oakesiana*, *Cladonia sp.*, *Parmelia rudecta*, *P. squarrosa*, *Parmotrema reticulatum*, and *Pseudoparmelia caperata* are the most prevalent species of the slope, for they occur at all elevation sites and on more than half of the *Q. rubra* sampled. The most prevalent fruticose species is *Ramalina fastigiata*, which occurs on half the *Q. rubra* sampled and on more than 75 percent of the elevation sites (Table 5). Most species display a vertical level preference. Rare species occur typically at the basal level. All lichen species that are prevalent on Q. rubra are also prevalent on Q. velutina (Table 6). However, three lichen species, Heterodermia obscurata, Physcia orbicularis, and P. stellaris, occur with a greater constancy on Q. velutina than on Q. rubra (Tables 5 and 6).

Prominence index analysis provides a more definitive indication of the distribution patterns of these species (Table 7). Varied elevation preferences of all prominent lichens and most species are apparent. Cetraria oakesiana, for example, is most prominent at the higher elevation sites. Lichen community composition also varies with elevation site (Table 7).

Vertical level preferences of lichen species likewise show some preferential altitude distributions. Species with a high tree frequency that prefer the basal vertical level on the tree also tend to prefer the upper elevation sites (Table 8). However, lichen species with a high tree frequency that prefer the top vertical level tend to prefer the lower elevation sites (Table 10). No elevation preference trends are exhibited by lichen species with a high tree frequency that have middle or no vertical level preferences (Tables 9 and 11). Two lichens with middle level preferences, Pyxine sorediata and Cetrelia olivetorum, demonstrate an unusual preference for the lowest and highest elevation sites (Tables 7 and 9).

Cover distributions of those lichen species that occur on 50 percent or more of the sample Q. rubra display varied reactions to altitude and vertical level (Figures 4-7). The cover of Cladonia sp., and C. oakesiana, appears positively related to moss cover (Figures 5 and 6).

The cover of the foliose species P. reticulatum and P. caperata (Figures 4, 7) and the number of individuals of the fruticose species R. fastigiata (Figure 5) seems negatively related to moss cover. P. squarrosa, P. sorediata, and P. rudecta cover appears independent of moss cover (Figures 5, 6, and 7). There is some indication that P. rudecta may be competing with P. caperata, particularly at elevation sites 1, 4, 7, and 10 (Figure 7).

Lichen Community Analysis

Kulczynski's coefficient of community (Table 12) indicates that the Q. rubra lichen communities of the lower elevations are more similar to each other than to the Q. rubra lichen communities of the rest of the study area. This is evident by the larger difference of their coefficients above the mean. The lichen communities of the two highest elevation sites are also more similar to each other than to those of the rest of the study area (Table 12). The lichen communities of middle elevation sites appear representative of those of the entire study area. The lichen communities at elevational sites 4 and 8 demonstrate an unexpected similarity. Q. velutina lichen communities ressemble those at comparable elevations on Q. rubra, but are not identical to them.

DISCUSSION

Sampling Corticolous Lichens

The methods utilized in lichen ecology studies are not standardized as they are in vascular plant ecology. Research in the neglected field of lichenology constantly introduces new considerations to be included in the design of a lichen field investigation. Difficulty was encountered in establishing the methodology of this study so that it was comparable to the pioneering works of Hale and Culberson and it also reflected recent findings in lichen ecology.

Sample Size. It was not possible to conduct as large a sample as Hale (1955) and Culberson (1955a). However, Hoffman (1971) and Stringer and Stringer (1974) demonstrated that sampling the epiphytic communities on a minimum of four trees provides a representative sample of the corticolous flora of a forest stand. An analysis of variance (Table 3) indicated that all lichen data in this study were reliable and were consistent with those found in other studies (Table 4). However, in future studies a larger sample might prove preferable if it were deemed desirable to include all the infrequent or rare species potentially in a given area.

Quadrat. Most researchers have used a cylindrical (encircling) quadrat to measure corticolous lichen communities. However, since these communities vary according to aspect, a square quadrat, with its limited aspect range, would be a more direct reflection of environmental influences. The 35 cm dimension of the quadrat was chosen to permit a comparison of these data with those of Hale (1955) and Culberson (1955a).

The selection of the NE-N-NW aspect was governed by evidence that it is the aspect most favorable to lichen communities. The consistent mean number of species per quadrat (Appendix C) suggests that a homogeneous lichen flora was sampled (Culberson, 1955a).

Sample Location. The tree base and/or breast height vertical sampling levels are typical in lichen ecology studies and were also chosen to enable comparison to Hale (1955) and Culberson (1955a). Although several authors have sampled at high levels on trees (Hale, 1952, 1965; Harrison, 1971a; Pike et al, 1975), there has been no previous sampling at the 3.0m level. This level was chosen because it was the highest level which could be accurately sampled with easily transported equipment without destruction of the tree.

Sample Procedure. Both Hale (1955) and Culberson (1955a) determined simply the frequency of lichen species among samples. Since their works, Kershaw (1964), Hoffman and Kazmierski (1969), and Harris (1971a) have noted that cover must be measured in addition to frequency, to properly evaluate environmental influences on a lichen species. Although visual estimation of lichen cover would be the most rapid procedure, the procedures utilized in this study followed Kershaw's (1964) suggestion that only quantitative measures of cover reflect lichen habitat range with accuracy. Quantification also permits precise comparisons of data.

Moss as a Moisture Indicator

Local available moisture trends were roughly estimated in situ by measuring moss cover. Moss cover was found to be greatest at the basal level (Table 4), the most mesic level of a tree (Kalgutkar and Bird, 1969). The persistent cloud cover observed at the highest elevation sites was also reflected by increased moss cover (Figure 2). However, an F test analysis of variance indicates a significant difference in moss cover between replicate samples on trees at an elevation site (Table 3). Therefore, the moss cover data collected in this study can be used to indicate only local moisture trends rather than specific levels of moisture. Nevertheless, the determination of moss percentage cover was found to be a simple and relatively accurate method to obtain information essential to the analysis of lichen distribution patterns.

Q. velutina as a Substitute Substrate

A substitute substrate for Q. rubra was necessitated by its absence at elevation site 6. Personal observation of the corticolous lichen communities at the research site indicated that only Q. velutina supported a sufficiently similar lichen flora to that on Q. rubra for consideration as a substitute substrate. At comparable elevations, the lichen communities on Q. velutina and Q. rubra proved similar, though not identical, according to Kulczynski's coefficient (Table 12). However, the similarity appears limited to only the most frequent lichen species (Table 7). Several lichen species, Heterodermia obscurata, Physcia orbicularis, and Physcia stellaris occur with greater constancy on Q. velutina than on Q. rubra (Tables 5, 6), even with consideration of the smaller sample size of the Q. velutina data. This affinity of the former two lichen species for Q. velutina has been noted previously (Adams and Risser; 1971a, 1971b), and all three have been noted for their high moisture requirements (Wetmore, 1968) (Sheard and Jonescu, 1974). Also, the moss cover at the basal level of Q. velutina is substantially higher than that of Q. rubra at the same location.

These discrepancies may be explained by the differences in bark characteristics between Q. velutina and Q. rubra. The bark of Q. rubra is characterized by flat-topped ridges, divided by shallow furrows, while the ridged bark of Q. velutina is divided by deep furrows and subdivided by many cross fissures, even in young trees (Blakeslee and Davis, 1972). These variations in bark configuration may permit greater water absorption by Q. velutina, and present a more humid microclimate to epiphytic lichen communities. The increased moss cover on Q. velutina suggests this is the case. The presence of quantities of tannic acid in the bark of Q. velutina, a compound not found in Q. rubra bark (Blakeslee and Davis, 1972), may also affect the frequency and cover of lichen species present. Therefore, the lichen data collected on Q. velutina at elevation 6 were considered to be an indication of the lichen communities potentially found on Q. rubra, but they were not considered to be an adequate substitute. This is contrary to Hale (1955), who combined lichen community data from Q. rubra and Q. velutina.

Lichen Community Richness

The characteristics of the lichen communities of Salt Pond Mountain appear to indicate that this area is relatively undisturbed by atmospheric sulfur dioxide (SO_2) pollution. It has been established (Rao and LeBlanc, 1967) that SO_2 pollution results in a reduction in corticolous lichen cover, crustose domination of corticolous lichen communities, and restriction of the corticolous lichen communities to tree bases. In contrast, on Salt Pond Mountain, corticolous lichen flora were present in all samples, were rarely dominated by the crustose growth form, and were never restricted to tree bases. Further evidence includes the abundance of the fruticose genera *Ramalina* and *Usnea* (Gibert, 1973), and the foliose species *Pseudoparmelia caperata* and *Parmelia rudecta* (Showman, 1975), all of which are highly sensitive to SO_2.

The richness of the lichen communities on Salt Pond Mountain is difficult to determine due to the absence of data from comparable forests in the southeast United States. However, the 7.1 mean number of fruticose and foliose lichen species per tree at BH (Table 4), compares favorably with the 8.5 and 7.6 mean numbers of epiphytes (which additionally includes crustose lichen and moss species) found on *Q. rubra* at BH respectively by Hale (1955) and Culberson (1955a) in Wisconsin. In this study, there were 10 fruticose and foliose lichen species out of a total of 30 frutiose and foliose lichen species with frequencies greater than 20 percent at BH on *Q. rubra*. Culberson (1955a) found 11 fruticose and foliose lichen species out of a total of 24 fruticose and foliose species with the same frequency at BH on *Q. rubra*. Hale (1955) found 7 fruticose and foliose lichen species with this frequency out of a total of 45 epiphytic lichen and bryophyte species at BH on *Q. rubra*. A comparison of lichen frequencies from this study and those of Hale (1955) and Culberson (1955a) is reduced by the difference in area of individual samples (40cm and 30cm cylindrical vs. 35cm square) and in sample number (36 *Q. rubra* vs. 507 and 125, respectively). The richness of the Q. rubra epiphytic lichen communities of Salt Pond Mountain seems intermediate between that of northern and southern Wisconsin, with a likelihood of a slightly increased mean of total epiphytes per tree on Salt Pond Mountain.

Changes in Local Lichen Flora

The epiphytic lichen community on Salt Pond Mountain appears to have changed since Culberson compiled a checklist of the fruticose and foliose lichens in Giles County (1965). Heterodermia leucomelaena, Menegazzia terebrata, and Parmelia subaurifera, previously described as common, were not found. Other species also listed as common, Heterodermia hypoleuca, Anaptychia palmatula, Lobaria pulmonaria, Lobaria quercizans, and Parmelina aurulenta, were encountered rarely, or, in the case of P. aurulenta, encountered commonly in only a portion of the study area. Platismatia tuckermannii, described as common by Culberson (1965), was not found on Q. rubra or observed on other hardwoods, although it still appears common on conifers. Ramalina fastigiata and Usnea mutabilis were found to be more common in this study than previously reported by Culberson (1965) while Nephroma helveticum and Parmelina dissecta are newly reported on hardwoods in Giles County.

Altitude Variations

Although there is a sharp increase in lichen cover at the highest elevations, with one exception, this study of the lichen communities on the Q. rubra of Salt Pond Mountain does not demonstrate linear variations in accordance with linear increases in altitude. As Dey (1976) conjectured, significant variations that do occur (Table 3) appear to be reflections of the microenvironment of a particular elevation site, rather than part of an altitudinal trend. For example, the increased lichen cover at high elevations seems to coincide with the increase in moss cover (Figure 3) previously described herein as a reflection of persistent summit clouds. Microclimatic influences are also apparent on examination of variation of lichen species number (Figure 2), elevation preferences of the most frequent lichen species (Table 7), the distributions of the dominant species (Figures 4-7), and resemblance of the lichen communities of different elevations to each other (Table 12). The lone exception is the fruticose growth form, which decreases with increasing elevation both in number of species (Figure 2) and in cover (Figure 3). The number of individuals of the fruticose Ramalina fastigiata (Figure 5) also exhibits this trend. One would expect increased fruticose cover with the progressively mesic conditions found here with increasing altitude (Figure 3), for high water availability promotes the abundance of these rapidly dessicating, filamentous growth forms (Harris, 1971a). It is suggested here that this reduction in fruticose lichens may be due to the increased wind velocity often encountered with increasing elevations. This wind may damage these fragile lichens which, due to their three dimensional structure, are more exposed than other lichen growth forms. Therefore, some exception must be made to Gough's (1975) earlier finding that there is no change in epiphytic composition with altitude.

Several other results of Gough (1975) do not hold true in this study of the effects of elevation on lichen communities. He found that the number of lichen species at a specific aspect increased with elevation up to a point, then decreased at the highest elevations studied. In this case, the number of lichen species remained almost constant with increasing elevation, although the decrease at the highest elevations was duplicated (Figure 2). Also, a vertical level preference shift in the total number of species with elevation is not clearly demonstrated in this study (Figure 2). As stated previously, the cover and frequency of the dominant lichens in this study appear to vary with elevation site rather than elevation, as in Gough's study, with the possible exception of P. reticulatum (Figure 4, Table 7).

Possible explanations for these discrepancies are that this study did not include analysis of crustose species, did not utilize a line intercept method of sampling, and did not limit the sampling to purely one aspect (northeasterly and northwesterly aspects were included). The elevations in this study range from 625 to 1175m while the elevations Gough examined range from 1830 to 3050m. Also, the general climatic conditions in this study may be more homogeneous than those in Gough's study, for this research was limited to a single slope of one mountain, rather than several slopes on several mountains. Although two host substrates were utilized in both studies, the conclusions of this study are based upon the data from only one host substrate.

Vertical Level Variations

As anticipated by the work of Hale (1952, 1955, 1965) and many others, this study indicates that vertical level on the tree trunk strongly affects lichen communities on Q. rubra. This is demonstrated by the mean percentage of the sample quadrat covered by all lichens

(Table 4), the vertical level constancy of many lichen species (Table 5), the fact that a vertical level preference, based on cover percentage, can be determined for most species (Tables 8, 9, 10) and the fact that no vertical level preference seems an uncommon occurrence (Table 11). It is interesting to note that the ratio of percentage crustose to percentage foliose lichen cover oscillates from site to site, but does not demonstrate a clear vertical level preference (Figure 3). This supports Pearson's (1969) finding that crustose cover is equal with height. However, fruticose cover, always scant, does show a preference for the top vertical level (Table 4). This may be due to protection from the wind afforded by the vicinity of tree branches.

As in Pearson and Lawrence (1965), lichen cover in this study increases with increasing height above the ground. Mean lichen cover was found to be greatest at the 3.0m or top level in this study, and least at the 0.5m or bottom level (Table 4). However, this is not always the case at a particular elevation site (Figure 3), for example among the lower elevations, which indicates strong local climatic influences.

More species occur in their greatest abundance at the top vertical level (3.0m) than at the other two levels sampled (Table 10). This corresponds with the results of the 1965 study of Hale dealing with the vertical distribution of lichens on <u>Acer rubrum</u>. The bottom vertical level is the preference of the next greatest number of species. However, unlike the species with top level preferences, almost half of the bottom level species are rare hydrophils (Table 8), indicative of the more constant humidity found at this level (Kalgutkar and Bird, 1969). The base is the least preferred level among the lichen species with their greatest preference at the middle or top level (Tables 9, 10). This suggests that the more constant humidity is actually limiting. Hale (1955) and Culberson (1955a) found also that conditions at the tree base do not favor lichen communities in terms of numbers of species. Competition with moss may additionally limit lichen species abundance at the basal level.

As stated in the results, there is a tendency for those species with a basal preference to occur with the greatest frequency and abundance at the highest elevation sites (Table 8). This more abundant presence roughly coincides with the increased moss presence at the highest elevation sites (Figure 2 or 3). Perhaps this is also a reflection of the persistent cloud cover found at the upper elevations of Salt Pond Mountain. The parallel tendency for those species with a top level preference to most commonly occur with abundance at the lower elevations may indicate that drier conditions exist there. However, as lichen species' presence and abundance at a specific vertical location depends upon a combination of several climatic factors as well as other variables, vertical level preference should only be used as a rough indication of a single climatic factor, such as moisture. Apparent relationships of a lichen species' abundance (cover) with moss cover (Figures 4, 5, 6, 7) should similarly be viewed with caution.

In most cases, a lichen species' vertical level preference, as determined in this study, corresponds to that found by Hale (1955) and

Culberson (1955a) in Wisconsin. Those species with similar level preferences for either the base or 1.3m in this study as well as in their studies include Parmelina aurulenta, Parmelia subrudecta ("P. borreri"), Pseudoparmelia caperata, Hypotrachyna livida ("P. subquercifolia"), Physcia ciliata, P. stellaris, Pyxine sorediata, Ramalina fastigiata, Cetraria ciliaris, Hypogymnia physodes ("P. physodes"), and Parmelia squarrosa ("P. saxatilis"). Parmelia rudecta and Parmelia sulcata had more equivalent distribution between these two vertical levels than indicated in the Wisconsin studies, while Parmotrema crinitum demonstrated a basal preference not indicated in Hale's study. Physcia orbicularis shows a basal preference in this study and in Hale's study, but shows a 1.3m preference in Culberson's study.

However, the frequencies with which these species occur on Q. rubra in Wisconsin and in this Virginia study differ greatly. P. aurulenta, H. livida, P. orbicularis, P. subrudecta and Physicia millegrana were more common in one or both of the Wisconsin studies than in Virginia, while P. caperata, P. rudecta, P. squarrosa, and Pyxine sorediata were less common in Wisconsin than in Virginia. R. fastigiata was similarly frequent in all three studies. P. sulcata was more common in Culberson's study than in Virginia but less common in Hale's study than in Virginia. It is interesting to note that two of the most frequently occurring lichen species found in this study, Parmotrema reticulata and Cetraria oaksiana, were not found in either Wisconsin study on Q. rubra.

Hale conducted another study of lichen species vertical distribution, on Acer rubrum, in Connecticut (1965). Although different host substrates were used, the trees in this study and in the Connecticut study are of roughly the same diameter (Table 2). Once again, P. caperata, P. rudecta, and P. squarrosa ("P. saxatilis") are less common than in Virginia, while P. sulcata and H. physodes ("P. physodes") are more common than in Virginia. All lichen species, except P. caperata, appear to have similar vertical distributions in Connecticut and Virginia, with the qualification that the Connecticut lichens avoid the base, initially occurring higher on the tree trunk.

The vertical level cover distribution patterns of P. caperata and P. rudecta in this study (Figure 7) provide a strong indication that there is competition between these two species in the Virginia Appalachians. This competition is especially evident at elevation sites 1, 4, 7, and 10. Elevational distribution patterns suggest that there may also be competition between P. squarrosa and P. sulcata on Salt Pond Mountain (Table 7), as reported on Long Island, New York (Brodo, 1965).

Lichen Community Variations

Kulczynski's coefficient of community indicates that the epiphytic lichen communities of Q. rubra on Salt Pond Mountain are impressively homogeneous (Table 12). Considering that these coefficients were calculated using the combined percentage cover and relative frequency (modified importance value) rather than the simple presence of those lichen species shared, the mean elevation site similarity of 59.3 percent with a standard deviation of 7.43 is surprisingly high (Table 12). This suggests that the elevation site locations are climatically as well as epiphytically comparable, test conditions not always attainable in field studies.

With one exception, all *Q. rubra* elevation site pairs with a coefficient of community exceeding the standard deviation are adjacent elevation sites (Table 12). However, sites 4 and 8 are not only widely separated, but are also subject to opposing microclimatic influences. The substantial number of *Pinus rigida* (Table 1) and the low basal area (Table 2) at site 4 permit greater light transmission through the forest canopy than that found at site 8, which is all hardwood and is high in basal area. Moss cover percentages suggest that low levels of available moisture are present at site 4 (Figures 2 or 3, Appendix E), while site 8 appears to be at the initiation of the persistent cloud cover observed at the mountain summit (Figures 2 or 3, Appendix E). These sets of microclimatic conditions, in conjunction with the highly similar epiphytic lichen communities these two elevation sites share, would seem to indicate that slight increases in either light or moisture have a similar effect on lichen community development.

The tendency for the lichen communities of the lower elevations and the two highest elevation sites to segregate may reflect available moisture patterns (Table 12, Figures 2 or 3). However, the lack of direct correspondence of moss cover, a rough indication of available moisture, to total lichen cover (Figure 3) and to the cover of certain dominant lichen species (Figures 4, 7), shows that other environmental factors exert strong influences. For example, the increase of lichen cover at the upper elevations precedes the increase in moss cover (Figure 3). In addition, there does not appear to be a direct relationship between moss cover and the number of lichen species, although

The reduced number of species at the elevation sites (9, 10) with the highest moss cover may indicate moisture stress (Figure 2). It is also noted that the ratio of crustose cover, which prefers dryer conditions, to foliose cover, which prefers moister conditions, does not appear related to moss cover or total lichen cover (Figure 3). Temperature may indirectly influence the distribution of lichen species by influencing available moisture.

Future Studies

Certain variables should be held constant whenever possible in designing future investigations of corticolous lichen communities. These variables include forest composition, compass aspect, vertical level, and substrate. Precise determinations of long-term moisture and light conditions would be valuable to future lichen ecology studies.

There is a need to examine the undisturbed corticolous lichen community structure in other geographical areas of Virginia and elsewhere throughout the southeast region of the United States. This data would provide the background information necessary for the use of lichens as indicators in analysis of the impact of atmospheric pollution, certain to increase with the continued industrial development of the region.

CONCLUSIONS

An investigation has been conducted on Salt Pond Mountain, Virginia, to evaluate the impact of elevation on the abundance and species composition of the corticolous lichen community on Q. rubra. With the exception of fruticose lichens, this lichen community does not demonstrate variations that parallel increases in altitude. It was found that fruticose lichen cover and number of species decreased with increasing altitude.

The lichen communities over the elevational gradient on Q. rubra were subjected to analyses of variance. It was found that foliose, crustose, and total lichen cover were significantly different by altitude. However, there was no significant difference among the cover on trees within an elevation site (Table 3). There was also no significant difference in the total number of foliose and fruticose lichen species among elevations or among trees within an elevation site. Crustose species were not identified.

The significant variations appear to result from localized microclimatic differences in moisture and light, rather than from the microclimatic differences associated with increasing elevation. This is evident on examination of the variation of lichen species number, lichen cover, elevation preferences of the most frequent lichen species, the cover distribution of the dominant lichen species and the resemblance of lichen communities of different elevations to each other. The strong influence of microclimate is also indicated by the occurrence of most lichen species at a characteristic vertical level.

The lichen communities on Q. rubra at this location appear at least as rich in species diversity and abundance as those examined on this substrate in other lichen ecology studies. Thirty-eight fruticose and foliose lichen species were found throughout the study area on Q. rubra. Of these, 22 have a frequency of 20 percent or greater (Table 7) with four species, P. caperata, P. rudecta, P. squarrosa, and P. reticulatum forming 39 percent of the total lichen cover. Kulczynski's coefficient of community indicates that these lichen communities also demonstrate homogeneity in lichen species composition over the study site. However, the corticolous lichen flora in this area is not entirely stable, as indicated by the minor modifications required to update a local checklist compiled 13 years previously (Culberson, 1965).

The character and species composition of the lichen communities at the study site indicate that it is undisturbed by atmospheric sulfur dioxide pollution. The apparent absence of this pollutant further supports the suitability of this area for basic research of lichen community ecology.

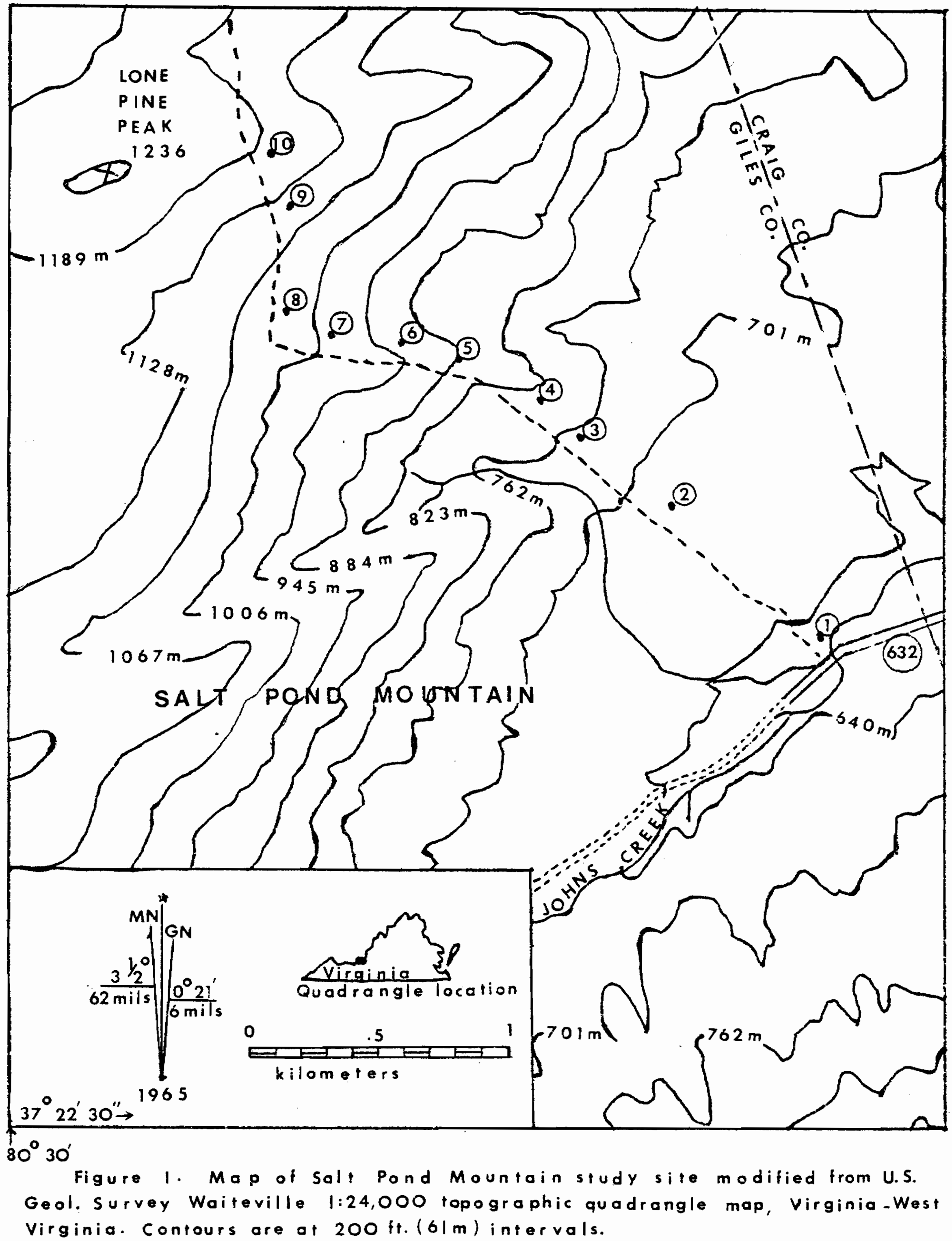

Figure 1. Map of Salt Pond Mountain study site modified from U.S. Geol. Survey Waiteville 1:24,000 topographic quadrangle map, Virginia-West Virginia. Contours are at 200 ft. (61m) intervals.

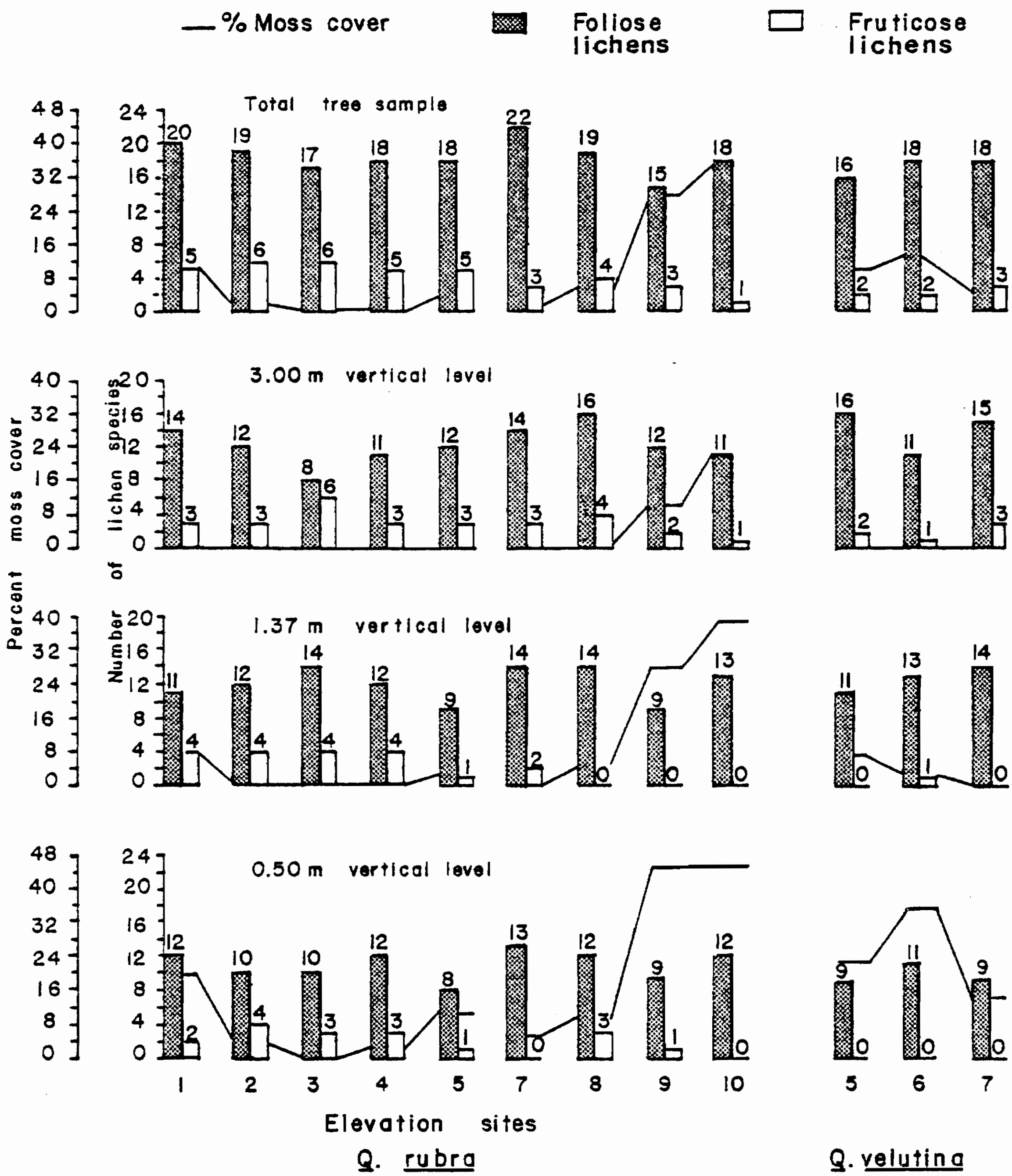

Figure 2. Species Diversity by Elevation Site and Vertical Level

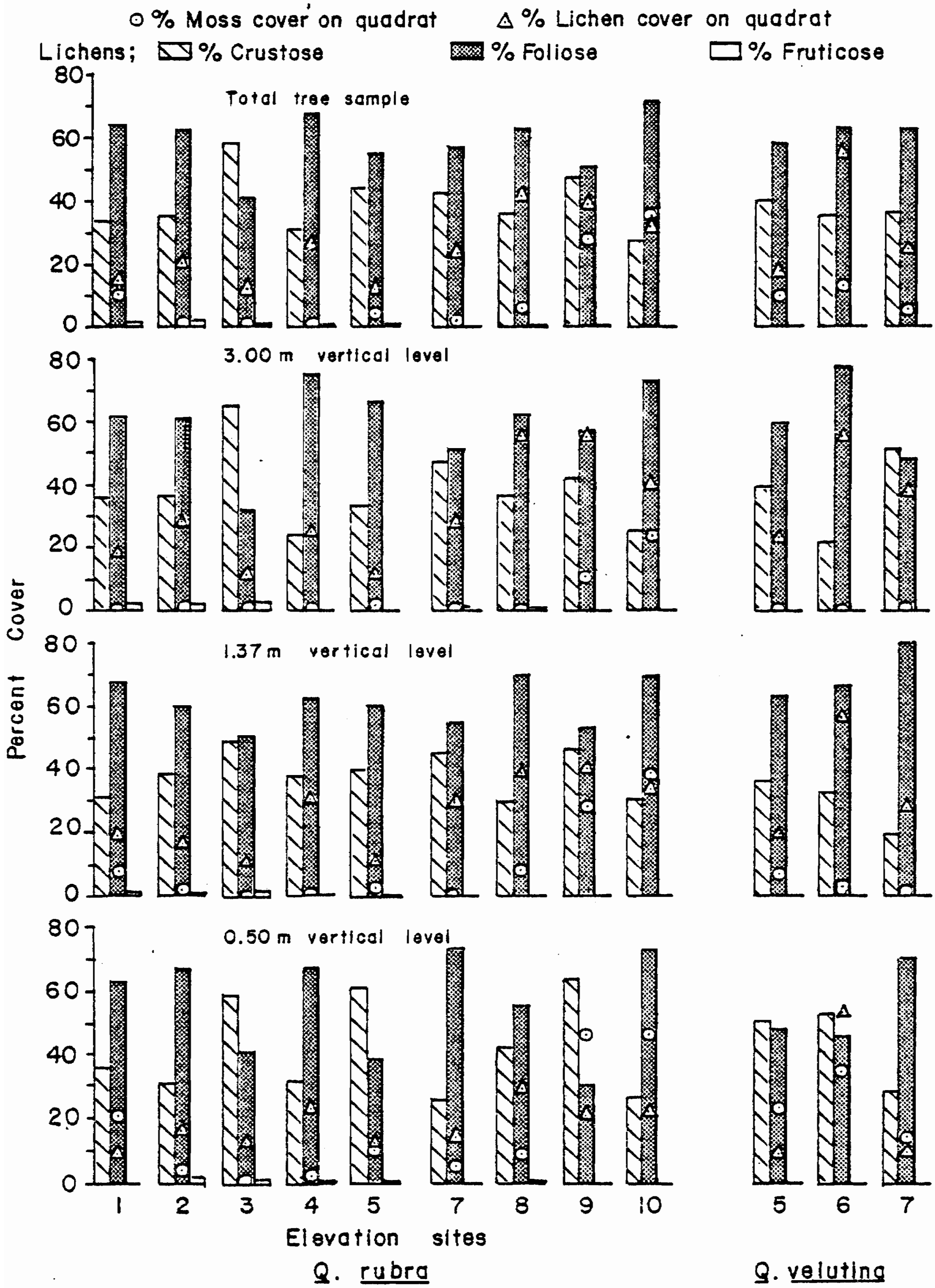

Figure 3. Lichen and Moss Percentage Cover by Elevation Site and Vertical Level

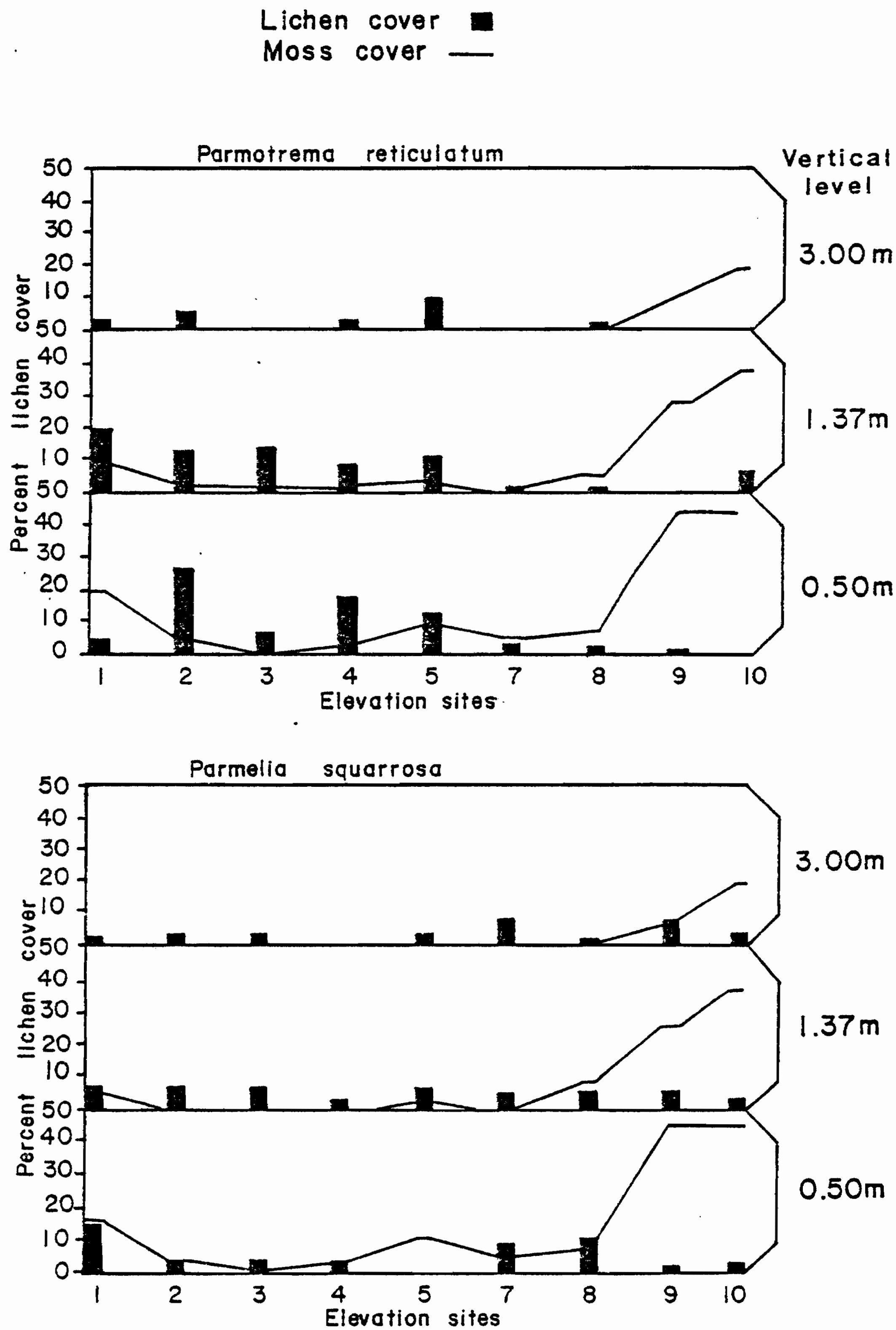

Figure 4. Percentage of Total Lichen Cover

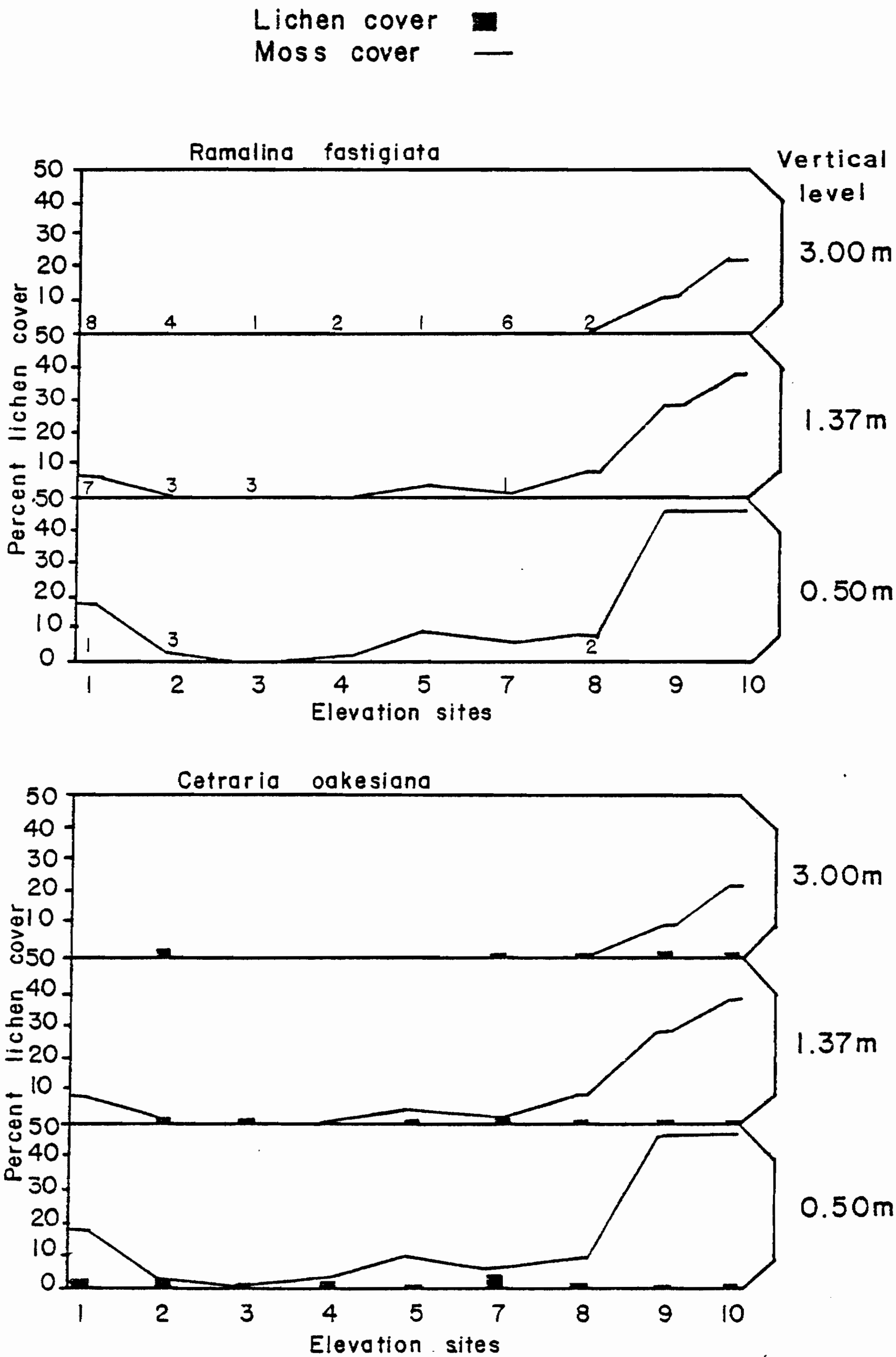

Figure 5. Percentage of Total Lichen Cover

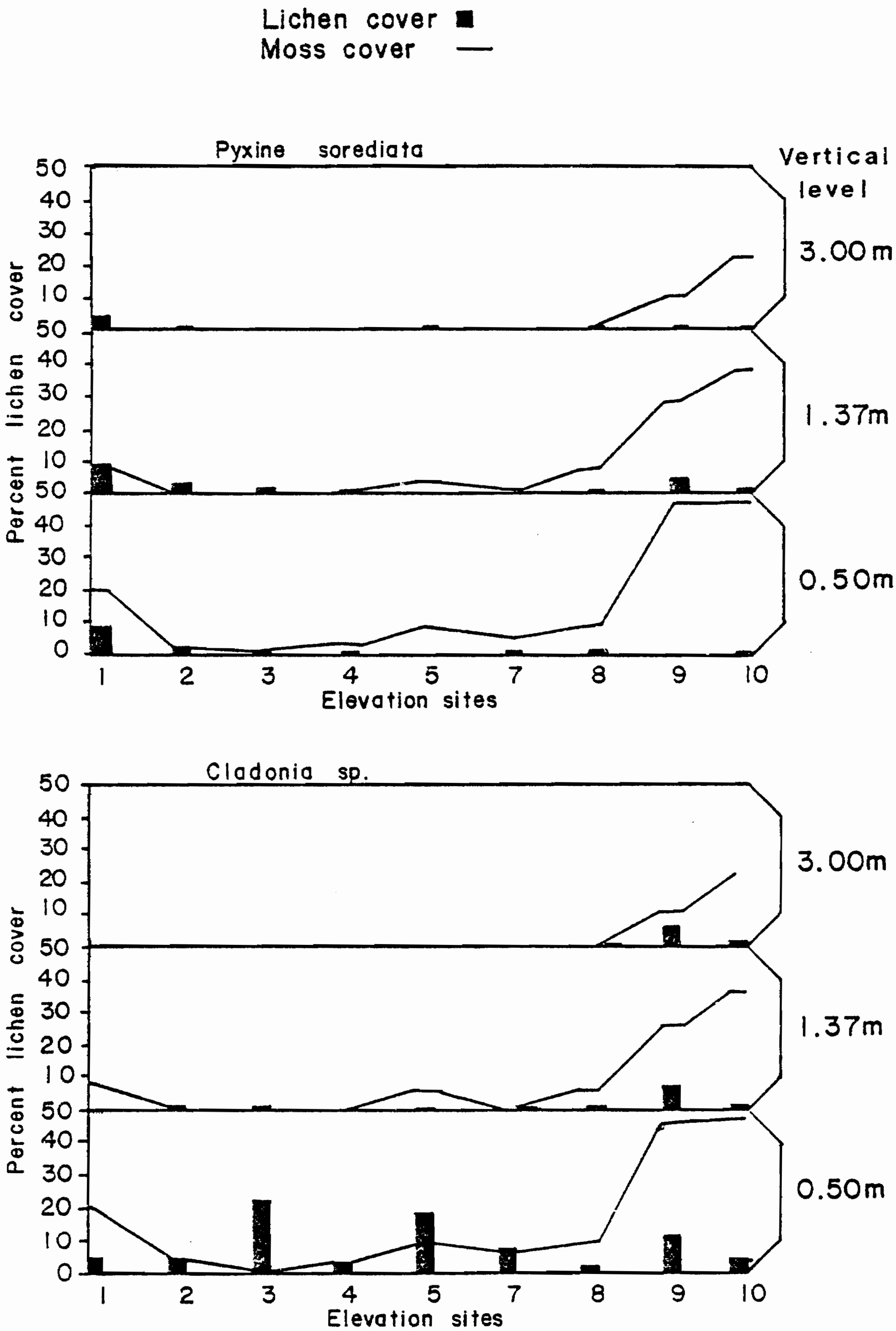

Figure 6. Percentage of Total Lichen Cover

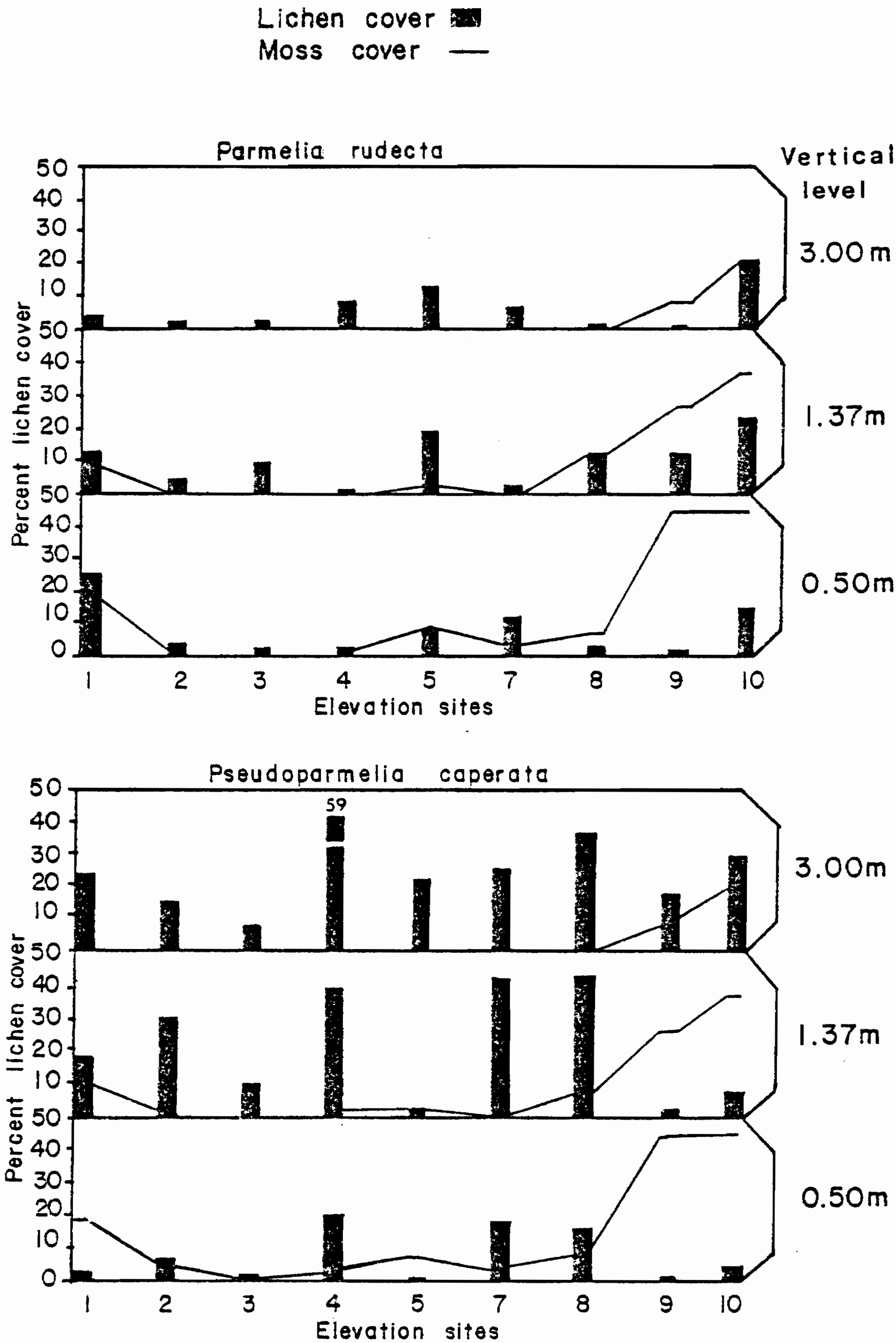

Figure 7. Percentage of Total Lichen Cover

TABLE 1

PRESENCE OF TREES AND SHRUBS ON THE ELEVATION SITES

	Elevation Sites									
	1	2	3	4	5	6	7	8	9	10
Tree Species										
Acer rubrum	+	+			+	+	+		+	+
Carya ovata	+									
Castanea dentata[a]			+	+	+	+	+	+	+	+
Cornus florida	+		+							
Hammamelis virginiana										+
Nyssa silvatica			+							
Oxydendron arboreum		+	+		+					
Pinus rigida				+		+				
Quercus alba	+			+					+	+
Q. prinus		+	+		+	+	+	+	+	
Q. rubra	+	+	+	+	+		+	+	+	+
Q. velutina		+	+		+	+	+	+	+	
Sassafras albidum[a]		+	+	+	+	+				
Shrub Species										
Gaylussacia baccata				+						
Kalmia latifolia	+	+	+	+	+	+				
Vaccinium sp.		+	+							

[a]Seedlings

TABLE 2

BASAL AREAS AND TREE DIAMETER BY ELEVATION SITE

	Elevation Sites									
	1	2	3	4	5	6	7	8	9	10
Total Basal (10 cm DBH), M^2/ha	32.3	27.8	27.7	20.1	33.0	21.0	33.0	66.5	58.7	44.2
Total _Q. rubra_ Basal Area (10 cm DBH), M^2/ha	13.5	21.4	15.6	8.4	10.7		16.0	1.9	27.0	24.6
Sample _Q. rubra_ $\bar{x}$ DBH, cm	23.2	22.5	17.9	19.0	19.7		26.1	18.6	35.8	23.8
S.D.	4.0	4.1	4.5	3.2	2.4		6.1	7.7	7.2	8.7
Sample _Q. velutina_ $\bar{x}$ DBH, cm					20.6	15.9	21.4			
S.D.					3.6	4.9	4.9			

TABLE 3

ANALYSIS OF VARIANCE OF LICHEN SPECIES NUMBER AND MOSS, LICHEN, AND LICHEN GROWTH FORM COVER

Source of Variation	df	SS	MS	Fs
No. of Species				
Altitude	8	60.33	7.541	1.68
Tree	27	121.25	4.491	1.04
Error	72	310.67	4.315	
Total	107	492.25		
Moss Cover				
Altitude	8	16491.17	2061.396	3.95[b]
Tree	27	14094.02	522.001	3.76[b]
Error	72	10007.83	138.998	
Total	107	40593.03		
Lichen Cover				
Altitude	8	1.17	0.146	6.46[b]
Tree	27	0.61	0.023	1.25
Error	72	1.31	0.018	
Total	107	3.10		
Crustose Cover				
Altitude	8	0.81	0.101	2.49[a]
Tree	27	1.10	0.041	1.15
Error	72	2.57	0.0357	
Total	107	4.50		
Foliose Cover				
Altitude	8	0.85	0.106	2.76[a]
Tree	27	1.05	0.039	1.07
Error	72	2.60	0.0361	
Total	107	4.50		
Fruticose Cover				
Altitude	8	0.02	0.003	1.65
Tree	27	0.04	0.001	0.93
Error	72	0.13	0.002	
Total	107	0.19		

[a]Significant at .05 level.

[b]Significant at .01 level.

TABLE 4

NUMBER AND PERCENT COVER OF LICHENS AND MOSS BY VERTICAL LEVEL ON Q. RUBRA AND Q. VELUTINA

	Q. rubra[a]			Q. velutina[b]		
	Study Area Mean	Vert. Level Means B/M/T[c]	Normalized Vert. Means	Study Area Mean	Vert. level Means B/M/T	Normalized Vert. Level Means
Number of foliose species	18.4	10.8/12.0/12.2	1/1.1/1.1	17.3	9.6/12.5/13.4	1/1.3/1.4
Number of fruticose species	4.2	1.9/2.2/3.1	1/1.2/1.6	2.3	0/0.3/2.0	0/1/6.7
Mean number of species/quadrat	6.9	6.7/7.1/7.0	1/1/1	6.7	5.8/7.3/6.9	1/1.3/1.2
Moss cover percent	8.5	15.6/9.4/3.7	4.5/2.5/1	9.5	23.8/3.9/0.6	39.7/6.5/1
Lichen cover percent	24.6	17.8/25.7/30.3	1/1.4/1.7	32.7	24.7/35.0/38.7	1/1.4/1.6
Crustose cover percent	39.7	42.1/38.4/38.8	1.1/1/1	37.9	44.8/29.6/38.0	1.5/1/1.3
Foliose cover percent	59.5	56.9/61.1/60.1	1/1.1/1.1	62.0	55.2/70.4/61.9	1/1.3/1.1
Fruticose cover percent	0.9	0.6/0.5/1.1	1.2/1/2.3	0.1	0/0/1.0	0/0/1

a mean of 9 elevation sites

b mean of 3 elevation sites

c B = basal quadrat at 0.5m, M = middle quadrat at 1.37m, T = top quadrat at 3.0m.

TABLE 5

LICHEN SPECIES CONSTANCY[a] ON Q. RUBRA

Lichen species	Tree N=36	Elev. N=9	B[b] N=36	M N=36	T N=36
Anaptychia palmatula	2	2	1	1	0
Anzia colpodes	9	6	3	3	3
Cetraria ciliaris	7	4	0	0	7
C. oakesiana	26	9	20	15	9
Cetrelia olivetorum	8	4	0	6	3
Cladonia sp.	33	9	30	15	9
Heterodermia hypoleuca	3	2	0	1	2
H. obscurata	4	3	2	3	0
H. squamulosa	12	8	9	4	2
Hypogymnia physodes	6	5	1	2	5
Hypotrachyna livida	12	5	0	5	11
H. revoluta	3	3	1	1	1
Lobaria pulmonaria	2	1	2	0	0
L. quercizans	2	1	2	0	0
Nephroma helveticum	1	1	1	0	0
Parmelia flaventior	4	3	1	0	3
P. rudecta	34	9	28	27	26
P. squarrosa	35	9	20	30	24
P. subrudecta	9	6	1	4	5
P. sulcata	16	6	8	9	12
Parmelina aurulenta	8	5	3	4	4
P. dissecta	17	8	13	12	2
P. galbina	2	2	0	1	2
Parmotrema crinitum	11	6	9	5	6
P. reticulatum	26	9	18	20	9
P. stuppeum	13	7	3	5	9
Pseudoparmelia caperata	36	9	23	31	35
Physcia ciliata	6	4	1	5	4
P. millegrana	3	3	0	0	3
P. orbicularis	6	4	6	3	3
P. stellaris	7	4	1	2	6
Pyxine sorediata	22	9	12	16	7
Ramalina fastigiata	18	7	4	8	13
Sticta weigelii	1	1	1	0	0
Usnea ceratina	1	1	1	0	0
U. mutabilis	8	6	3	3	3
U. rubiginea	10	6	5	2	4
U. strigosa	6	4	1	2	5
U. subfloridana	10	5	3	4	5
Usnea sp.	14	8	4	5	9

[a](Hale, 1955a), see text p. 18.

[b]B = Basal quadrat at 0.5m; M = Middle quadrat at 1.37m; T = Top quadrat at 3.0m.

TABLE 6

LICHEN SPECIES CONSTANCY[a] ON Q. VELUTINA

Lichen species	Tree N=12	Elev. N=3	B[b] N=12	M N=12	T N=12
Cetraria oakesiana	10	3	9	4	2
Cetrelia olivetorum	3	2	0	1	2
Cladonia sp.	12	3	12	12	3
Heterodermia hypoleuca	1	1	0	1	0
H. obscurata	7	3	4	4	4
H. squamulosa	4	2	3	1	1
Hypotrachyna livida	1	1	0	0	1
Parmelia flaventior	2	2	0	0	2
P. rudecta	12	3	8	11	7
P. squarrosa	10	3	5	9	8
P. subrudecta	2	2	0	1	2
P. sulcata	6	3	3	3	6
Parmelina dissecta	5	2	5	3	1
P. galbina	3	2	0	0	3
Parmotrema crinitum	4	2	4	1	1
P. reticulatum	8	3	2	7	2
P. stuppeum	6	2	0	4	2
Pseudoparmelia caperata	12	3	4	10	12
Physcia millegrana	1	1	0	0	1
P. orbicularis	8	3	7	6	5
P. stellaris	8	3	0	3	8
Pyxine sorediata	9	3	3	5	3
Ramalina fastigiata	3	2	0	0	3
Usnea rubiginea	3	2	0	1	2
U. subfloridana	1	1	0	0	1
Usnea sp.	2	2	0	1	1

[a](Hale, 1955a), see text p. 18.

[b]B = Basal quadrat at 0.5m; M = Middle quadrat at 1.37m; T = Top quadrat at 3.0m.

TABLE 7

ELEVATION PREFERENCES BASED ON PROMINENCE INDEX

OF SPECIES WITH ≥ 20% TREE FREQUENCY

Lichen species	Freq.	1	2	3	4	5	5b[a]	6b	7b	7	8	9	10
Pseudoparmelia caperata	A[b]	◕	●	◐	●	◕	◕	●	◕	●	●	◐	◕
Parmelia rudecta	A	●	◐	◐	◕	◕	◕	◕	◕	◕	◕	◐	●
P. squarrosa	A	●	◐	◕	◔	◔	◐	◐	◐	◕	◕	◕	◐
Cladonia sp.	A	+	◔	◔	⊕	◔	◕	◐	◕	◐	◔	◕	◐
Parmotrema reticulatum	A	◐	◕	◐	◐	◐	◔	⊕	+	⊕	⊕	+	+
Cetraria oakesiana	A	+	⊕	◔	⊕	⊕	◔	⊕	◔	◐	◔	◐	◐
Pyxine sorediata	A	◐	◔	⊕	+	+	⊕	◔	◔	+	⊕	⊕	◔
Parmelina dissecta	B	+	◔	⊕	◐	⊕	◔	⊕		⊕	+	+	
Parmelia sulcata	B	+	+		◐		+	◕	+	⊕	◐		⊕
Parmotrema crinitum	B	+	+			+		+	⊕	+	◔	◕	
Ramalina fastigiata	A	◔	◔	⊕	+	+				+	+		
Hypotrachyna livida	B	◔	◔	⊕		+			+	+			
Usnea sp.	B	+	⊕	◔	+	+		+	+		+	+	+
Parmotrema stuppeum	B	+	+		⊕			⊕	+	+	+	+	◔
Hetrodermia squamulosa	B	+	+	+	+		⊕		+	⊕	+	⊕	⊕
Usnea rubiginea	C	+	+	⊕	⊕	+	+	+				+	
U. subfloridana	C		+	+	⊕		+		+	+	⊕		
Anzia colpodes	C	⊕		+		+				+		+	+
Parmelina aurulenta	C	+	+	+	⊕						+		
Cetraria ciliaris	C		+	⊕		+							+
Cetrelia olivetorum	C	+	+					+	+			⊕	+
Physcia stellaris	C				+	+	⊕	⊕	⊕	+	⊕		
Parmelia subrudecta	C		+	+	+			+	+	+	+		+
Usnea mutabilis	C	+	+	+	+	+	+	+			+		

Legend: ● - prominence ≥ 300; ◕ - prominence ≥ 240;
◐ - prominence ≥ 180; ◔ - prominence ≥ 120;
⊕ - prominence ≥ 60; + - present, but prominence is ∠ 60.

[a]"b" indicates the transects in which Q. velutina was the host substrate. In all other transects Q. rubra was the host substrate.

[b]A freq. = 50-100%; B = 30-49%; C = 20-29%.

TABLE 8

SPECIES WITH 0.5m VERTICAL LEVEL PREFERENCE

Lichen species	Tree frequency[a]	Vert. pref. ratio[b] B/M/T	Elev. Site Pref.
Caldonia sp.	A	3.5/1.7/1	7-10
Cetraria oakesiana	A	2.3/1.7/1	7-10
Parmotrema reticulata	A	2.1/2.3/1	1-5
Heterodermia squamulosa	B	4.8/2.0/1	7-10
Parmotrema crinitum	B	1.9/1.0/1.2	8,9
Parmelina dissecta	B	6.8/5.5/1	2-7
Usnea rubiginea	C	1.7/1.0/1	1-5
Physcia orbicularis	D	2/1/1	5-8
Anaptychia palmatula	E	1/1/0	5,10
Lobaria pulmonaria	E	1/0/0	10
Lobaria quercizans	E	1/0/0	10
Nephroma helveticum	E	1/0/0	9
Sticta weigelii	E	1/0/0	10
Usnea ceratina	E	1/0/0	9

[a]A = frequency 50-100%, B = frequency 30-49%, C = frequency 20-29%.

[b]All values have been normalized by dividing the smallest positive value into the other values. B = 0.5m level; M = 1.37m level; T = 3.0m level.

TABLE 9

SPECIES WITH 1.37m VERTICAL LEVEL PREFERENCE

Lichen species	Tree[a] frequency	Vert. pref. ratio[b] B/M/T	Elev. Site Pref.
Pyxine sorediata	A	1.7/2.3/1	1,2,9,10
Parmelia squarrosa	A	1.0/1.4/1.2	1-10
Parmotrema reticulatum	A	2.1/2.3/1	1-5
Cetrelia olivetorum	C	0/1.8/1	1,2,9,10
Parmelina aurulenta	C	1.0/1.4/1.4	1-4
Physcia ciliata	D	1/5.1/4.1	1-4
Heterodermia obscurata	D	1/1.5/1	1,2,7
Anaptychia palmatula	E	1/1/0	5,10

[a]A = frequency 50-100%, B = frequency 30-49%, C = frequency 20-29%.

[b]All values have been normalized by dividing the smallest positive value into the other values. B = 0.5m level, M = 1.37m level, T = 3.0m level.

TABLE 10

SPECIES WITH 3.0m VERTICAL LEVEL PREFERENCE

Lichen species	Tree frequency[a]	Vert. pref. ratio[b] B/M/T	Elev. Site Pref.
Ramalina fastigiata	A	1.0/2.0/3.3	1-4
Pseudoparmelia caperata	A	1.0/1.5/1.7	1-10
Parmelia squarrosa	A	1.0/1.4/1.2	1-10
Hypotrachyna livida	B	0/1.0/2.4	1-3
Parmotrema stuppeum	B	1.0/1.8/3.1	1-10
Usnea sp.	B	1.0/1.3/2.3	2,3
Parmlia sulcata	B	1.0/1.1/1.5	4-10
Cetraria ciliaris	C	0/0/1	1-10
Physcia stellaris	C	1.0/2.0/6	4-8
Parmelia subrudecta	C	1.0/4.4/5.4	1-10
Usnea subfloridana	C	1.0/1.3/1.6	2-8
Parmelina aurulenta	C	1.0/1.4/1.4	1-4
Hypogymnia physodes	D	1/2/5.6	7-10
Usnea strigosa	D	1/2/5.2	1-3
Parmelia flaventior	D	1/0/3	3,4,8
Physcia millegrana	E	0/0/1	1,2,7
Heterodermia hypoleuca	E	0/1/2	5,7
Parmelina galbina	E	0/1/2	4,7

[a]A = frequency 50-100%, B = frequency 30-49%, C = frequency 20-29%.

[b]All values have been normalized by dividing the smallest positive value into the other values. B = 0.5m level; M = 1.37m level; T = 3.0m level.

TABLE 11

SPECIES WITH NO VERTICAL LEVEL PREFERENCE

Lichen species	Tree[a] frequency	Vert. pref. ratio[b] B/M/T	Elev. Site Pref.
Parmelia rudecta	A	1.1/1.1/1	1-10
Anzia colpodes	C	1.0/1.0/1	1-10
Usnea mutabilis	C	1.0/1.0/1	1-8
Hypotrachyna revoluta	E	1/1/1.1	3,4,5

[a]A = frequency 50-100%, B = frequency 30-49%, C = frequency 20-29%.

[b]All values have been normalized by dividing the smallest positive value into the other values. B = 0.5m level; M = 1.37m level; T = 3.0m level.

TABLE 12

KULCZYNSKI'S COEFFICIENT OF COMMUNITY[a]

BY ELEVATION SITE

	1	2	3	4	5	5b[b]	6b	7b	7	8	9
1											
2	70.3										
3	62.5	68.3									
4	54.1	61.9	58.7								
5	61.0	64.8	63.8	57.9							
5b	59.0	54.1	61.7	51.6	71.6						
6b	61.6	59.3	51.1	65.5	56.7	61.8					
7b	53.0	44.4	50.4	39.7	61.1	72.3	59.9				
7	61.3	60.5	59.3	64.2	62.5	61.6	73.0	63.9			
8	57.1	56.6	54.8	70.4	56.9	56.0	78.8	57.2	77.6		
9	53.8	48.4	56.5	40.4	55.8	60.3	60.4	64.0	60.3	55.2	
10	56.9	52.3	51.7	47.5	60.2	57.7	65.0	61.1	60.3	55.8	60.7

Mean = 59.3

S.D. = 7.43

[a](Culberson, 1955a) see text p. 18.

[b]"b" indicates the transects in which *Quercus velutina* was the host substrate. In all other transects *Quercus rubra* was the host substrate.

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APPENDIX A

LIST OF LICHEN SPECIES FOUND ON *Q. RUBRA* ON SALT POND MOUNTAIN, GILES COUNTY, VIRGINIA 1976

Since the publication, in 1970, of Hale and Culberson's *A Fourth Checklist of the Lichens of the Continental United States and Canada*, there has been an extensive taxonomic revision of the genus *Parmelia* by M. E. Hale, Jr. All species are listed here as they are currently termed. Beneath those species which have undergone revision is the 1970 name in parentheses. Nomenclature for all other species follows Hale and Culberson (1970).

A list of the foliose and fruticose lichens found in the Mountain Lake area (Mountain Lake is located on Salt Pond Mountain) was published by Culberson in 1965. For ease of reference, the nomenclature used in that work is also listed, if different from Hale and Culberson (1970).

1. *Anaptychia palmatula* (Michx.) Vain.
2. *Anzia colpodes* (Ach.) Stizenb.
3. *Cetraria ciliaris* Ach.
4. *C. oakesiana* Tuck.
5. *Cetrelia olivetorum* (Nyl.) W. Culb. & C. Culb.
6. *Cladonia* sp.
7. *Heterodermia hypoleuca* (Muhl.) Trev.
   ≡ *Anaptychia hypoleuca* (Muhl.) Mass.
8. *Heterodermia obscurata* (Nyl.) Trev.
   ≡ *Anaptychia obscurata* (Nyl.) Vain.
9. *Heterodermia squamulosa* (Degel.) W. Culb.
   ≡ *Anaptychia squamulosa* Degel.
10. *Hypogymnia physodes* (L.) W. Wats
11. *Hypotrachyna livida* (Tayl.) Hale.[1]
    (*Parmelia livida* Tayl.)
12. *Hypotrachyna revoluta* (Florke) Hale.[1]
    (*Parmelia revoluta* Florke)

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[1]Hale (1975).

13. Lobaria pulmonaria (L.) Hoffman
14. L. quercizans Michx.
15. Nephroma helveticum Ach.
16. Parmelia flaventior Stirt.
17. P. rudecta Ach.
18. P. squarrosa Hale[2]
    (P. saxatilis (L.) Ach.)
19. Parmelia subrudecta Nyl.
    ≡ P. borreri (Sm.) Turn.
20. P. sulcata Tayl.
21. Parmelina aurulenta (Tuck.) Hale[3]
    (Parmelia aurulenta Tuck.)
22. Parmelina dissecta (Nyl.) Hale[3]
    (Parmelia dissecta Nyl.)
23. Parmelina galbina (Ach.) Hale[3]
    (Parmelia galbina Ach.)
24. Parmotrema crinitum (Ach.) Choisy[4]
    (Parmelia crinita Ach.)
25. Parmotrema reticulatum (Tayl.) Choisy[4]
    (Parmelia reticulata Tayl.)
26. Parmotrema stuppeum (Tayl.) Hale[5]
    (Parmelia stuppea Tayl.)
27. Pseudoparmelia caperata (L.) Hale[6]
    (Parmelia caperata (L.) Ach.)
28. Physcia ciliata (Hoffmn.) DuRietz
29. P. millegrana Degel.
30. Physcia orbicularis (Neck.) Thoms.
31. P. stellaris (L.) Nyl.
32. Pyxine sorediata (Ach.) Mont.
33. Ramalina fastigiata (Pers.) Ach.
34. Sticta weigelli (Ach.) Vain.
35. Usnea ceratina Ach.
36. U. mutabilis Stirt.
37. U. rubiginea (Michx.) Mass.
38. U. strigosa (Ach.) Eat.
39. U. subfloridana Stirt.
    ≡ U. comosa (Ach.) Rohl.
40. Usnea sp.

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[2]Hale (1971).

[3]Hale (1974a).

[4]Hale (1976), personal communication.

[5]Hale (1974b).

[6]Hale (1974c).

APPENDIX B

FIELD KEY TO FOLIOSE AND FRUITCOSE LICHENS[a] FOUND ON *Q. RUBRA* ON SALT POND MOUNTAIN, GILES COUNTY, VIRGINIA, 1976.

[a]Some descriptive phrases from M. E. Hale's How to Know the Lichens (1969) have been utilized. Current species names appear at the end of the descriptive phrase, species names which appear in parentheses are those used in Hale's book. All color descriptions refer to color exhibited when specimen is dry.

I. 1. a. Fruticose (three dimensional) - II

b. Foliose (two dimensional - flattened) - 2

2. a. With soredia ("sandy clumps") or isidia ("minature coral") - 3

b. Without soredia or isidia, with apothecia ("cups"), or sterile - V

3. a. With soredia - III

b. With isidia - IV

II. Fruticose

1. a. Dorso - ventrally flattened, no central cord - *Ramalina fastigiata*

b. Round in cross-section, central cord present - 2

2. a. Terminal apothecia present - *Usnea strigosa*

b. No apothecia present - 3

3. a. Thallus elongate and hair-like - *Usnea ceratina*

b. Thallus in tufts, shrub-like - 4

4. a. Thallus surface becomes rust-red or blackened toward point of attachment - 5

b. Thallus surface without color change toward point of attachment - 6

5. a. Thallus becomes rust-red toward point of attachment - Usnea rubiginea

b. Thallus becomes blackened toward point of attachment - Usnea subfloridana (U. comosa)

6. a. Cross-section of mature branch exposes rose-red medulla - Usnea mutabilis

b. Cross-section of mature branch exposes white medulla - Usnea sp. (likely to be a juvenile form of one of the above Usnea species)

III. Foliose - soredia

1. a. Thallus composed of many small lobes or squamules - Cladonia sp.

b. Thallus not composed of squamules - 2

2. a. Upper surface of thallus broadly ridged, lower side with felty tomentum under ridges - Lobaria pulmonaria

b. Upper surface without broad ridges - 3

3. a. Lower thallus surface interrupted by recessed pores - Sticta weigelii

b. Lower thallus surface without pores - 4

4. a. Lower thallus surface yellow-orange in color - Heterodermia obscurata (Anaptychia obscurata)

b. Lower thallus surface not yellow-orange in color - 5

5. a. Lower thallus surface white to tan in color - 6

b. Lower thallus surface dark brown to jet black in color - 8

6. a. Upper thallus surface yellow-green in color - marginal soredia present - Cetraria oakesiana

   b. Upper thallus surface mineral gray to green mineral gray in color - soredia not marginal - 7

7. a. Upper thallus surface green mineral gray with white pores, thallus lobes 4-20 mm. wide - Parmelia subrudecta

   b. Upper thallus surface mineral gray, without pores, thallus lobes 0.2 - 0.5 mm. wide - Physcia millegrana

8. a. Thallus lobes inflated and hollow - Hypogymnia physodes

   b. Thallus lobes flattened and solid - 9

9. a. Upper thallus surface yellow-green - 10

   b. Upper thallus surface mineral gray - 11

10. a. Laminal pustular soredia on upper surface, with white pores toward lobe tips - Parmelia flaventior

    b. Laminal pustular soredia on upper surface, without white pores, although small white patches on the continuous surface may appear toward lobe tips - Pseudoparmelia caperata (Parmelia caperata)

11. a. Thallus lobes broad (4-20 mm.) - 12

    b. Thallus lobes narrow (1-4 mm.) - 14

12. a. Upper thallus surface reticulately cracked - Parmotrema reticulatum (Parmelia reticulata)

    b. Upper thallus surface without patterned cracks - 13

13. a. Cilia at lobe tips and axils, marginal soredia, white mineral gray surface continuous - Parmotrema stuppeum (Parmelia stuppea)

b. No cilia present, laminal and marginal soredia, green mineral gray, white pores on upper surface - Cetrelia olivetorum

14. a. Cross-section of thallus exposes pigmented medulla - 15

b. Cross-section of thallus exposes white medulla - 16

15. a. Cross-section of thallus exposes red medulla - Physcia orbicularis

b. Cross-section of thallus exposes yellow medulla - Pyxine sorediata

16. a. Lobe margins turn under, soredia are laminal-toward lobe Hypotrachyna revoluta (Parmelia revoluta)

b. Lobe margins flat - 17

17. a. Upper surface weakly reticulately ridged with angular markings, soredia laminal and marginal along ridges, thallus white mineral gray - Parmelia sulcata

b. Upper surface smooth to wrinkled, with laminal pustular soredia, thallus green mineral gray - Parmelina aurulenta (Parmelia aurulenta)

IV. Foliose - isidia

1. a. Lower thallus surface white to tan, upper surface lobes with small white pores, green-blue mineral gray - Parmelia rudecta

b. Lower thallus surface dark brown to black - 2

2. a. Thallus lobes broad (4-20 mm.), isidia with dark tip - Parmotrema crinitum (Parmotrema crinita)

b. Thallus lobes narrow (0.5-4.0 mm.) - 3

3. a. Upper thallus surface weakly reticulately ridged with angular markings, isidia on ridges and margins, branched rhizines - Parmelia squarrosa (P. saxatilis)

   b. Upper surface smooth to wrinkled, isidia distributed over entire surface, simple rhizines, marginal cilia - Parmelina dissecta (Parmelia dissecta)

V. Foliose - apothecia or sterile

1. a. Apothecia on lower surface, on upturned lobe tips - Nephroma helveticum

   b. Apothecia, if present, on upper surface - 2

2. a. Lobes inflated and solid - Anzia colpodes

   b. Lobes flattened - 3

3. a. Upper surface broadly reticulately ridged, with felty tomentum under ridges - Lobaria pulmonaria

   b. Upper surface without broad ridges - 4

4. a. Lower thallus surface white to tan - 5

   b. Lower thallus surface dark brown to black - 10

5. a. Lower surface with white rhizines - Physcia stellaris

   b. Lower surface with dark rhizines (may be sparse) - 6

6. a. Lobe margins lined with black pycnidia - Cetraria ciliaris

   b. Lobe margins without pycnidia - 7

7. a. Thallus lobes broad (6-15 mm.), lower surface with felty tomentum - Lobaria quercizans

   b. Thallus lobes narrow (1-4 mm.) - 8

8. a. Upper thallus surface brownish mineral gray, apothecia with squamulose rim - Anaptychia palmatula

b. Upper thallus surface white mineral gray - 9

9. a. Upper surface squamulose, particularly on mature portions of thallus, rare apothecia - Heterodermia squamulosa (Anaptychia squamulosa)

b. Upper surface without squamules, though lobe and apothecia rim margins may become lobulate with age, apothecia common - Heterodermia hypoleuca (Anaptychia hypoleuca)

10. a. Lobe margins lined with black pycnidia - Cetraria ciliaris

b. Lobe margins without pycnidia - 11

11. a. Thallus lobe 0.5 - 1.0 mm. wide, often fine hairs on upper surface - Physcia ciliata

b. Thallus lobe 1-4 mm. wide - 12

12. a. Apothecia and medulla appear yellowish, pycnidia common on thallus surface, simple rhizines, marginal axial cilia - Parmelina galbina (Parmelia galbina)

b. Apothecia dark brown, medulla white, pycnidia uncommon on thallus surface, branched rhizines, no cilia - Hypotrachyna livida (Parmelia livida)

APPENDIX C

NUMBER OF LICHEN SPECIES PRESENT ON *Q. RUBRA* BY ELEVATION SITE AND VERTICAL LEVEL

			Elevation Sites								
			1	2	3	4	5[a]	7	8	9	10
Foliose spp.	Vert. level	B	12	10	10	12	8	13	12	9	12
		M	11	12	14	12	9	14	14	9	13
		T	14	12	8	11	12	14	16	12	11
	Total tree[b]		20	19	17	18	18	22	19	15	18
Fruticose spp.	Vert. level	B	2	4	3	3	1	0	3	1	0
		M	4	4	4	4	1	2	0	0	0
		T	3	3	6	3	3	3	4	2	1
	Total tree		5	6	6	5	5	3	4	3	1
Mean number of spp. per tree	Vert. level	B	6.25	8.0	7.0	9.75	4.25	7.25	7.25	5.5	5.25
		M	8.5	7.75	8.75	7.75	4.75	6.25	6.75	6.0	7.0
		T	7.5	7.5	6.0	5.5	7.0	7.5	7.75	7.25	6.75
	Total tree		7.42	7.75	7.25	7.67	5.33	7.0	7.25	6.25	6.33

[a]There is no *Q. rubra* at site 6.

[b]Total number of species on all three quadrats.

APPENDIX D

NUMBER OF LICHEN SPECIES PRESENT ON *Q. VELUTINA* BY ELEVATION SITE AND VERTICAL LEVEL

			Elevation Sites		
			5	6	7
Foliose spp.	Vert. level	B	9	11	9
		M	11	13	14
		T	16	11	15
	Total tree[a]		16	18	18
Fruticose spp.	Vert. level	B	0	0	0
		M	0	1	0
		T	2	1	3
	Total tree		2	2	3
Mean number of spp. per tree	Vert. level	B	5.0	7.25	5.0
		M	7.0	8.5	6.5
		T	8.5	5.5	6.75
	Total tree		6.83	7.08	6.08

[a]Total number of species at all 3 quadrats.

APPENDIX E

LICHEN AND MOSS PERCENTAGE COVER ON Q. RUBRA BY ELEVATION SITE AND VERTICAL LEVEL

			Elevation Sites								
			1	2	3	4	5[a]	7	8	9	10
Lichen cover[b]	Vert. level	B	9	17	12	23	12	14	30	21	22
		M	19	17	11	31	12	29	39	40	34
		T	18	28	12	25	12	28	55	55	40
	Total tree[d]		15.3	20.7	11.7	26.3	12.0	23.6	41.3	38.7	32.0
Fruticose lichens[c]	Vert. level	B	0.2	2.2	1.4	0.4	0.4	0	0.8	5.0	0
		M	1.1	1.6	0.9	0.7	0.2	0.05	0	0	0
		T	2.6	2.0	2.8	0.2	0.2	0.8	0.9	0.4	0.3
	Total tree		1.3	1.9	1.7	0.4	0.3	0.3	0.6	1.8	0.1
Foliose lichens[c]	Vert. level	B	63.4	67.0	40.4	67.7	38.8	74.0	56.7	30.7	73.4
		M	67.7	60.2	50.5	62.5	60.3	54.9	70.5	53.7	69.6
		T	61.4	61.2	32.2	75.3	66.4	51.4	62.2	57.4	73.4
	Total tree		64.2	62.8	41.0	68.5	55.2	60.1	63.1	47.2	72.2
Crustose lichens[c]	Vert. level	B	36.4	31.5	58.9	31.9	60.8	26.0	42.4	64.2	26.6
		M	31.3	38.2	48.6	36.8	39.5	45.0	29.5	46.3	30.4
		T	36.0	36.8	65.0	24.5	33.4	47.8	36.8	42.3	26.2
	Total tree		34.6	35.5	57.5	31.1	44.6	39.6	36.2	50.9	27.7
Moss cover[b]	Vert. level	B	20.1	2.9	0	2.1	9.0	4.9	8.8	46.3	46.3
		M	7.5	0.1	0	0	2.8	0.5	7.8	27.5	38.8
		T	0	0	0	0	0.3	0.1	0	10.3	22.5
	Total tree		9.2	1.0	0	0.7	4.0	1.8	5.5	28.0	35.9

[a] There is no Q. rubra on site 6.

[b] Percent cover of quadrat.

[c] Percent of lichen cover.

[d] Total cover on all three quadrats.

APPENDIX F

LICHEN AND MOSS PERCENTAGE COVER ON *Q. VELUTINA*

BY ELEVATION SITE AND VERTICAL LEVEL

			Elevation Sites		
			5	6	7
Lichen cover[a]	Vert. level	B	10	54	10
		M	20	57	28
		T	23	55	38
	Total tree[c]		17.7	55.3	25.3
Fruticose lichens[b]	Vert. level	B	0	0	0
		M	0.1	0.004	0
		T	0.1	0.04	0.2
	Total tree		0.1	0.01	0.1
Foliose lichens[b]	Vert. level	B	48.3	46.3	70.9
		M	63.7	67.0	80.5
		T	59.9	77.7	48.0
	Total tree		57.3	63.7	66.5
Crustose lichens[b]	Vert. level	B	51.7	53.5	29.1
		M	36.2	33.0	19.5
		T	39.6	22.3	52.1
	Total tree		42.5	36.3	33.6
Moss cover[a]	Vert. level	B	22.5	35.0	14.0
		M	7.6	3.3	0.8
		T	0.6	0	1.1
	Total tree		10.2	12.8	5.3

[a]Percent cover of quadrat.

[b]Percent of total lichen cover.

[c]Total percent cover on all three quadrats.

APPENDIX G

LICHEN SPECIES PERCENTAGE COVER ON Q. RUBRA BY ELEVATION SITE AND VERTICAL LEVEL

Elevation Sites

	1			2			3			4			5[b]			7			8			9			10		
Vertical Level	B[a]	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T
Lichen Species																											
Anaptychia palmatula														+[c]											+		
Anzia colpodes	2	2							2						+			+				+			1		
Cetraria ciliaris						1			3						2												1
C. oakesiana	+			3	+	1	1	+		3			+	+		4	2	+	2	1	+	1	1	1	1	1	1
Cetrelia olivetorum		1	8			2																	8	3		3	
Cladonia sp.	3			4	+		21	1		3			17	1		7	+	+	1	1	+	10	6	6	4	2	2
Heterodermia hypoleuca															1		+										
H. obscurata		+		+												+	+										
H. squamulosa	+		1		+			+		1						+	+				+	1			19	+	
Hypogymnia physodes															4			2	+	1	4			4		+	+
Hypotrachyna livida		3	7		3	27		2	13						1		1	3									
H. revoluta								1		1					4												
Lobaria pulmonaria																									4		
L. quercizans																									6		
Nephroma helveticum																						1					
Parmelia flaventior							1		+			+									2						

[a] B = Basal quadrat at 0.5m; M = Middle quadrat at 1.37m; T = Top quadrat at 3.0m.

[b] There is no Q. rubra at elevation site 6.

[c] Present but less than 1%.

APPENDIX G (continued)

	Elevation Sites																										
	1			2			3			4			5			7			8			9			10		
Vertical Level	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T
Lichen Species																											
Parmelia rudecta	25	12	4	4	4	1	3	9	3	3	1	8	1	19	13	13	2	6	4	13	1	2	13	1	16	24	22
P. squarrosa	14	6	3	2	6	4	3	6	4	3	3			6	4	8	5	9	20	11	4	1	6	8	3	4	5
P. subrudecta				+				3	+		3							2			2					3	5
P. sulcata	2			6	+					3	2	2				1	+	1	+	3	4					2	4
Parmelina aurulenta		1	1		1	1	1	3		1	1	2							+								
P. dissecta	1			16	1		1	3		11	2		4	13		1	+			+				3			
P. galbina												+								+	1						
Parmotrema crinitum			1		+	+							2			16			3	1	+	12	9	11			
P. reticulatum	4	18	1	25	11	5	6	13		17	8	3	12	10	9	3	1		3	1	3		2	1		6	
P. stuppeum			7			2				1	2							2			2	1		4	2	13	2
Pseudoparmelia caperata	3	17	24	6	30	16	2	10	8	20	39	59	1	4	23	19	42	26	22	44	36	1	3	14	5	9	30
Physcia ciliata		+	+					1	1	+	1	+					1	1									
P. millegrana			1			+												+									
P. orbicularis	2		+										2	6	4	1	+		1	2	+						
P. stellaris											+	+			+			+	+	+	+						
Pyxine sorediata	8	7	3	1	2	+	1	1		+	+				1	1			+	1	1		4	1	1	1	+
Ramalina fastigiata	+	+	1	+	+	+		+	+			+			+		+	+	+		+						
Sticta weigelii																									10		
Usnea ceratina																						5					
U. mutabilis		1	+	+			+		+	+	+			+							+						
U. rubiginea		+		1			1		+	+	+	+			+									+			
U. strigosa			2	+	1	1		+	1									+									
U. subfloridana					+			+	+	+	+					+	+	+	1		+						
Usnea sp.	+	+			+	+	+	1	1		+	+	+						+		+			+			+

APPENDIX H

LICHEN SPECIES PERCENTAGE COVER ON *Q. VELUTINA* BY ELEVATION SITE AND VERTICAL LEVEL

Elevation Sites	5			6			7		
Vertical Level	B[a]	M	T	B	M	T	B	M	T
Lichen Species									
Cetraria oakesiana	1	+[b]	+	2			3	1	+
Cetrelia olivetorum						3			3
Cladonia sp.	18	8	1	7	1		26	6	+
Heterodermia hypoleuca								+	
H. obscurata	3	1	2		+		2	+	+
H. squamulosa	1	+	+				1		
Hypotrachyna livida									+
Parmelia flaventior			1			1			
P. rudecta	17	22	16	11	20	2	21	48	21
P. squarrosa	1	20	4	3	18	11	6	4	13
P. subrudecta					+	1			2
P. sulcata			3	2	2	2			+
Parmelina dissecta	5	1	1	10	+				
P. galbina			1			1			
Parmotrema crinitum				4			8	2	3
P. reticulatum	1	6	2	1	2			1	1
P. stuppeum					5	1		+	1
Pseudoparmelia caperata		5	25	4	16	55	3	13	4
Physcia millegrana			+						
P. orbicularis	3	1	1	+	+	+	2	+	+
P. stellaris			1		+	1		+	1
Pyxine sorediata		+	2	1	1			2	+
Ramalina fastigiata			+						+
Usnea rubiginea		+	+			+			
U. subfloridana	+								+
Usnea sp.					+				+

[a]B = Basal quadrat at 0.5m; M = Middle quadrat at 1.37m; T = Top quadrat at 3.0m.

[b]Present but less than 1%.

APPENDIX I

LICHEN SPECIES ABSOLUTE FREQUENCY ON Q. RUBRA BY ELEVATION SITE AND VERTICAL LEVEL

Elevation Sites

	1			2			3			4			5			7[b]			8			9			10		
Vertical Level	B[a]	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T
Lichen Species																											
Anaptychia palmatula											25														25		
Anzia colpodes	25	75						25							25			25				25			25		
Cetraria ciliaris						25			75						50												25
C. oakesiana	25			25	50	25	75	50		100			50	50		100	50	25	50	50	25	50	50	75	25	75	75
Cetrelia olivetorum		25	25			25																	75	25		50	
Cladonia sp.	50			100	25		100	50		100			100	50		100	50	25	50	50	25	75	75	100	75	75	75
Heterodermia hypoleuca															50		25										
H. obscurata		50		25												25	25										
H. squamulosa	25		25		25			25		50						50	25				25	75			25	25	
Hypogymnia physodes															25			25	25	25	25			25		25	25
Hypotrachyna livida		50	75		25	100		25	50						25		25	25									
H. revoluta								25		25					25												
Lobaria pulmonaria																									50		
L. quercizans																									50		
Nephroma helveticum																						25					
Parmelia flaventior							25		25				25								25						

[a]B = Basal quadrat at 0.5m; M = Middle quadrat at 1.37m; T = Top quadrat at 3.0m.

[b]There is no Q. rubra at elevation site 6.

APPENDIX I (continued)

	Elevation Sites																										
	1			2			3			4			5		b	7			8			9			10		
	B[a]	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T
Lichen Species																											
Parmelia																											
rudecta	100	75	100	100	75	25	50	75	50	100	50	100	50	75	100	100	50	100	75	100	50	75	75	25	50	100	100
P. squarrosa	75	100	100	50	75	50	75	100	75	50	75			50	100	50	100	75	100	75	50	50	100	100	50	75	50
P. subrudecta				25				25	25		50							25				50				25	25
P. sulcata	25			25	25					75	75	100				25	25	50	50	75	75					25	75
Parmelina																											
aurulenta		25	25		25	25	25	25	50										25								
P. dissecta	25			100	25		50	25		100	75		25	75		25	50			25				50			
P. galbina												25								25	25						
Parmotrema																											
crinitum			25		25	25							25			25		75	25	25	100	75	75				
P. reticulatum	75	75	25	75	100	75	75	100		100	75	25	50	50	50	50	25		25	25	25		25	25		25	
P. stuppeum			25			50				25	50							50			25	25		25	25	75	50
Pseudoparmelia																											
caperata	25	100	100	75	75	100	50	75	75	75	100	100	75	75	100	100	100	100	100	100	100	25	75	100	50	75	100
Physcia ciliata		25	25					25	25	25	50	25					25	25									
P. millegrana			25			25												25									
P. orbicularis	50		25										25	25	25	50	25		25	25	25						
P. stellaris											25	25			25			50	25	25	50						
Pyxine sorediata	75	75	25	50	100	25	50	50		25	25				25	25			25	50	25		50	50	50	50	25
Ramalina																											
fastigiata	25	75	75	50	50	75		50	25			25			25		25	75	25		25						
Sticta weigelii																									25		
Usnea ceratina																					25						
U. mutabilis		25	25	25			25		25	25	25			25							25						
U. rubiginea		25		50			50		25	25	25	25			25	25								25			
U. strigosa			25	25	25	50		25	25									25									
U. subfloridana					25			25	25	50	25						25	25	25		50						
Usnea sp.	25	25			25	50		50	50		25	25	25						25		25			25			50

APPENDIX J

LICHEN SPECIES ABSOLUTE FREQUENCY ON *Q. VELUTINA*

BY ELEVATION SITE AND VERTICAL LEVEL

	Elevation Sites								
	5			6			7		
Vertical Level	B[a]	M	T	B	M	T	B	M	T
Lichen Species									
Cetraria oakesiana	50	50	25	100			75	50	25
Cetrelia olivetorum						50		25	
Cladonia sp.	100	100	25	100	100		100	100	50
Heterodermia hypoleuca								25	
H. obscurata	50	50	75			25	50	25	25
H. squamulosa	50	25	25				25		
Hypotrachyna livida									25
Parmelia flaventior			25			25			
P. rudecta	50	75	100	100	100	25	50	100	50
P. squarrosa	25	75	75	50	100	50	50	50	75
P. subrudecta					25	25			25
P. sulcata			25	75	75	100			25
Parmelina dissecta	75	50	25	50	25				
P. galbina			25			50			
Parmotrema crinitum				50			50	25	25
P. reticulatum	25	100	25	25	50			25	25
P. stuppeum					75	25		25	25
Pseudoparmelia caperata		50	100	75	100	100	25	100	100
Physcia millegrana			25						
P. orbicularis	75	75	75	25	25	25	75	50	25
P. stellaris			75		50	50		25	75
Pyxine sorediata		25	50	75	75			25	25
Ramalina fastigiata			50						50
Usnea rubiginea		25	25			25			
U. subfloridana	25								25
Usnea sp.					25				25

[a]B = Basal quadrat at 0.5m; M = Middle quadrat at 1.37m; T = Top quadrat at 3.0m.

APPENDIX K

LICHEN SPECIES RELATIVE FREQUENCY ON Q. RUBRA BY ELEVATION SITE AND VERTICAL LEVEL

Elevation Sites	1			2			3			4			5[b]			7			8			9			10		
Vertical Level	B[a]	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T
Lichen Species																											
Anaptychia palmatula														5											5		
Anzia colpodes	4	9							4						4			3				5			5		
Cetraria ciliaris						3			13						7												4
C. oakesiana	4			3	6	3	11	6		10			12	10		14	8	3	7	7	3	9	8	10	5	11	11
Cetrelia olivetorum		3	3			3																	13	3		7	
Cladonia sp.	8			13	3		15	6		10			24	10		14	8	3	7	7	3	14	13	14	14	11	11
Heterodermia hypoleuca															7		4										
H. obscurata		6		3												3	4										
H. squamulosa	4		3		3			3		5						7	4				3	14			5	4	
Hypogymnia physodes															4			3	3	4	3			3		4	4
Hypotrachyna livida		6	10		3	13		3	8						4		4	3									
H. revoluta								3		3					4												
Lobaria pulmonaria																									10		
L. quercizans																									10		
Nephroma helveticum																						5					
Parmelia flaventior							4		4			5									3						
P. rudecta	16	9	13	13	10	3	7	9	8	10	6	18	12	15	15	14	7	13	10	15	6	14	13	3	10	14	15

[a]B = Basal quadrat at 0.5m; M = Middle quadrat at 1.37m; T = Top quadrat at 3.0m.

[b]There is no Q. rubra at elevation site 6.

APPENDIX K (continued)

Elevation Sites

	1			2			3			4			5[b]			7			8			9			10		
Vertical Level	B[a]	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T
Lichen Species																											
Parmelia squarrosa	12	12	13	6	10	7	11	12	13	5	10			10	15	7	15	10	14	11	6	9	17	14	10	11	7
P. subrudecta				3				3	4		6							3			6					4	4
P. sulcata	4			3	3					8	10	18				3	4	7	7	11	10					4	11
P. aurulenta		3	3		3	3	4	3		3	3	9							3								
P. dissecta	4			13	3		7	3		10	10		6	15		3	7			4				7			
P. galbina												5								4	3						
Parmotrema crinitum			3		3	3							6			3			10	4	3	18	13	10			
P. reticulatum	12	9	3	9	13	10	11	12		10	10	5	12	10	7	7	4		3	4	3		4	3		4	
P. stuppeum			3			7				3	6							7			3	5	3	5	11	7	
Pseudoparmelia caperata	4	12	13	9	10	13	7	9	13	8	13	18	18	15	15	14	15	13	14	15	13	5	13	14	10	11	15
Physcia ciliata		3	3					3	4	3	6	5					4	3									
P. millegrana			3			3												3									
P. orbicularis	8		3										6	5	4	7	4		3	4	3						
P. stellaris											3	5			4			7	3	4	6						
Pyxine sorediata	12	9	3	6	13	3	7	6		3	3				4	3			3	7	3		8	7	10	7	4
Ramalina fastigiata	4	9	10	6	6	10		6	4			5			4		4	10	3		3						
Sticta weigelii																									5		
Usnea ceratina																						5					
U. mutabilis		3	3	3			4		4	3	3			5							3						
U. rubiginea		3		6			7		4	3	3	5			4									3			
U. strigosa				3	3	3	7		3	4								3									
U. subfloridana					3			3	4	8	3					4	3	3			6						
Usnea sp.	4	3			3	7	4	6	8		3	5	6						3		3			3			7

APPENDIX L

LICHEN SPECIES RELATIVE FREQUENCY ON *Q. VELUTINA*

BY ELEVATION SITE AND VERTICAL LEVEL

	Elevation Sites								
	5			6			7		
Vertical Level	B[a]	M	T	B	M	T	B	M	T
Lichen Species									
Cetraria oakesiana	10	7	3	14			15	8	4
Cetrelia olivetorum						9		4	
Cladonia sp.	19	14	3	14	12		20	15	7
Heterodermia hypoleuca								4	
H. obscurata	10	7	9		3		10	4	4
H. squamulosa	10	4	3				5		
Hypotrachyna livida									4
Parmelia flaventior			3			5			
P. rudecta	10	11	12	14	12	5	10	15	7
P. squarrosa	5	11	9	7	12	9	10	8	11
P. subrudecta					3	5			4
P. sulcata			3	10	9	18			4
Parmelina dissecta	14	7	3	7	3				
P. galbina			3			9			
Parmotrema crinitum				7			10	4	4
P. reticulatum	5	14	3	3	6			4	4
P. stuppeum					9	5		4	4
Pseudoparmelia caperata		7	12	10	12	18	5	15	14
Physcia millegrana			3						
P. orbicularis	14	11	9	3	3	5	15	8	4
P. stellaris			9		6	9		4	11
Pyxine sorediata		4	6	10	9			4	4
Ramalina fastigiata			6						7
Usnea rubiginea		4	3			5			
U. subfloridana	5								4
Usnea sp.					3				4

[a]B = Basal quadrat at 0.5m; M = Middle quadrat at 1.37m; T = Top quadrat at 3.0m.

APPENDIX M

LICHEN SPECIES MODIFIED IMPORTANCE VALUE ON Q. RUBRA BY ELEVATION SITE AND VERTICAL LEVEL

Elevation Sites

	1			2			3			4			5[b]			7			8			9			10		
Vertical Level	B[a]	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T
Lichen Species																											
Anaptychia palmatula														5											5		
Anzia colpodes	6	11							6						4			3				5			6		
Cetraria ciliaris						4			16						9												5
C. oakesiana	4			6	6	4	12	6		13			12	10		18	10	3	9	8	3	10	9	11	6	12	12
Cetrelia olivetorum		4	11			5																	21	6		10	
Cladonia sp.	11			17	3		36	7		13			41	11		21	8	3	8	8	3	24	19	20	18	13	13
Heterodermia hypoleuca															8		4										
H. obscurata		6		3												3	4										
H. squamulosa	4		4		3			3		6						7	4				3	15			24	4	
Hypogymnia physodes															8			5	3	5	7			7		4	4
Hypotrachyna livida		9	17		6	40		5	21						5		5	6									
H. revoluta								4		4					8												
Lobaria pulmonaria																									14		
L. quercizans																									16		
Nephroma helveticum																						6					
Parmelia flaventior							5		4			5															
P. rudecta	41	21	17	17	14	4	10	18	11	13	7	26	13	24	38	27	9	19	14	28	17	16	26	4	26	38	37

[a]B = Basal quadrat at 0.5m; M = Middle quadrat at 1.37m; T = Top quadrat at 3.0m.

[b]There is no Q. rubra at elevation site 6.

APPENDIX M (continued)

Elevation Sites

	1			2			3			4			5 [b]			7			8			9			10		
Vertical Level	B[a]	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T	B	M	T
Lichen Species																											
Parmelia squarrosa	26	18	16	8	16	11	14	18	17	8	13			16	19	15	20	19	34	22	10	10	23	22	13	15	12
P. subrudecta				3				6	4		9							5			8					7	9
P. sulcata	6			9	3					11	12	20				4	4	8	7	14	4					6	15
Parmelina aurulenta		4	4		4	4	5	6		4	4	11							3								
P. dissecta	5			29	4		8	6		21	12		10	28	19	4	7			4				10			
P. galbina												5								4	4						
Parmotrema crinitum			4		3	3							8			19			13	5	3	30	22	21			
P. reticulatum	16	27	4	34	24	15	17	25		27	18	8	24	20	16	10	5		6	5	6		6	4		10	
P. stuppeum			10			9				4	8							9			5	6		7	7	24	9
Pseudoparmelia caperata	7	29	37	15	40	29	9	19	21	28	52	77	19	19	38	33	57	39	36	59	49	6	16	28	15	20	45
Physcia ciliata		3	3					4	5	3	7	5					5	4									
P. millegrana			4			3												3									
P. orbicularis	10		3										8	11	8	8	4		4	6	3						
P. stellaris											3	5			4			7	3	6	4						
Pyxine sorediata	20	16	6	7	15	3	8	7		3	3				5	4			3	8	4		12	8	11	8	4
Ramalina fastigiata	4	9	11	6	6	10		6	4			5			4		4	10	3		3						
Sticta weigelii																									15		
Usnea ceratina																						10					
U. mutabilis		4	3	3			4		4	3	3			5							3						
U. rubiginea		3		7			8		4	3	3	5			4									3			
U. strigosa			5	3	4	8		3	5									3									
U. subfloridana					3			3	4	8	3						4	3	4		6						
Usnea sp.	4	3			3	7	4	7	9		3	5	6						3		3			3			7

APPENDIX N

LICHEN SPECIES MODIFIED IMPORTANCE VALUE ON *Q. VELUTINA* BY ELEVATION SITE AND VERTICAL LEVEL

	Elevation Sites								
	5			6			7		
Vertical Level	B[a]	M	T	B	M	T	B	M	T
Lichen Species									
Cetraria oakesiana	11	7	3	16			18	9	4
Cetrelia olivetorum						12		7	
Cladonia sp.	37	22	4	21	13		46	21	7
Heterodermia hypoleuca								4	
H. obscurata	13	8	11		3		12	4	4
H. squamulosa	11	4	3				6		
Hypotrachyna livida									4
Parmelia flaventior			4			6			
P. rudecta	27	33	28	25	32	7	31	63	28
P. squarrosa	6	31	13	10	30	20	16	12	24
P. subrudecta					3	6			6
P. sulcata			6	12	11	20			4
Parmelina dissecta	19	8	4	17	3				
P. galbina			4			10			
Parmotrema crinitum				11			18	6	7
P. reticulatum	6	20	5	4	8			5	5
P. stuppeum					14	6		4	5
Pseudoparmelia caperata		12	37	14	28	73	8	28	18
Physcia millegrana			3						
P. orbicularis	17	12	10	3	3	5	17	8	4
P. stellaris			10		6	10		4	12
Pyxine sorediata		4	8	11	10			6	4
Ramalina fastigiata			6						7
Usnea rubiginea		4	3			5			
U. subfloridana	5								4
Usnea sp.					3				4

[a]B = Basal quadrat at 0.5m; M = Middle quadrat at 1.37m; T = Top quadrat at 3.0m.

APPENDIX O

PROMINENCE INDEX[a] OF LICHEN SPECIES WITH A Q. RUBRA FREQUENCY ≧ 20% BY ELEVATION SITE AND VERTICAL LEVEL

	Lichen Species	Elevation Sites												Vertical Level		
		1	2	3	4	5	5b[b]	6b	7b	7	8	9	10	B[c]	M	T
1.	Anzia colpodes	104	0	27	0	25				25	0	25	26	78	77	77
2.	Cetraria ciliaris	0	26	78	0	52				0	0	0	26	0	0	182
3.	C. oakesiana	25	104	126	103	100	126	102	154	181	128	178	178	515	380	228
4.	Cetrelia olivetorum	59	27	0	0	0	0	53	28	0	0	111	53	0	162	88
5.	Cladonia sp.	53	129	172	103	168	252	208	282	182	127	272	233	820	386	233
6.	Heterodermia squamulosa	51	25	25	51	0	101	0	26	75	25	76	69	246	100	51
7.	Hypotrachyna livida	135	155	90	0	26	0	0	25	54	0	0	0	0	134	326
8.	Parmelia rudecta	316	209	190	262	258	280	258	290	271	243	191	312	771	772	709
9.	P. squarrosa	298	187	263	131	160	200	232	198	247	260	265	187	554	803	641
10.	P. subrudecta	0	25	53	53	0	0	51	27	27	52	0	58	25	109	134
11.	P. sulcata	27	56	0	257	0	28	256	25	102	207	0	106	212	232	311
12.	Parmelina aurulenta	52	52	54	104	0				0	25	0	0	77	106	104
13.	P. dissecta	26	142	79	188	117	157	85	0	76	25	53	0	359	294	53
14.	Parmotrema crinitum	26	50	0	0	27	0	54	113	41	129	282	0	258	135	162
15.	P. reticulatum	198	291	194	228	181	159	78	52	79	82	53	31	520	570	247
16.	P. stuppeum	32	52	0	78	0	0	106	51	52	27	55	167	79	140	244
17.	Pseudoparmelia caperata	269	302	220	393	278	180	350	245	387	402	218	269	654	973	1111
18.	Physica stellaris	0	0	0	50	25	76	101	101	50	100	0	0	25	50	150
19.	Pyxine sorediata	193	178	102	50	26	77	152	152	25	102	105	127	311	416	181
20.	Ramalina fastigiata	176	175	75	25	25				100	50	0	0	100	200	326
21.	Usnea mutabilis	51	25	50	50	25	50	25	0	0	25	0	0	75	76	75
22.	U. rubiginea	25	51	76	75	25	50	25	0	0	0	25	0	127	75	75
23.	U. subfloridana	0	25	50	75	25	25	0	25	50	76	0	0	76	100	125
24.	Usnea sp.	50	75	127	50	25	0	25	25	0	50	25	50	100	126	226

[a]See text p. 18.

[b]"b" indicates the transects in which Q. velutina was the host substrate. In all other transects Q. rubra was the host substrate.

[c]B = Basal quadrat at 0.5m; M = Middle quadrat at 1.37m; T = Top quadrat at 3.0m.

VITA

Marguerite Proffitt Morris was born in Newport News, Virginia, on June 3, 1952. She is the daughter of Garland Jackson and Marguerite Hess Morris. She attended Armstrong Elementary School in Hampton, Virginia for 2 years, and completed her elementary education at Hidenwood Elementary School, Newport News. She graduated 4th in her class from Homer L. Ferguson High School, Newport News, in June, 1970. She was active in girl scouting for 10 years, was recognized for outstanding achievement in science, and won a Letter of Commendation from the National Merit Scholarship Corporation.

She matriculated at Randolph-Macon Woman's College, Lynchburg, Virginia. Summer employment included teaching nature lore and recreation skills as a day camp counselor for the City of Newport News. She also completed a summer course at the Virginia Institute of Marine Science, Gloucester Point. She graduated from R.M.W.C. cum laude with an A.B. degree in biology in 1974.

She entered the Master's degree program in Botany at Virginia Polytechnic Institute and State University, Blacksburg, in the fall of 1974. Her program included field courses during the summers of 1974 and 1975 at the nearby Mountain Lake Biological Station of the University of Virginia. She supported her graduate work through a teaching assistantship, with teaching responsibilities for lab courses in general biology and plant kingdom. She is a member of the Phi Sigma Society, an association for the promotion of research in the biological sciences. She is engaged to marry Charles I. Dubay of Newport News, Virginia.

Marguerite Proffitt Morris

THE ECOLOGY OF CORTICOLOUS LICHEN COMMUNITIES
AT VARIOUS ALTITUDES ON SALT POND MOUNTAIN,
GILES COUNTY, VIRGINIA

by

Marguerite Proffitt Morris

(ABSTRACT)

A study was conducted of the corticolous lichen community of Q. rubra on the southeast face of Salt Pond Mountain, Giles County, Virginia. These communities were examined according to altitude, vertical level on the tree, total lichen cover, lichen growth form composition, and the presence and abundance of foliose and fruticose species. Moss percentage cover was also estimated in situ as an indicator of available moisture trends.

The results of this study indicate that, with the exception of fruticose lichens, the character and species composition of this lichen community does not vary directly in accordance with altitude. Most of the 38 fruticose and foliose lichen species examined exhibited their greatest frequency and abundance at a preferred vertical height above the ground. These lichen communities appear to lack the characteristics of those disturbed by atmospheric sulfur dioxide.