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MAPPING ELEMENTAL CONCENTRATIONS IN GREAT SMOKY MOUNTAINS NATIONAL PARK WITH LICHENS

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Mapping Elemental Concentrations in Great Smoky Mountains National Park with Lichens

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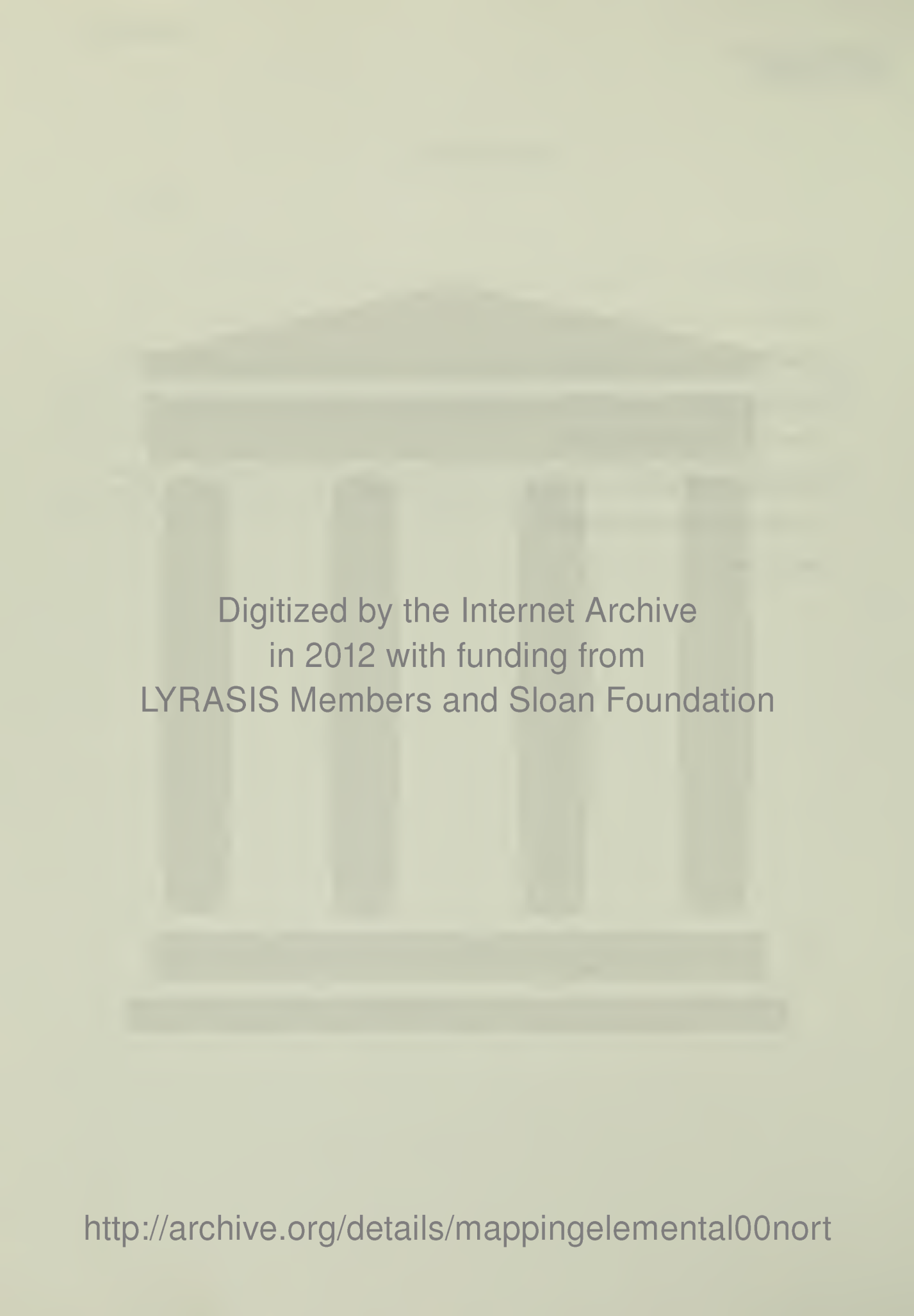

INTRODUCTION

In recent years, there has been increasing scientific concern over the effects of air pollution on the high elevational forests of the southern Appalachians. These peaks, many reaching well above 5000 ft elevation, act as a "screening zone" (Knabe, 1982) for pollutants, as the mountain ranges intercept the continental air masses sweeping eastward from the urban and industrial regions of the Tennessee and Ohio Valleys. In particular, the Great Smoky Mountains National Park is susceptible to this "screening zone" effect because it contains 16 peaks with elevations exceeding 6000 ft. Located on the east-west boundary of Tennessee and North Carolina, this National Park is the quintessential natural laboratory for monitoring the air quality of high elevational forests because it contains a unique ecological arrangement of northern hardwoods and Fraser-fir communities. Since the 1960s two species – red spruce and Fraser fir – have shown a marked decline due to various biological and environmental stresses. The annual radial increments of red spruce have been suppressed since the early 1960s, and the Fraser fir is in danger of complete destruction from balsam wooly aphid infestation (White, 1984).

Since the late 1970s, air quality has been monitored throughout the Great Smoky Mountains National Park. Three pollution monitoring stations are currently operating at various elevations in the region. One station is located on Clingman's Dome (elevation 6,642 ft), the highest peak in the Smoky Mountains. A midelevational monitoring site is on Cove Mountain (elevation 4,080 ft), and a low elevation site is at Look Rock on Chilhowee Mountain (elevation 2,400 ft), along the scenic Foothills Parkway. Another low elevation monitoring station at Tremont (elevation 1,350 ft) is no longer operational.

Although these monitoring stations represent three different elevation zones, their effectiveness for establishing a viable air quality index for the Great Smoky Mountains National Park is limited. Within any elevational zone, an endless number of combinations of topographic and spatial arrangements are possible, each with different prevailing wind patterns and, therefore, different pollutant loads. Such spatial variances, especially in mountain ranges, can greatly effect depositional levels of air pollutants in spatial scales on the order of tens of kilometers (Lovette, 1984). Given the size and landscape of the Great Smoky Mountains National Park, these three operating monitoring stations clearly need the support of a more extensive monitoring network to provide a greater resolution of pollutant levels.

The goal of this project is to establish a more extensive pollution monitoring network. Instead of three monitoring sites, this project establishes 200 individual sites throughout the Great Smoky

Mountains National Park. Rather than using typical physical-chemical instrumentation, these sites monitor pollutant levels through biomonitors. In this case, the biomonitor is a pollution-sensitive lichen, Hypogymnia physodes. These 200 biomonitoring sites, in effect, map the elemental concentration of pollutants throughout the national park, determine an air quality baseline for the area, and test the effects of the high elevational "screening zone."

Biomonitors provide quantitative information on both pollutant levels and pollutant impact in a given study area (Knabe, 1982). Two classes of biomonitors are available, but each class provides a different type of information and is appropriate under different conditions. Bioindicators show visible physiological symptoms related to specific pollutants or pollutant level. Bioaccumulators collect pollutants from their surrounding environment and can be analyzed to identify the specific pollutant(s) and indicate levels of pollutant accumulation. Bioaccumulators have the advantage of detecting pollutants before damage is visible or measurable.

Previous mapping studies using bioaccumulators have demonstrated enhanced levels of pollutants (Erdman and Gough, 1977; Gough and Erdman, 1977; Addison and Puckett, 1980). Zones of similar pollutant impact are identified by evenly distributing sampling sites over a uniform study area. These zone maps can be used to determine the extent of pollutant influence, or to implicate the pollution source. In mountainous terrain, such as the Great Smoky Mountains National Park, topography and spatial position greatly affect pollution deposition. Knabe (1982) cautions that systematic grids are less valuable in areas where topography and position influence pollutant deposition.

Since Grindon (1859) in England and Nylander (1866) in Paris first noted depletion of lichen flora around a pollution source, lichens have been used to study the effects of air pollution in urban-industrial areas. A number of reviews (Hawksworth, 1971; Ferry et al, 1973; LeBlanc and Rao, 1973, 1975; Nieboer and Richardson, 1981; Nash, 1976; and Anmadjian, 1982) provide excellent summaries of these studies.

Four categories of studies are included. The earliest and most common method is mapping zones of pollution effects using indices of lichen flora, vegetation, or visible damage. These studies are most effective when lichen zones are correlated with ambient levels of pollutants. The second technique, transplantation of lichens of estimated sensitivity into areas of elevated pollution, allows the level of ambient pollution to be evaluated as the cause of lichen death or damage. This technique is particularly valuable when the lichen species is absent from the study area. Where field studies have correlated visible damage of death with levels of pollutants, laboratory studies are needed to elucidate biological mechanisms. Submergence in aqueous solutions or fumigation with aerosols of known concentrations to simulate field concentrations links a particular pollutant with

visible or physiological damage and predicts mechanisms of damage. However, these studies are limited by their inability to recreate field conditions and examine the synergistic effects of pollutants and environmental conditions. Any pollution effect presumes uptake and accumulation of pollutant, which is measured in the fourth type of study. Elevated levels of elements can be correlated with distance from a pollutant source or ambient levels. Visible damage and subsequent death can be used to establish threshold levels of pollutants.

From these types of studies it is possible not only to evaluate the effect of pollutants on the lichen flora, but also to predict the threat to the entire community. Lichens, because of their thallus structure, may be sensitive to pollutants even at low levels. Damage and disappearance of lichen species may signal sublethal, but physiologically damaging, levels of pollution for other plant species.

Lichen species respond differentially to air pollutants. A number of systems have been used to categorize levels of pollution tolerance. These include order of species appearance relative to a pollution source, presence/absence of indicator species, and the Index of Atmospheric Purity (IAP) values (Hawksworth and DeSloover, 1970). Because of the wide range of responses, a lichen-indicator species determines the effectiveness of the study. A species that is too sensitive for a given area will be removed by small increases in pollution before mechanisms of effects can be elucidated. If insensitive, a species will have no easily measurable responses and may actually increase in distribution and abundance due to lowered competition and acidification of substrates.

In selecting a lichen species as a bioaccumulator, four criteria are valuable:

1. The species should occur across the entire study area and should not be approaching its distributional limit.
2. The species should have intermediate sensitivity to the potential pollutants.
3. The species should have observable responses at sublethal levels, and, if possible, responses that can be correlated with dose levels.
4. The species should accumulate pollutants in proportion to the ambient level and have stable background levels of these elements.

The selection of H. physodes for this project was based on the above criteria. This epiphytic species is distributed throughout the Southern Appalachians (see Figure 1). However, it approaches the southernmost limit of its distribution and is variable at lower elevations in the Southern Appalachians.

Hypogymnia physodes

Figure 1: Distribution of Hypogymnia physodes in North America

SCALE
0 200 400 600 800 1000 MILES
0 200 400 600 800 1000 1200 1400 KILOMETERS

LAMBERT AZIMUTHAL EQUAL-AREA PROJECTION

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First used as an indicator species by Vaarnea (1934) in Helsinki, H. physodes is one of the most pollutant-tolerant foliose species throughout its range. In Europe it has proven tolerant in urban, multiple-source areas (Jaugsja, 1930; Felfoldy, 1942; Barkman, 1952 and 1958; Natho, 1964; Skye, 1968; Gilbert, 1970a, 1970b; Johnsen and Sochting, 1973; Sochting and Johnsen, 1974; Arvidsson and Skoog, 1984), as well as industrial, single source, and rural areas (Skye and Hallberg, 1969; Laaksovirta and Sibrola, 1975; Macher and Steubing, 1984; Laaksovirta and Olkkonen, 1977 and 1979; Kauppi and Mikkonen, 1980). Pollution tolerance is demonstrated in a number of areas in North America (Rao and LeBlanc, 1967; Hocking et al, 1978; Case, 1984; Roberts and Thompson, 1980; Goward and Schofield, 1983). However, studies demonstrating sensitivity to pollutants (Newberry, 1974; LeBlanc and DeSloover, 1970; Nash, 1972; Vick and Revan, 1976) may reflect rarity or enhanced sensitivity of the species in areas near its southernmost limit of distribution.

Mapping studies have documented lethal pollutant levels for this species as well as morphological symptoms of sublethal damage. Critical levels of sulfur dioxide have been estimated in a number of areas (Tallis, 1964; Laundon, 1967; Rao and LeBlanc, 1967; LeBlanc, 1969; Hawksworth and Rose, 1970; Johnsen and Sochting, 1973; Morgan-Huws and Haynes, 1973; Sochting and Johnsen, 1974; Rose and James, 1974; LeBlanc et al, 1974; O'Hare, 1974; DeWitt, 1976; Deurelle, 1977; Arvidsson and Skoog, 1984). Critical values range from 65 to 150 $\mu g/m^3$ sulfur dioxide and may be affected by the humidity of the region (Arvidsson and Skoog, 1984).

At sublethal levels, cover, frequency, physiology, and visible symptoms have been used to quantify pollution effects and map pollutant levels. Many studies have shown a decrease in the frequency of H. physodes in areas of elevated pollution (Rao and LeBlanc, 1967; LeBlanc, 1969; Hawksworth and Rose, 1970; Rose and James, 1974; DeWitt, 1976) and a decrease in percent cover (Kauppi and Mikkonen, 1980; Bell and Taylor, 1984; Case, 1984). However, in areas of light pollution (40 $\mu g/m^3$ sulfur dioxide, Rose and James, 1974), H. physodes may increase in cover and represent the dominant lichen species (Hocking et al, 1978; Goward and Schofield, 1983). This may reflect changes in ecological habitat due to bark acidification (James and Rose, 1974; DeWitt, 1976; Arvidsson and Lindstrom, 1980; Skye, 1968; Haynes and Morgan-Huws, 1970; Gilbert, 1970; Johnsen and Sochting, 1973), lowered competition, or stimulation by low levels of pollutants (Rosentreter and Ahmadjian, 1977). In ameliorating environments, H. physodes increases in both frequency and cover (Skye and Hallberg, 1969; Sochting and Johnsen, 1974) but may be restricted to protected crevices (DeWitt, 1976; Kauppi and Mikkonen, 1980) and buffered tree bases (Hawksworth and Rose, 1970; Rao and LeBlanc, 1967).

Morphological and physiological changes may indicate the presence of specific levels of pollutants. In H. physodes, damage scales have shown a correlation with the ambient level of pollution (Takala et al, 1978). Visible damage includes thallus bleaching (Skye and Hallberg, 1969) or

discoloration (Roberts and Thompson, 1980), stunting of lobes (Holopainen, 1984b; Kauppi and Mikkonen, 1980), and cracking of the cortex due to the deposition of a waxy material (LeBlanc and Rao, 1973). Changes in the thallus color may represent death of the algae and transformation of the chlorophyll to phaeophytin (Rao and LeBlanc, 1967). Brown and Hooken (1977) hypothesized that the presence of physodalic and physodic acids, both found in H. physodes, may enhance production of phaeophytin.

In ultrastructural examinations of the algal layer of H. physodes, sulfur dioxide damage includes a reduction in the ratio of living to dead algal cells (Kauppi and Mikkonen, 1980) and the number of dividing cells (LeBlanc and Rao, 1973). However, in areas of enhanced nitrogen compounds, especially in the vicinity of fertilizer plants and pulp mills, the number of living algal cells may increase (Holopainen, 1983 and 1984a; Kauppi, 1980).

Many studies have used lichens to map the extent and degree of pollution influence. Isolines connecting sites of similar response define zones that correlate with pollutant level. In early studies around urban centers these zones marked the reappearance of lichen species (Sernanda, 1926). Hawksworth and DeSloover (1970) developed the Index of Atmospheric Purity (IAP), which combines cover and tolerance for each species at a site to produce a site rating that correlates with pollutant levels. A number of studies, many including H. physodes (LeBlanc and DeSloover, 1970; LeBlanc et al, 1972a, 1972b, and 1974; Johnson, 1979; Kauppi and Mikkonen, 1980; Case, 1984), have used IAP values to define pollution zones. Typically, these zones form concentric circles around the pollution source; however, in urban, multiple-source areas, the zones may appear more complex. The prevailing winds skew the circle and elongate it in the direction of the winds, in a pattern similar to a wind rose. In North America, most pollution maps show a elongation on the west to east axis, unless topography modifies these wind patterns. Anomalous areas within zones may represent sites protected by topographic position, as in a ravine (Gilbert, 1970) or beneath a dense forest canopy (Hawksworth and DeSloover, 1970).

In the past 20 years, H. physodes has been used in over 40 studies as a bioaccumulator (see Table 1). Lounamaa (1956 and 1965) and Solberg (1967) first established regional background levels of various elements in Europe. Subsequent European studies have correlated elemental enhancement with distance from pollution point sources (Pyatt, 1973; O'Hare, 1974; Olkkonen and Takala, 1975; Pararinen et al, 1978, Lodenuis and Laaksovirta, 1979), reduction in presence and cover (Laaksovirta and Sibrola, 1975; Takala et al, 1978; Laaksovirta and Olkkonen, 1977 and 1979), and visible damage (Kauppi and Mikkonen,1980; Seaward, 1974; Takala and Olkkonen, 1981).

ELEMENTAL CONTENTS IN HYPOGYMNIA PHYSODES (L.) NYL.

EXPRESSED AS PARTS PER MILLION DRY WEIGHT OR IN PARENTHESIS PARTS PER MILLION ASH WEIGHT

REFERENCES	S	K	Ca	V	Fe	Zn	Ti	F	Pb	Hg
LOUNAMAA, 1956						(3000)				
LOUNAMAA, 1965					(25000-59900)	(2100-4400)				
SOLBERG, 1967	1400	4200	2900							
NAARAJOKI, 1971										4.6
PYATT, 1973	933									
O'NARE, 1974	537-1293									
SCHONBECK, 1974						157-274				
SEAWARD, 1974					1080-3150	21-101			15-56	
NORNTVEDT, 1975	650-1200	1600	3000-33000							13-32
KROG & BRANDT, 1975	700-5100									
O'NARE & WILLIAMS, 1975	548-1059									
OLKKONEN & TAKALA, 1975	550-1500									
LAAKSOVIRTA *et al*, 1976									19-270	
OLKKONEN & TAKALA, 1976	471-1644									
LAAKAJOKI, 1977										4.2-7.6
LAAKSOVIRTA & OLKKONEN, 1977	632-1664	1620-4087	909-2781	18-291	1075-21410	177-5621	3600			
MAKINEN & PAKARINEN, 1977									35-124	
STEINNES & KROG, 1977	3000									6
TULIKKAJARVI, 1977										7.2-4.9
SWIEBODA & KALEMBA, 1978	1400							150		
TAKALA *et al*, 1978								3-940		
FOLKESON, 1979									14-33	
LAAKSOVIRTA & OLKKONEN, 1979	532-1672	1600-4157	1187-3287	24-678	623-7389	160-326	446-6820			
LODENIUS & LAAKSOVIRTA, 1979										0.13-0.87
ADDISON & PUCKETT, 1980	1000-2500			100-250						
ROBERTS & THOMPSON, 1980										
TAKALA & OLKKONEN, 1981									14-306	

In North America, Erdman and Gough (1977) established the regional baseline of 23 elements for a species of Parmelia chlorochroa. In a subsequent study, Gough and Erdman (1977) correlated enhanced elemental concentrations with distance from a designated source. H. physodes was used in a limited number of elemental enhancement studies in North America. LeBlanc et al (1971) correlated fluoride level and visible damage in transplanted material with distance from a point source. Roberts and Thompson (1980) reported enhanced fluoride levels in natural material in the vicinity of a phosphorus plant. Visible damage, including discoloration and thallus shrinkage, was related to the level of fluoride accumulation.

Addison and Puckett (1980) found that the topography around point sources in the Athabasca oil sand area modified the distribution of aluminum, potassium, sulfur, titanium, and vanadium in H. physodes. Titanium and vanadium are considered signature elements of petroleum combustion pollution, and enhanced levels strongly indicate anthropogenic sources. Levels of these and other elements agreed well with physical and chemical measures of pollutant level.

Krouse (1977) and Case and Krouse (1980) used sulfur content and isotope ratios in a variety of vegetation types, including lichens, to map sulphur emissions from sour gas processing plants in Alberta, Canada. While the sulphur content of lichens was suggested as an "early warning system to locate hot-spots," correlations between sulfur content, isotope ratio, and ambient levels were weak due to selective excretion of the light isotope of sulfur when concentrations exceeded 1400 ppm. Based on these studies, Case (1984) correlated distance from these pollution sources with reduction in cover, vitality, and distribution of 10 lichen species, including H. physodes.

In the present study, H. physodes is used as a bioaccumulator to monitor pollution input in the Great Smoky Mountains National Park. The concentrations of 23 elements will be mapped over a sampling grid of 200 cells. This design allows for the determination of a baseline elemental concentration for the region. Also, areas of enhanced pollution input can be identified and related to topographic position. When correlated with the existing physical and chemical monitors, this will extend the monitoring network throughout the park.

METHODS

Sampling Grid

The study area was divided into 200 sampling cells, each 3 x 3 km, based on the 1:125,000 scale map of the Great Smoky Mountains National Park and Vicinity (USGS, 1972). The sampling grid, prepared as an acetate overlay, was centered on the 83° longitudinal and 35°37'30" hatch mark (see Figure 2). The cells were numbered from 1 to 200, beginning with the northernmost line and moving from west to east, and north to south. Because the boundary is irregular, only those cells which were at least 90% filled (by visual inspection) received a number. Forty sites were selected for duplicate collections to serve as an internal control. These sites were identified from a random-numbers table.

Site Selection

Because standardization of aspect, slope, ridge position, and sheltering (all influencing pollution interception) is not feasible in such a topographically varied study area, sampling sites were located on ridgelines. This included knobs, ridge points, saddles, gaps, and ridge noses (see Figure 3). Whenever possible, sites were located at least 2 km away from any other collection site and 0.2 km from any access roads.

Potential sites for collection were identified from the grid-overlay map, appropiate quandrangle maps (USGS), trail guides, and historical maps. However, grid boundaries were determined solely from the grid overlay maps due to variation in map resolution and map distortion. When ridgeline sites were not available (such as in site 114) or accessible (sites 27 and 174), trailside areas were surveyed for material.

Substrate Selection

Betula lutea was the preferred substrate species for collecting the epiphytic lichen. However, due to the diversity of sites and the distribution of this phorophyte, B. lutea was not available in every site. An alternate phorophyte, Acer rubrum was sampled when B. lutea was not available. In the absence of both of these species, collections were made from other hardwood species.

Initially, collections were to be made on branches extending from the tree trunk at a height between 3 and 6 ft from the ground. Because these low hanging branches were rarely available, samples were also taken from tree trunks, up to a height of 6 ft on the bole. These samples were collected and labeled separately.

Figure 2: Sampling Grid for Great Smoky Mountains National Park: each cell is three by three kilometers.

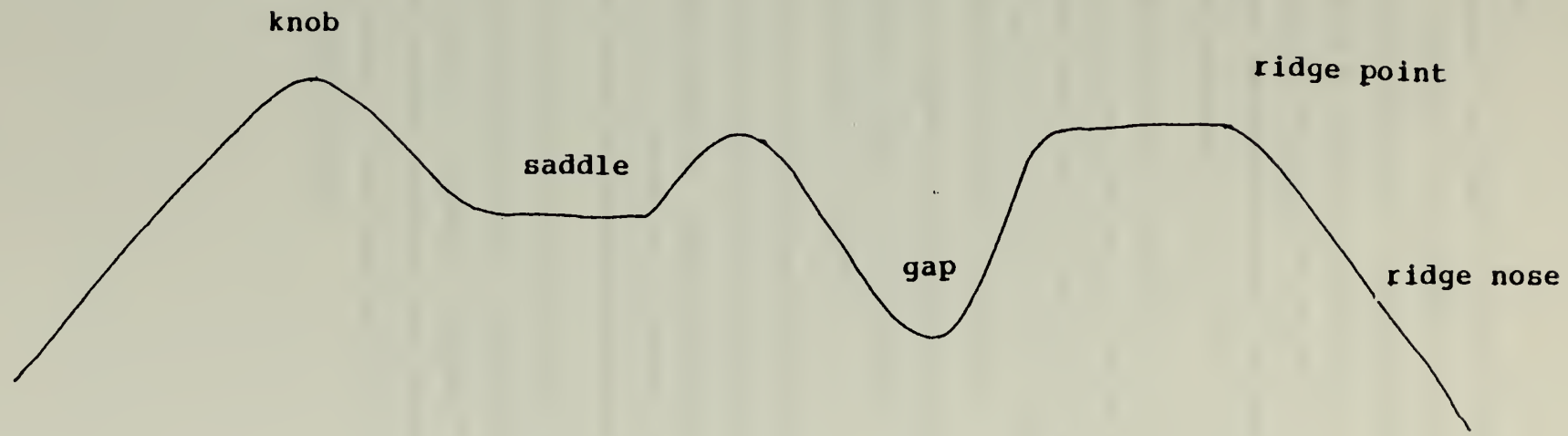

Figure 3: Topographic Positions on Ridgeline

Sample Collection

After locating the appropiate phorophyte species bearing H. physodes, the sites were marked and ecological notes taken. The substrate tree was tagged with a circular aluminum tree tag, bearing the sampling cell number. The tag was placed on the side of the bole facing away from trails or developed areas, at a height of approximately 5 ft. For most sites, documentation included photographic slides of the tagged tree and the site. Site notes included site location, elevation, aspect, and slope; vegetational community and dominant species; and any recent disturbances. Each site location was mapped on the appropriate quadrangle map.

Sample material was collected noting the number of individuals included in the sample. All lichen material was stored in sand core bags (Hubco Sentry). Each sample bag was assigned a seven-digit alphanumeric code. The first three digits indicated the sampling cell; the fourth denoted the lichen species; the fifth and sixth, the number of individuals in the sample (between 0 and 99); and the seventh, the phorophyte within the sample site. In sites where more than one collection was taken, letters were assigned for each phorophyte individual. "A" denoted the primary substrate tree that was permanently tagged. "B" and subsequent letters denoted additional samples taken. For each, the phorophyte species was recorded.

For the duplicate collection sites, a second tree was tagged, and a collection made. When possible, the tree was at least 50 ft from the original host tree. The above procedure was followed with the duplicate collections. Repeat collections were made in 15 sites in the spring of 1985, approximately one year after the initial sampling. When possible, these samples were taken from the original site. The original sampling procedure was followed.

Collected material was allowed to air dry in the collection bags. Each individual was examined, and contaminating epiphytic species were separated. Special care was taken to identify and remove individuals of H. krogii, H. tubulosa, and H. vittata. Any unusual conditions, such as apothecia, were recorded. Specimens were mechanically cleaned of bark and other detritus to provide a pure sample. Cleaned specimens were inventoried and mailed to Larry Gough, USGA, Denver, CO, for chemical analysis.

RESULTS

Between February and October 1984, samples of Hypogymnia physodes were collected in a total of 159 (80%) of the 200 sampling cells (see Figure 4 and Appendix 1). The success rate reflects problems with pre-determining collection site locations as experienced in other studies (Gough and Erdman, 1975). The 41 cells entered without collection represent inaccessible ridgelines or low elevational ridges. Three cells, 197, 198, and 199, were not entered because they represented low elevational ridges and had no access trails.

Of the 159 collections, 53 (33%) offered over 2 g of material, the minimum required for complete analysis (see Figure 5). Repeat collections were made in the first 15 sites where samples weighing under 2 g had been collected in the original visit (see Appendix 2). Additional material was collected from high elevational sites 62, 92, and 114, bringing the total number of sites with 2 g of material to 84.

The collection sites ranged from 1500 to 6500 ft elevation. Of the total 159 collections, 100 were made at elevations above 4000 ft (see Table 2), with 50 sites in the zone between 4000 and 5000 ft elevations. The zone 5000 to 6000 ft elevation had 42 collection sites, and the zone over 6000 ft elevation had 8 sites. These sites may reflect the ridgeline area of these zones. However, below 4000 ft elevation, the number of collection sites decreases; 25 sites were found between 3000 and 4000 ft, 30 between 2000 and 3000 ft elevation, and three below 2000 ft elevation.

Table 2. Number of Sample Collections within Weight Classes Grouped by Elevational Zone

Weight (g)	Elevational Zones (1000 ft elevation)						
	<2	2-3	3-4	4-5	5-6	>6	TOTAL
0-0.5	2	12	1	8	4	1	28
0.5-1.0	0	6	7	5	4	0	22
1.0-1.5	1	7	1	6	5	0	20
1.5-2.0	0	1	7	6	5	2	21
2.0-3.0	0	2	3	11	9	2	27
3.0-4.0	0	2	3	3	2	0	10
>4.0	0	0	3	11	13	3	30
TOTAL	3	30	25	50	42	8	159

COLLECTIONS OF HYPOGYMNIA PHYSODES FOR
ELEMENTAL ANALYSIS

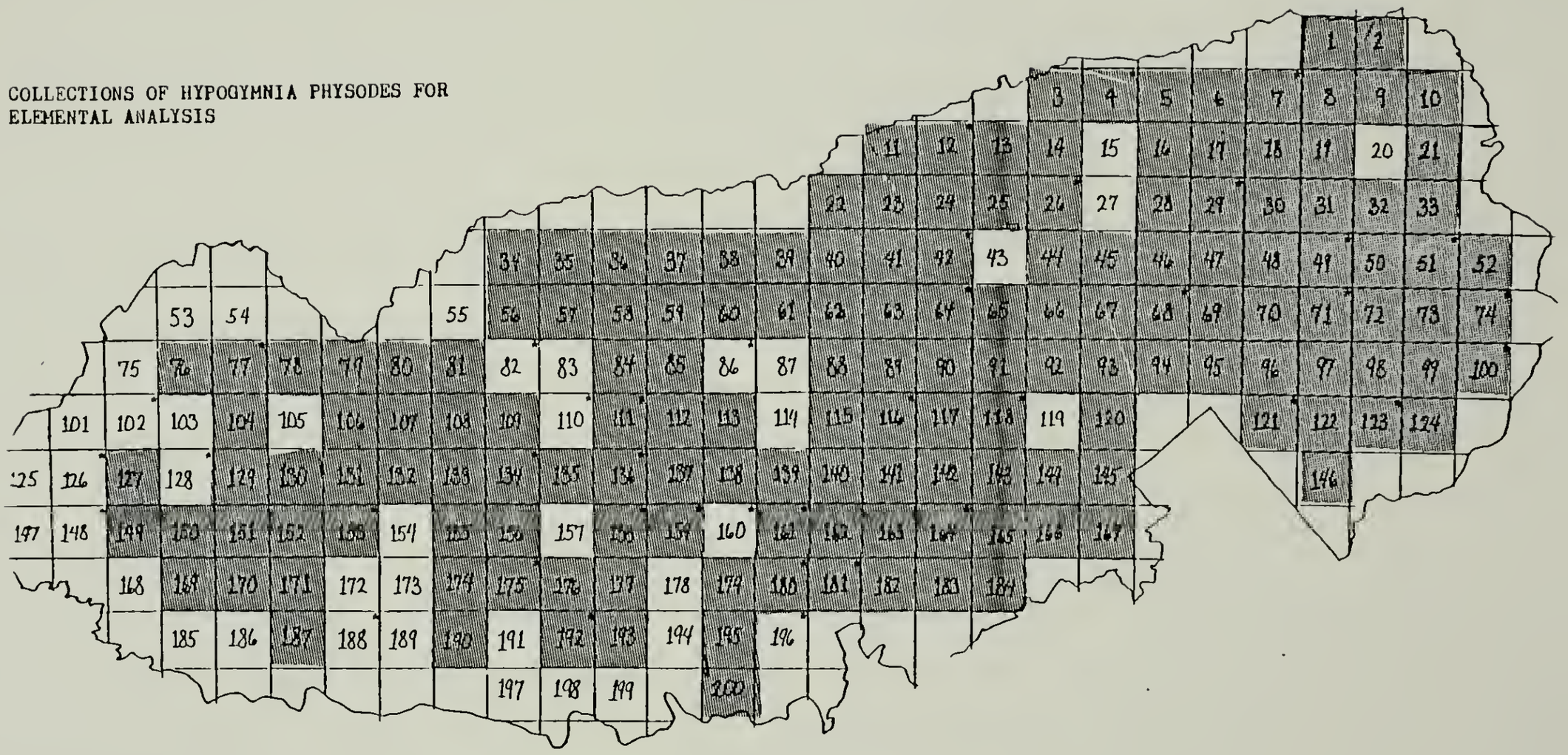

Figure 4: Collection Sites for Hypogymnia physodes: shading indicates successful sampling.

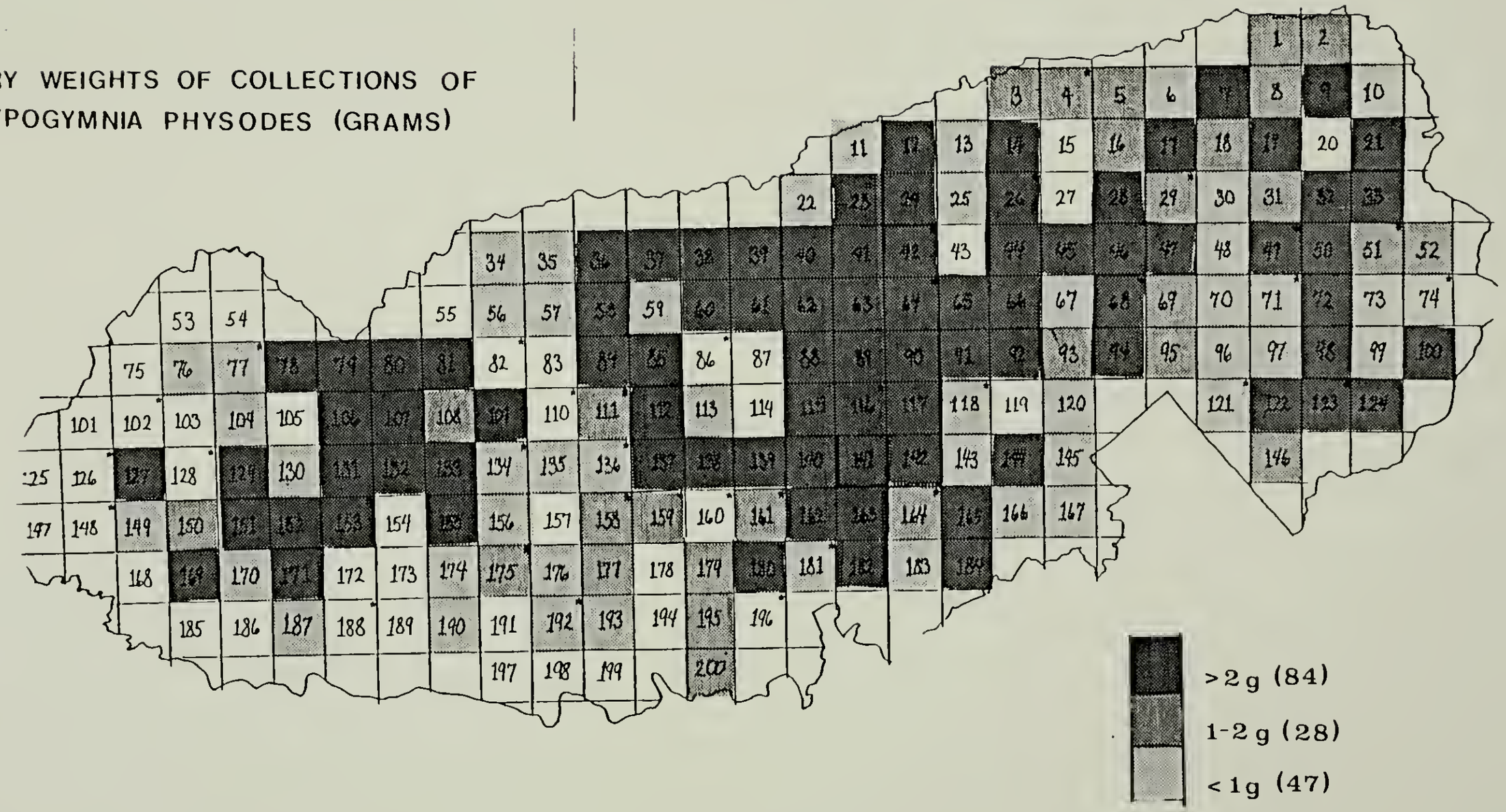

Figure 5: Collection Weight for Sampling Sites: weight grouped by class

More striking is the average sample weight for these zones (see Table 3.) Average sample weight increases up to 6000 ft elevation. The slightly lower average sample weight for the zone over 6000 ft elevation may reflect the small sample number or the sparsity of hardwood trees in this spruce-fir zone. Also, mildew on high elevation sample material reduced the number of collections over 2 g and the average sample size for this zone.

Table 3. Average Weight of Samples for Elevational Classes

	Elevational Zones (1000 ft elevation)						
(g)	<2	2-3	3-4	4-5	5-6	>6	TOTAL
x Weight	0.54	1.00	2.17	2.24	2.89	2.53	

The sample availability and size were affected by the distribution of appropriate host species (Dey, 1975, 1978). In ridgeline sites above 4000 ft elevation, Betula lutea is common. The percentage of sites where H. physodes was collected on this tree species increases with elevation as its availability increases (see Table 4). While preferential collection from B. lutea may reduce the percentage of collections on other trees at elevations above 4000 ft elevation, other phorophytes are important substrates in lower elevational zones. Acer rubrum, the alternative species, is common as a substrate below 5000 ft elevation (its elevational limit) with 56% of the collection sites (including this species as a collection substrate) in the zone between 4000 and 5000 ft elevation; 43% between 2000 and 3000 ft elevation; and 33% below 2000 ft elevation. Quercus is the most common (50%) between 2000 and 3000 ft elevation; Oxydendron (below 4000 ft elevation) has 44% between 3000 and 4000 ft elevation and 33% below 2000 ft elevation; and Prunus occurs between 4000 and 6000 ft elevation.

Table 4. Number of Sample Collections from Phorophyte Genus from Each Elevational Zone[1]

Phorophyte Genus	Elevational Zones (1000 ft elevation)						
	<2	2-3	3-4	4-5	5-6	>6	TOTAL
Betula	0(0)	1	9	23	38	8	79
Acer	1(1)	13	14	28	8		65
Quercus	1	15	8	6	0	0	30
Oxydendron	1	7	11	3	0	0	23
Prunus	0	3	2	14	12	0	32
Other	1	4	12	9	17	0	54

[1] Samples may come from more than one phorophyte in each site and therefore the sum for all phorophytes will exceed the number of sites given in Table 2.

Community type was important in determining the availability of the appropriate phorophytes. Within the elevational range of the ridges present in this study, a number of community types are present. At low elevations, common community types are pine, pine-oak, closed oak, and oak-hickory. At middle elevations, maple is an important species in mixed hardwood forests. Higher elevations are characterized by maple, spruce, and spruce-fir, with transitional communities of fire cherry. Often, collection sites were located on saddles or noses of ridgelines, where the community is in transition between xeric ridgeline communities dominated by pine or ericades and more mesic hardwood communities dominated by hardwoods such as beech and maple.

The total lichen flora, including H. physodes, increases with the influx of light in a forest opening. Areas of continual disturbance preventing forest closure, such as heath balds and exposed ridgelines, often contain dwarfed birch and maple trees with large amounts of H. physodes. In areas of perpetual canopy openings along narrow ridges, the margins of grassy balds, or blow-down, mature trees may be extensively colonized by this species. Homesites and farm sites are frequently indicated by opening and cleared pastures. These areas have been slow to close and may contain introduced trees and shrubs. Especially in the Little Carolochee Cove and Bone Valley areas, introduced apple and cherry trees are covered with lichens including H. physodes. Old railroad grades and road beds are still present as hiking trails and produce a forest opening with increased lichen cover. These forest openings have provided the most successful collection of H. physodes.

DISCUSSION AND CONCLUSIONS

This study represents the most ambitious use of a lichen species as a bioaccumulator in North America. The sampling design of 200 cells far exceeds the number of sites used in other studies of elemental concentration in lichens. Erdman and Gough (1977) sampled 32 sites, Gough and Erdman (1977) sampled 12, Addison and Puckett (1980) sampled 69, and Case (1984) sampled 99. The total of 84 samples collected in excess of 2 g provides for complete analysis of the 23 elements and exceeds all studies considering more than one element.

H. physodes was found in 159 sites, representing a success rate of 80%. This collection success is similar to other studies. Erdman and Gough (1977), with a design of 32 sites, collected material in 22 sites for 69% recovery; and Gough and Erdman (1977), with a design of 12 sites, collected material in 9 sites for 75% recovery.

However, Roberts and Thompson (1980) observed two major problems with H. physodes as a bioaccumulator: "It is difficult to get an adequate sample size and to avoid including bark or twig material in the sample." These same problems occurred in this project. The small amount of material available in many sites may be a result of the southern limit of the distribution of this species in the Great Smoky Mountains National Park (Figure 1). Especially at elevations lower than 3000 ft, this species is rare, reflected in both the low rate of successful collection in this elevational zone and the low average sample weight (see Tables 2 and 3). This problem is compounded by the low weight of individual thalli. Often 30 to 50 individual thalli were required to provide a 2-g sample, making collecting and cleaning a tedious and time-consuming process.

Material was most abundant in disturbed areas, along trailsides, and on narrow ridgelines. The total lichen vegetation, as well as H. physodes, increased in areas with open canopies. H. physodes was common on two types of substrates: young and dwarfed trees and mature stands. Young, dwarfed trees, typically, had a large population of this species on their boles and branches. Similarly, very mature trees, especially yellow birch, had large amounts of H. physodes at their bases. Barkman (1958) and Kershaw (1964) observed similar charactersistics in the distribution of this species.

The study area included a great degree of topographical variety, which affected not only the availability of the sample material, but also the use of the resulting data. Knabe (1982) states that systematic sampling grids are of little use in mountainous terrains because of the complexity of wind patterns. Lovette (1984) also suggests that depositional levels may vary over a scale of tens of kilometers in regions of topographical variety. Given the range of elevations, exposures, and sites

included in this survey, patterns may not be clearly mapped. The strongest use of the data may, therefore, be in establishing a regional baseline.

While the elemental concentrations cannot be used to determine ambient concentrations of air pollutants (Knabe, 1982), enhanced levels can be used to identify areas of special concern. Increased pollutant input in high elevational sites relative to low elevation sites will indicate that pollutant screening is occurring. Signature elements may indicate specific types or anthropogenic pollutants though their particular source cannot be identified.

The problems of sample availability and abundance can be avoided in the future by using a panel of bioaccumulators. Folkeson (1979) used nine species of mosses and lichen to measure heavy-metal concentration. By "calibrating" the species in sites of co-occurrence, any subset of these species could be collected in different sites and compared. "Concentration in a species not found in a certain site can be estimated from concentrations measured in any of the other species sampled." This would increase the sampling success and provide more material for complete measurements.

APPENDIX 1

SITE DESCRIPTIONS

SITE 1: ELEVATION 2800 ft; LOCATION Leadmine Ridge, NE of Mount Cammerer summit, in trail switchback NE of Robinson Cr. backcountry campsite; COMMUNITY TYPE closed oak stand on xeric ridgeline. COLLECTION No. 001H11A, on Quercus sp., 6" dbh.

SITE 2: ELEVATION 4900 ft; LOCATION Mount Cammerer Ridgeline, near horse hitch rack, W of summit, 0.5 miles from Appalachian Trail (AT) on trail spur to lookout tower; COMMUNITY TYPE high elevation deciduous forest dominated by Betula lutea in saddle gap. COLLECTION No. 002H01A, on Betula lutea, 4" dbh; 002H05B, on Fagus americana; 002H09C Prunus pensylvanica.

SITE 3: ELEVATION 2500 ft; LOCATION unnamed ridge N between Timothy Creek and Cat Stairs Branch extending N from Greenbrier Pinnacle along old homesite road, ca. 3 miles along Timothy Cr S of the fourth creek crossing on narrow ridge; COMMUNITY TYPE open oak forest on xeric ridgeline. COLLECTION No. 003H10A, on Quercus sp., 6" dbh; 003H05B, on Quercus sp.; 003H12C Prunus pensylvanica.

SITE 4: ELEVATION 1900 ft; LOCATION unnamed ridge parallel to TN HWY 73, across from Gatlinburg Municipal Golf Course on unnamed trail along Noisy Cr. ca. 0.3 miles from highway W of homesite in saddle where ridgeline joins N-S ridge of Greenbrier Pinnacle; COMMUNITY TYPE closed oak-pine forest on xeric ridge. COLLECTION No. 004H04A, on Quercus sp., 8" dbh; 004H07B*, on Quercus sp., 004H12C, on Quercus sp.

SITE 5: ELEVATION 2200 ft; LOCATION lower ridge of Maddron Bald along Indian Camp Cr. on W. side of Indian Camp Cr. Trail, just N of junction with Gabes Mtn. Trail; COMMUNITY TYPE mesic cove hardwood dominated by hemlock on low elevation, rounded ridgeline. COLLECTION No. 005H07A, on Quercus sp., 6" dbh; 005H02B, on Quercus sp.; 005H07C on Rhododendron sp.

SITE 6: ELEVATION 4800 ft; LOCATION Maddron Bald, NW of state-line ridge, on Maddron Bald Trail 1.5 miles from intersection with Snake Den Mtn. Trail ca. 50 yds. E. of switchback across from large outcrop; COMMUNITY TYPE spruce and north hardwood forest on narrow rocky ridgeline. COLLECTION No. 006H07A, on Betula lenta, 6" dbh; 006H20B, on Prunus pensylvanica; 006H01C, on Rhododendron sp.

SITE 7: ELEVATION 4400 ft; LOCATION Snake Den Mtn. Ridge, NE of Inadu Knob on Snake Den Mtn. Trail, 2 miles from AT junction, NE of second trail switchback before Maddron Bald Trail junction; COMMUNITY TYPE spruce with north hardwood forest on mesic ridgeline. COLLECTION No. 007H30A, on Prunus pensylvanica, 12" dbh; 007H11B*, on Prunus pensylvanica; 007H02C, on Betula lutea fallen branch.

SITE 8: ELEVATION 4500 ft; LOCATION NE spur of Cosby Knob on state-line ridge along W side of AT 0.2 miles S of Low Gap on crest of narrow ridge point; COMMUNITY TYPE high elevation deciduous

forest dominated by Acer. COLLECTION No. 008H05A, on Acer rubrum, 10" dbh; 008H25B, on Betula lutea; 008H01C, on fallen Betula lutea; 008H01D, on Prunus pensylvanica.

SITE 9: ELEVATION 4800 ft; LOCATION state-line ridge N of Sunup Knob, along N side of AT ca. 1 mile NE of Low Gap; COMMUNITY TYPE open beech garden on mesic ridge crest; COLLECTION No. 009H11A, on Betula lutea, 12" dbh, rooted over a large boulder; 009H05B, on Betula lutea; 009H06C, on Acer rubrum; 009H01D, on Betula lutea, fallen branch; 009H04E, on Fagus americana, fallen.

SITE 10: ELEVATION 2700 ft; LOCATION unnamed ridge N of Mt. Sterling summit between Baxter Cr. and Betlis Branch, on Baxter Cr. Trail SE of second ridge nose, ca. 2 miles from Big Creek Primitive Campground; COMMUNITY TYPE open maple-oak-pine stand on xeric ridgeline. COLLECTION No. 010H01A, on Acer rubrum, 8" dbh; 010H02B, Acer rubrum; 010H06C Acer, fallen bole; 010H01D Kalmia latifolia.

SITE 11: ELEVATION 2400 ft; LOCATION unnamed ridge NW of Mt. Winnesoka in narrow saddle along bridle path ca. 0.7 miles from intersection with Little Dudley Cr. Bridle Path; COMMUNITY TYPE pine-oak stand on xeric ridgeline. COLLECTION No. 011H01A, on Quercus sp., 1" dbh; 011H01B, on Rhododendron sp.

SITE 12: ELEVATION 2600 ft; LOCATION Grapeyard Ridge NE of Mt. Winnesoka in narrow saddle on ridgeline at intersection with abandoned trail section along unnamed trail 0.7 miles from origin at Profitt Road; COMMUNITY TYPE pine-oak on xeric and exposed ridgeline. COLLECTION No. 012H01A, on Quercus sp., 3" dbh; 012H02B*, on Quercus rubra; 012H06C Quercus rubra; 012H01D, on Quercus sp.; 012H01E, on Quercus sp. fallen branch; 012H02F, on Quercus sp. fallen bole. REPEAT COLLECTION No. 012H19A', on Quercus sp.; 012H08B'; on Oxydendron arboreum; 012H03C'; on Acer rubrum.

SITE 13: ELEVATION 2000 ft; LOCATION Copeland Divide NW of Greenbrier Pinnacle, first ridge point after trail reaches ridgeline, along Copeland Divide Trail 2 miles E of Ramsey Prong Road, COMMUNITY TYPE mixed hardwoods dominated by Acer sp. on xeric, narrow ridgeline. COLLECTION No. 013H06A, on Quercus rubra, 4" dbh.

SITE 14: ELEVATION 4500 ft; LOCATION Greenbrier Pinnacle, W of Old Black on state-line ridge, ca. 500 yds. E of fire lookout tower site in ridgeline saddle; COMMUNITY TYPE high elevation deciduous forest in mesic ridge saddle. COLLECTION No. 014H05A, Acer rubrum, 8" dbh; 014H25B, on Acer rubrum; 014H01C, on Betula lutea.

SITE 15: No collections made.

SITE 16: ELEVATION 3400 ft; LOCATION unnamed ridge N of Inadu Knob in Albright Grove, along the Albright Grove Nature Trail ca. 0.3 miles from Indian Camp Creek intersection; COMMUNITY TYPE virgin cove hardwoods on rounded ridges. COLLECTION No. 016H04A, on Betula lutea fallen branch; 016H03B, unidentified fallen branch.

SITE 17: ELEVATION 6000 ft; LOCATION Deer Creek Gap NW of summit of Old Black on state-line ridge, ca. 1 mile SW from Inadu Knob, along the SW border of the grassy meadow, COMMUNITY TYPE yellow birch thicket in zone between grassy meadow and spruce forest. COLLECTION No. 017H15A, on Betula lutea branches, 10" dbh; 017H11B, on Betula lutea branches; 017H05C, on Betula lutea branches.

SITE 18: ELEVATION 5200 ft; LOCATION state-line ridge just W of Camel Hump Knob, ca. 2.5 miles W of Low Gap and 1 mile W of Camel Gap, along Appalachian Trail where trail joins ridgeline after circling Camel Hump Knob, COMMUNITY TYPE heath bald with occasional spruce and hardwoods on narrow, rocky ridgeline. COLLECTION No. 018H06A, on Betula lutea branches, 4" dbh, dwarfed tree; 018H10B, on Rhododendron; 018H02C, on Prunus pensylvanica; 018H01D, on Fagus americana; 018H05E, on Betula lutea; 018H25F, on Betula lutea branches.

SITE 19: ELEVATION 4900 ft; LOCATION state-line ridge just NE of Ross Knob and SW of Cosby Knob, ca. 0.7 miles SW of Cosby Knob Shelter and 1.5 miles SW of Low Gap, where trail enters level ridgeline after circling the south slopes of Cosby Knob, COMMUNITY TYPE beech gap on narrow ridgeline. COLLECTION No. 019H21A, on Betula lutea, 6" dbh; 019H01B, on Betula lutea fallen branch; 019H12C, on Betula lutea; 019H10D, on Prunus pensylvanica fallen branch; 019H14E Prunus pensylvanica fallen bole.

SITE 20: No collections made.

SITE 21: ELEVATION 5100 ft; LOCATION Mt. Sterling ridge NE of summit, along Baxter Cr. Trail ca. 4.5 miles from origin at Big Cr. Primitive Campground, just beyond junction with unmaintained Big Branch Trail and N of first switchback, on N rim of ridgeline; COMMUNITY TYPE open, mature spruce-birch stand on steep ridge slope. COLLECTION No. 021H20A, on Betula lutea, >18" dbh; 021H11B, on Betula lutea fallen bole; 021H06C, on Fagus americana.

SITE 22: ELEVATION 2700 ft; LOCATION unnamed ridge NW of Piney Mtn., along bridle path ca. 0.7 miles from origin on Roaring Fork Motor Nature Trail, in saddle of ridgeline just W of point where trail leaves ridgeline to follow the Falls Branch of Baskins Cr., COMMUNITY TYPE closed pine-oak forest on xeric ridgeline. COLLECTION No. 022H01A, on Acer rubrum, 8" dbh; 022H02B, on Oxydendron arboreum; 022H02C, on Oxydendron arboreum.

SITE 23: ELEVATION 3000 ft; LOCATION unnamed ridge NW of Round Top on Mt. Winnesoka, along bridle path ca. 1 mile from origin at homesite on Roaring Fork Motor Nature Trail, 70 yds. NE of intersection with bridle trail to stables (sign), in saddle of ridge, COMMUNITY TYPE open oak-pine stand on xeric, exposed ridge. COLLECTION No. 023H01A, on Magnolia sp. 8" dbh with curved base; 023H01B, on Quercus sp.; 023H05C, on Rhododendron sp.; 023H10D, on Oxydendron arboreum; 023H02E, on Rhododendron; 023H02F, on unidentified fallen branches. REPEAT COLLECTION No. 023H01A', on Oxydendron arboreum; 023H07B', on Acer rubrum; 023H24C', on Oxydendron arboreum; 023H04D', on Acer rubrum.

SITE 24: ELEVATION 4900 ft; LOCATION Brushy Mtn., ca. 100 yds. SW of benchmark at summit 0.3 miles NE of Trillium Gap, COMMUNITY TYPE heath bald on exposed, rounded ridgeline. COLLECTION No. 024H01A, on Acer rubrum, dwarfed tree with low hanging branches and root sprouts; 024H10B, on Rhododendron.

SITE 25: ELEVATION 2000 ft; LOCATION Potato Ridge, E of Mt. Winnesoka, between Long Branch and Rhododendron Branch, on ridgeline above picnic shelter on Porters Cr. Road, along old property boundary ca. 200 yds. on ridge spur NE from the main Potato Ridge, COMMUNITY TYPE pine-oak stand on narrow, exposed ridgeline. COLLECTION No. 025H01A, on Oxydendron arboreum, 4" dbh with "s" shaped bole; 025H01B, on Quercus sp.

SITE 26: ELEVATION 2800 ft; LOCATION Bald Top Ridge, main ridge NW from Wooley Tops Mtn., in narrow saddle where abandoned trail crosses ridgeline, COMMUNITY TYPE closed canopy pin forest on narrow, xeric ridge. COLLECTION No. 026H02A, on Quercus sp., 6" dbh; 026H02B*, on Quercus sp.; 026H17C, on Quercus sp. fallen branch; 026H19D, on Picea rubra fallen branch.

SITE 27: No collections made.

SITE 28: ELEVATION 5800 ft; LOCATION Mt. Chapman Ridge, western slopes of summit; along Appalachian Trail 1.8 miles SW of junction with Balsam Mtn. Trail at Tricorner Knob, just before trail descends into a narrow gap, COMMUNITY TYPE spruce-fir forest. COLLECTION No. 028H19A, on Betula lutea branches, 6" dbh; 028H03B, on Betula lutea branches; 028H10C, on Acer rubrum.

SITE 29: ELEVATION 5900 ft; LOCATION Balsam Mtn, Ridge, in unnamed gap just E of Mt. Yonaguska, along the Balsam Mtn. Trail ca. 9 miles from origin at Pin Oak Gap on Balsam Mtn. Road, where trail regains ridgeline after passing south of Luftee Knob and Thermo Knob, COMMUNITY TYPE open birch grove in mesic gap. COLLECTION No. 029H02A, on Betula lutea, a group of 3 trees, 3-5" dbh; 029H09B*, on Betula lutea; 029H14C, on Betula lutea fallen bole.

SITE 30: ELEVATION 6000 ft; LOCATION Thermo Knob on Balsam Mtn. ridge, just W of Luftee Knob, along Balsam Mtn. Trial ca. 8 miles from origin at Pin Oak Gap on Balsam Mtn. Road, on S slope of

knob where trail crosses a ridge "nose," COMMUNITY TYPE mature fir forest on mesic slope. COLLECTION No. 030H01A, on Betula lutea branches, 6" dbh; 030H01B, on Betula lenta.

SITE 31: ELEVATION 5700 ft; LOCATION Balsam Mtn. Ridge, between Balsam Corner and Luftee Knob, along Balsam Mtn. Trail ca. 6 miles from origin at Pin Oak Gap on Balsam Mtn. Road, in a saddle gap just E of the point where the trail moves to the N side of the ridgeline; COMMUNITY TYPE spruce and northern deciduous forest. COLLECTION No. 031H08A, on Betula lutea branches, 6" dbh with many low hanging branches; 031H07B, on Betula lutea branches; 031H04C, on Betula lutea.

SITE 32: ELEVATION 5300 ft; LOCATION Mt. Sterling Ridge, between two small knobs of horseshoe shaped ridge, SE of Pretty Hollow Gap, along Mt. Sterling Ridge Trail just beyond trail junction with Pretty Hollow Gap Trail, COMMUNITY TYPE birch grove in mesic saddle. COLLECTION No. 032H03A, on Betula lutea 8" dbh; 032H54B, on Betula lutea fallen bole.

SITE 33: ELEVATION 5700 ft; LOCATION Mt. Sterling Ridge, SW of summit, ca. 0.2 miles along the lookout tower spur from its origin at the Mt. Sterling Ridge Trail, on W margin of the trail; COMMUNITY TYPE mature spruce-fir forest on narrow ridge. COLLECTION No. 033H09A Betula lutea >10" dbh; 033H13B, on Betula lutea; 033H06C, on Betula lutea; 033H12D, on unidentified fallen branches.

SITE 34: ELEVATION 1900 ft; LOCATION unnamed spur E of Curry He Mtn., along game trail originating on the S side of the Buckhorn Gap Trail in a sheltered saddle ca. 1 mile from origin at the "Sinks" Parking Area, COMMUNITY TYPE closed pine stand on xeric ridgeline. COLLECTION No. 034H02A, on Oxydendron arboreum 3" dbh with "L" shaped bole; 034H01B, on Oxydendron arboreum; 034H02C, on Pinus sp.

SITE 35: ELEVATION 2300 ft; LOCATION eastern projection of unnamed ridge SE of Curry He Mtn., along Curry Gap Trail ca. 1.5 miles from origin at Metcalf Bottoms picnic area, COMMUNITY TYPE open oak stand on xeric broad ridge. COLLECTION No. 035H01A, on Quercus sp. 6" dbh; 035H01B, on Acer rubrum fallen bole; 035H01C, on Kalmia latifolia; 035H01D, on Quercus sp.

SITE 36: ELEVATION 3700 ft; LOCATION Chinquapin Knob on Cove Mtn. Ridge, just SW of intersection of Cove Mtn. Trail and Little Brier Trail, on the NW rim of the rectangular knob; COMMUNITY TYPE closed oak forest on xeric ridge. COLLECTION No. 036H08A, on Quercus rubra 8" dbh; 036H03B, on Quercus alba; 036H03C, on Quercus rubra.

SITE 37: ELEVATION 2800 ft; LOCATION Sugarland Mtn. Ridge, spur extending NE from the ridgeline, along Sugarland Mtn. Trail where trail first gains the ridgeline, ca. 1 mile from origin at Fighting Cr. Gap on Little River Road, COMMUNITY TYPE, open pine-oak forest on xeric, exposed

ridge point. COLLECTION No. 037H03A, on Acer rubrum 4" dbh; 037H10B, on Kalmia latifolia; 037H01C, on Prunus sp.

SITE 38: ELEVATION 2900 ft; LOCATION Sugarland Mtn. Ridge, NW of main peak, along Sugarland Mtn. Trail just beyond Mids Gap, where trail reaches ridgeline in a saddle, ca. 2.0 miles from origin at Fighting Cr. Gap on Little River Road. COMMUNITY TYPE transition zone between xeric pine stand and mesic cover hardwoods. COLLECTION No. 038H02A, on Acer rubrum 6" dbh; 038H03B, on Quercus sp. REPEAT COLLECTION No. 038H03A', on Acer rubrum; 038H07B', on Oxydendron arboreum; 038H01C', on Acer rubrum; 038H16D', Oxydendron arboreum; 038H12E', on Oxydendron arboreum, dead bole.

SITE 39: ELEVATION 2400 ft; LOCATION unnamed spur of Mt. LeConte, NW of Bullhead Ridge, along Two Mile Branch Bridle Trail ca. 0.5 miles from its origin on gravel service road connecting the Bullhead Trailhead with the Sugarlands Utility Area, in open, parklike area adjacent to trail; COMMUNITY TYPE transition between deciduous forest and cove hardwoods, on open, mesic flat. COLLECTION No. 039H02A, on Acer rubrum; 039H02B, on Quercus sp. REPEAT COLLECTION No. 039H01A', on Oxydendron arboreum; 039H05B', Quercus sp.; 039H02C', Quercus sp.; 039H02D', on Magnolia sp.

SITE 40: ELEVATION 3600 ft; LOCATION Bullhead Ridge, W of Mt. LeConte, along Bullhead Trail just W of Bullhead Knob at sharp left turn, ca. 1.5 miles from origin at Cherokee Orchard Road, COMMUNITY TYPE open oak forest with dense heath understory, on narrow ridge point. COLLECTION No. 040H07A, on Oxydendron arboreum 4" dbh; 040H05B, on Prunus pensylvanica fallen bole; 040H06C, on Prunus pensylvanica fallen bole.

SITE 41: ELEVATION 4800 ft; LOCATION Rocky Spur Ridge NW fof Mt. LeConte, along the Rainbow Falls Trail ca. 1 mile beyond Rainbow Falls where the trail first joins the ridgeline, ca. 20 yds. beyond the switchback on east rim of the ridgeline; COMMUNITY TYPE a transition zone between the heath ridgeline and mesic high elevation deciduous forest. COLLECTION No. 041H16A, on Betula lutea, 10" dbh; 041H28B, on Prunus pensylvanica.

SITE 42: ELEVATION 6000 ft; LOCATION unnamed ridge extending N from Mt. LeConte, on crest of ridge above the Trillium Gap Trail, at a point just beyond a sharp right switchback where the trail runs along the east slopes of the ridge, 5.5 miles from its origin on the Roaring Fork Motor Nature Trail, COMMUNITY TYPE spruce stand on a mesic, rocky ridge. COLLECTION No. 042H02A, on Betula lutea 10" dbh; 042H08B, on Betula lutea fallen bole; 042H10C, on Prunus pensylvanica fallen bole; 042H04D, on Picea rubra.

SITE 43: No collections made.

SITE 44: ELEVATION 5600 ft; LOCATION state-line ridge between Laurel Top summit and Porters Gap, along the AT ca. 1.5 miles NE of Porters Gap trail sign, where trail ascends to the ridgeline after skirting the N slopes of a spur, narrow built-up section of the trail, COMMUNITY TYPE high elevation deciduous dominated by birch with interspersed spruce. COLLECTION No. 044H12A, on Betula lutea branches; 044H40B, on Betula lutea; 044H03C, on Prunus pensylvanica; 044H02D, on Rhododendron.

SITE 45: ELEVATION 6000 ft; LOCATION state-line ridge between Pecks Corner and Laurel Top, along AT ca. 1.5 miles NW of Pecks Corner, at point where trail skirts the S slope of unnamed knob; COMMUNITY TYPE spruce forest on mesic slope. COLLECTION No. 045H06A, on Betula lutea; 045H07B, on Betula lutea; 045H08C, on Betula lutea; 045H24D, on Betula lutea branches.

SITE 46: ELEVATION 6300 ft; LOCATION Copper Gap on state-line ridge just S of Mt. Sequoia summit, along AT ca. 2.5 miles N of Pecks Corner, on rim of gap where trail ascends summit; COMMUNITY TYPE mature spruce-fir. COLLECTION No. 046H10A, on Betula lutea; 046H14B, on Betula lutea; 046H06C, on Betula lutea; 046H01D, on Betula lutea; 046H02E, on Betula lutea.

SITE 47: ELEVATION 6000 ft; LOCATION Dashoga Ridge of Mt. Hardison, along unmaintained trail ca. 0.3 miles SW of its origin on the Balsam Mtn. Trail 0.6 miles SE of Tricorner Knob, on the W slope of the Mt. Hardison summit, COMMUNITY TYPE spruce-fir forest. COLLECTION 047H12A, on Betula lutea; 047H10B, on Betula lutea; 047H02C, on Betula lutea.

SITE 48: ELEVATION 5000 ft; LOCATION summit of Hyatt Ridge, S of Mt. Yonaguska on the Balsam Mtn. Ridge, along the unmaintained Hyatt Ridge Trail, ca. 0.8 miles N of McGee Springs Backcountry Campsite; COMMUNITY TYPE mature spruce forest with many fallen trees on broad, mesic ridge. COLLECTION No. 048H01A, on Betula lutea 18" dbh with twin trunks; 048H04B, on Acer rubrum.

SITE 49: ELEVATION 5500 ft; LOCATION Laurel Gap of Balsam Mtn., just SW of Balsam Corner, along manway at the S edge of the Laurel Gap Shelter clearing; COMMUNITY TYPE hardwood gap in spruce forest. COLLECTION No. 049H06A, on Betula lutea branches, 8" dbh, with many low-hanging branches; 049H06B*, on Betula lutea branches, 6" dbh, E of shelter; 049H13C, on Prunus pensylvanica fallen bole.

SITE 50: ELEVATION 5500 ft; LOCATION Butt Mtn. Ridge, extending SW from Cataloochee Mtn., along Mt. Sterling Ridge Trail ca. 6.5 miles from its origin at Mt. Sterling Gap on old NC 284, on the E rim of a gap where the trail crosses this narrow ridge, COMMUNITY TYPE high elevation deciduous forest dominated by birch. COLLECTION No. 050H04A, on Betula lutea; 050H10B, on Betula lutea, fallen branch; 050H01C, on Betula lutea; 050H10D, on Prunus pensylvanica.

SITE 51: ELEVATION 4200 ft; LOCATION unnamed ridge between Pretty Hollow Cr. and Onion Bed Branch, extending SE from Mt. Sterling Ridge, along Pretty Hollow Gap Trail, ca. 0.2 miles NE of the trail crossing of Onion Bed Branch as trail crosses the "nose" of the ridge, ca. 3 miles from its origin at Palmer Cr. Trail; COMMUNITY TYPE mixed hardwood forest dominated by birch. COLLECTION No. 051H01A, on Betula lutea 5" dbh; 051H01B*, on Betula lutea; 051H14C, on Prunus pensylvanica fallen branch; 051H01D, on Betula lutea fallen branch.

SITE 52: ELEVATION 3800 ft; LOCATION Long Bunk Ridge, on a dry ridge above the Hannah Cemetery, extending SE form the Mt. Sterling Ridge, along Pig Pen Trail ca. 0.5 miles from its origin on the Little Cataloochee Road, E of the point where the road crosses the ridgeline, COMMUNITY TYPE dry pine and hardwood stand. COLLECTION No. 052H02A, on Acer rubrum; 052H07B, on Acer sp.; 052H04C, on Oxydendron arboreum; 052H02D, on Oxydendron arboreum.

SITE 53: No collections made.

SITE 54: No collections made.

SITE 55: No collections made.

SITE 56: ELEVATION 2000 ft; LOCATION Mill Ridge extending SW of Lumber Ridge, along Lumber Ridge (Meigs Mtn.) Trail ca. 1 mile from its origin at the Environmental Education Center in Tremont, just W of the third switchback on eastern ridge projection; COMMUNITY TYPE closed pine forest on xeric ridgeline. COLLECTION No. 056H01A, on Quercus sp., 12" dbh.

SITE 57: ELEVATION 2400 ft; LOCATION Lumber Ridge extending NW of Meigs Mtn., along Lumber Ridge (Meigs Mtn.) Trail ca. 3.5 miles from its origin at the Environmental Education Center in Tremont and 0.2 miles W of Lower Buckhorn Gap, on SW edge of knob, COMMUNITY TYPE pine stand on xeric ridge. COLLECTION No. 057H01A, on Quercus sp. 2" dbh; 057H01B, on Quercus sp.

SITE 58: ELEVATION 4600 ft; LOCATION Blanket Mtn. summit, at the E margin of the clearing, along Blanket Mtn. Trail ca. 4.0 miles from its origin on Jakes Cr. Road, COMMUNITY TYPE beech and birch garden with areas of dense heath. COLLETION No. 058H08A, on Aesculus octandra; 058H05B, on Acer rubrum; 058H07C, on Rhododendron; 058H01D, on Acer rubrum; 058H08E

SITE 59: ELEVATION 2500 ft; LOCATION unnamed ridge extending NW from Bent Arm Ridge, along Cucumber Gap Trail 0.5 miles from its origin on Blanket Mtn. Trail in a ridge crossing just W of Cucumber Gap, N of the trail on the S slope of a small knob, COMMUNITY TYPE closed oak forest on xeric ridge. COLLECTION No. 059H01A, on Quercus sp.

SITE 60: ELEVATION 3400 ft; LOCATION Sugarland Mtn. Ridge, NW of the main peak, at the point where Sugarland Mtn. Trail turns sharply east and begins to climb, 0.4 mi S of Husky Gap; COMMUNITY TYPE pine-oak forest on xeric ridgetop, heavily damaged with standing and fallen

dead trees. COLLECTION No. 060H05A, on Acer rubrum, located at the E end of an opening; 060H01B, on Oxydendron arboreum; 060H08C, on Prunus pensylvanica. REPEAT COLLECTION No. 060H01A', on Quercus alba; 060H03B', on Quercus alba; 060H04C', on Quercus sp.; 060H11D', on Oxydendron arboreum; 060H12E', on Quercus sp.; 060H08F', on Oxydendron arboreum; 060H04G', on Quercus sp.; 060H07H', on Oxydendron arboreum.

SITE 61: ELEVATION 4400 ft; LOCATION narrow ridgeline of Sugarland Mtn. Ridge, SE of the main peak where the Sugarland Mtn. Trail descends the western slope of the ridge, ca. 1.5 miles S of the connector manway to Chimney Tops; COMMUNITY TYPE high elevational deciduous forest. COLLECTION No. 061H11A, on Prunus pensylvanica, fire scared bole, 10" dbh; 061H01B, on Oxydendron arboreum; 061H08C Prunus pensylvanica. REPEAT COLLECTION No. 061H21A', on Prunus pensylvanica; 061H02B', on Prunus pensylvanica; 061H03C, on Betula lutea; 061H04D', on Betula lutea; 061H22E', on Prunus pensylvanica.

SITE 62: ELEVATION 4800 ft; LOCATION Chimney Tops Ridge, narrow spur extending NE from Sugarland Mtn. Ridge, along an unmaintained connector trail ca. 50 ft S its junction of the Chimney Tops Trail and 0.3 miles SW of the Chimney Tops pinnacles, COMMUNITY TYPE mature spruce forest with high elevation deciduous trees on a razor-back ridge. COLLECTION No. 062H03A, on Betula lutea, mature tree with broken top; 062H05B, on decorticated log; 062H03C, on twigs; 062H02D, on twigs. REPEAT COLLECTION No. 062H05A', on Betula lutea; 062H04B', on branches; 062H12C', on Betula lutea; 062H04D', on Betula lutea; 062H08E', on Betula lutea, fallen bole; 062H31E', on Prunus pensylvanica.

SITE 63: ELEVATION 5200 ft; LOCATION Peregrine Peak extending SW of the Mt. LeConte Ridgeline, in a sheltered bend of the Alum Cave Trail at the upper end of Alum Cave, ca. 2.5 miles from its origin on the Newfound Gap Road and 100 ft N of the intersection with a manway, COMMUNITY TYPE high elevation deciduous forest with interspersed spruce. COLLECTION No. 063H17A, on Betula lutea fallen branches; 063H04B, on fallen branches; 063H02C, on Betula lutea fallen bole; 063H07D, on Acer sp.; 063H10E, on branches; 063H13F, on Rhododendron.

SITE 64: ELEVATION 5700 ft; LOCATION Mt. LeConte Ridge E of Anakeesta Knob, along the Boulevard Trail at a point where the trail follows the narrow ridgeline after passing N of a small Knob, ca. 1.2 miles from its origin on the AT; COMMUNITY TYPE spruce-fir forest. COLLECTION No. 064H04A, on Betula lutea 4" dbh; 064H07B*, on Betula lutea; 064H03C, on branches; 064H01D, on Betula lutea. REPEAT COLLECTION No. 064H50A', on Betula lutea, branches; 064H06B', on Betula lutea; 064H07C', on Prunus pensylvanica; 064H20D', on Prunus pensylvanica; 064H06E', on Betula lutea.

SITE 65: ELEVATION 5500 ft; LOCATION state-line ridge on the W slope of Masa Knob, near Charlie's Bunion, along the AT just E of the point where the AT moves to the north slope of Masa Knob, ca. 3.6 miles NE from the Newfound Gap Parking Area; COMMUNITY TYPE open beech garden on rounded, rocky ridgeline. COLLECTION No. 065H20A, on Betula lutea 20" dbh; 065H06B*, on Betula lutea; 065H04C, on branches. REPEAT COLLECTION No. 065H10A', on Betula lutea.

SITE 66: ELEVATION 5300 ft; LOCATION state-line ridge at the Sawteeth between Porters Gap and Dry Sluice Gap, along AT at the SE of built-up trail section, ca. 5 miles NE of the Newfound Gap Parking Area; COMMUNITY TYPE spruce-fir on a narrow, rocky ridgeline. COLLECTION No. 066H20A, on Betula lutea 7" dbh; 066H17B, on Betula lutea branches.

SITE 67: ELEVATION 5300 ft; LOCATION Hughes Ridge extending S from Pecks Corner on the state-line ridge, along Hughes Ridge Trail ca. 0.7 miles N of junction with Taywa Cr. Trail at point where trail reaches the ridgeline and proceeds E, COMMUNITY TYPE spruce forest with interspersed dedicuous trees on broad, mesic ridge. COLLECTION No. 067H05A, on *Betula lutea; 067H03B, on Betula lutea.

SITE 68: ELEVATION 5800 ft; LOCATION Katalsta Ridge, extending S from state-line ridge between Eagle Rocks and Pecks Corner, in gap where spur ridge joins state-line ridge, at point where AT skirts the S slopes of small knob and turns NNE toward Eagle Rocks, 1.0 mile E of Pecks Corner; COMMUNITY TYPE high elevation deciduous gap in spruce-fir forest dominated by Fagus americana. COLLECTION No. 068H04A, on Betula lutea; 068H35B*, on Betula lutea.

SITE 69: ELEVATION 5100 ft; LOCATION Breakneck Ridge, extending W from Hyatt Ridge, along the unmaintained Raven Fork Trail, ca. 0.8 miles W of its origin at the Hyatt Ridge Trail, at the W end of a saddle gap just E of the highest knob on the ridge, COMMUNITY TYPE birch grove at margin of grassy saddle of mesic, rounded ridge. COLLECTION No. 069H09A, on Betula lutea 12" dbh; 069H03B, on Betula lutea branches; 069H07C, on Prunus pensylvanica.

SITE 70: ELEVATION 4500 ft; LOCATION unnamed ridge extending NE form Hyatt Bald on Hyatt Ridge, along the Hyatt Bald Trail at the point where the trail first gains the ridgeline in a cut back to the left, ca. 2.2 miles from its origin at the Round Bottom Camping Area; COMMUNITY TYPE mixed deciduous forest in a dry saddle in the ridge. COLLECTION No. 070H04A, on Acer spicatum 6" dbh.

SITE 71: ELEVATION 5000 ft; LOCATION Balsam Mtn. Ridge between Ledge Bald and Beech Gap, Along the Balsam Mtn. Trail, just W of Ledge Bald at the point where the trail drops to Beech Gap, ca. 2 miles from its origin at Pin Oak Gap on the Balsam Mtn. Road; COMMUNITY TYPE spruce forest with interspersed hardwoods. COLLECTION No. 071H02A, on Betula lutea 20" dbh; 071H01B*, on Betula lutea; 071H01C Betula lutea.

SITE 72: ELEVATION 4000 ft; LOCATION Trail Ridge extending E from Balsam Mtn. Ridge, along Palmer Cr. Trail ca. 0.7 miles from origin on Balsam Mtn. Road in narrow gap in the ridgeline, SE in the bend of the trail as it skirts the S slopes of a small knob; COMMUNITY TYPE mid-elevation deciduous forest dominated by Acer rubrum adjacent to a closed hemlock stand. COLLECTION No. 072H11A, on Acer rubrum; 072H03B, on Acer rubrum; 072H50C, on Oxydendron arboreum.

SITE 73: Elevation 3000 ft; LOCATION Noland Mtn.Ridge extending SW from Canadian Top, along Little Cataloochee Trail ca. 0.5 from its origin at Palmer Cr. Trail, SE of the trail on a low ridge, COMMUNITY TYPE dry, mixed deciduous forest dominated by oak. COLLECTION No. 073H05A, on Betula lenta 4" dbh; 073H06B, on Oxydendron arboreum; 073H01C, on fallen branch; 073H01D, on Betula lenta; 073H02E, on Liriodendron tulipfera.

SITE 74: ELEVATION 3900 ft; LOCATION Bald Top Gap just N of the Canadian Top summit on Noland Mtn. Ridge, along Little Cataloochee Trail ca. 3.2 miles from origin on old NC 284, just E of Davidson Gap on the trail; COMMUNITY TYPE mid-elevation deciduous forest dominated by Quercus sp. COLLECTION No. 074H01A, on Betula lenta; 074H05B*, on Betula lenta; 074H03C, on Betula lenta.

SITE 75: No collections made.

SITE 76: ELEVATION 2000 ft; LOCATION Hatcher Mtn. NE of small knob,, along Abrams Falls Trail ca. 6 miles from origin at Abrams Falls parking area in Cades Cove and ca. 1 mile SW of intersection with Cooper Road; COMMUNITY TYPE pine-oak forest on xeric ridgeline. COLLECTION No. 076H02A, on Quercus sp.; 076H01B, on Quercus sp.

SITE 77: ELEVATION 2100 ft; LOCATION Arbutus Ridge, switchback where Cooper Road reaches the ridgeline, ca. 3 miles from origin at Cades Cove Loop Road, COMMUNITY TYPE open pine-oak forest, with many fallen trees. COLLECTION No. 077H01A, on Acer rubrum; 077H01B*, on Acer rubrum; 077H04C, on Acer rubrum.

SITE 78: ELEVATION 3100 ft; LOCATION Tater Ridge extending SW from the Rich Mtn. Ridge, where the Rich Mtn. Loop trail first crosses the ridgeline ca. 0.5 miles S of intersection with connector to Rich Mtn. Road along Rich Mtn. Loop; COMMUNITY TYPE closed oak forest on xeric ridge. COLLECTION NO. 078H02A, on Quercus sp.; 078H17B, on Quercus sp.

SITE 79: ELEVATION 3500 ft; LOCATION narrow saddle of Rich Mtn. Ridge, along Rich Mtn. Loop ca. 0.2 miles E of Lookout Tower; COMMUNITY TYPE open oak forest with many mature trees. COLLECTION No. 079H28A, on Quercus sp.; 079H12B, on Quercus sp.; 079H06C, on Quercus sp.; 079H02D, on Quercus sp.; 079H03E, on Quercus sp.; 079H02F, on Quercus sp.

SITE 80: ELEVATION 3300 ft; LOCATION unnamed ridge extending S from Rich Mtn. Ridge, at point where Rich Mtn. Loop crosses ridgeline and climbs steeply on E slope through a number of

switchbacks, ca. 0.5 miles S of junction with Indian Grave Gap jeep road; COMMUNITY TYPE pine-oak ridgeline. COLLECTION No. 080H05A, on Quercus sp.; 080H03B, on Quercus sp.; 080H03C, on Quercus sp. REPEAT COLLECTION No. 080H02A', on Oxydendron arboreum; 080H61B', on Oxydendron arboreum; 080H05C', on Oxydendron arboreum; 080H01D', on Jugulans sp.

SITE 81: ELEVATION 2700 ft; LOCATION Hickory Gap on Bote Mtn. Ridge, along Bote Mtn. Road ca. 1 mile N of junction with Lead Cove Trail at Sandy Gap; COMMUNITY TYPE hardwood gap dominated by Quercus, in xeric pine ridgeline. COLLECTION No. 081H02Z, on Acer rubrum; 081H10B, on Rhododendron sp.; 081H05C, on fallen branch.

SITE 82: No collections made.

SITE 83: No collections made.

SITE 84: ELEVATION 4400 ft; LOCATION Dripping Springs Mtn., nose of ridge where Miry Ridge Trail turns sharply to E; COMMUNITY TYPE closed oak forest. COLLECTION No. 084H01A, on Fagus americana; 084H08B, on Prunus pensylvanica. REPEAT COLLECTION No. 084H41A', on Betula lenta.

SITE 85: ELEVATION 4400 ft; LOCATION Miry Ridge just N of Ben Parton Lookout, along Miry Ridge trail at intersection with Lynn Camp Prong Trail; COMMUNITY TYPE hemlock stand with mid-elevation deciduous trees interspersed, on mesic, narrow ridge. COLLECTION No. 085H01A, on Betula lutea; 085H02B, on Fagus americana, fallen bole; 085H04C, on Prunus pensylvanica, fallen bole. REPEAT COLLECTION No. 085H03A', on Betula lenta branch; 085H27D', on Acer rubrum; 085H06C', on Acer rubrum; 085H17D', on Prunus pensylvanica, fallen bole.

SITE 86: No collections made.

SITE 87: No collections made.

SITE 88: ELEVATION 5400 ft; LOCATION Sugarland Mtn. Ridge, in a broad saddle where Sweet Ridge diverges, along the Sugarland Mtn. Trail ca. 3.2 miles N of its origin at the Clingmans Dome Road, and 1 mile S of the junction with the connector trail to the Chimney Tops, ; COMMUNITY TYPE mature high elevation deciduous forest. COLLECTION No. 088H20A, on Betula lutea >20" dbh; 088H18B, on fallen logs.

SITE 89: ELEVATION 5600 ft; LOCATION Mingus Lead SE of Mt. Mingus summit, on north rim of the ridge ca. 0.3 miles NW along a game trail which originates on the AT 0.5 miles E of Indian Gap, area of heavy windfall damage; COMMUNITY TYPE high elevation deciduous forest with abundant spruce. COLLECTION No. 089H12A, on Betula lutea 12" dbh; 089H20B, on fallen logs. REPEAT COLLECTION No. 089H50A', on Betula lutea; 089H04B', on Betula lutea, fallen branch; 089H16C', on Betula lutea.

SITE 90: ELEVATION 5300 ft; LOCATION state-line ridge just E of Newfound Gap, where the AT regains the main ridgeline, ca. 0.6 miles E of the Newfound Gap Parking Area; COMMUNITY TYPE beech gap along a narrow rocky ridgeline. COLLECTION No. 090H11A, on Betula lutea 5" dbh; 090H41B, on Betula lutea. REPEAT COLLECTION No. 090H10A', on Betula lutea.

SITE 91: ELEVATION 5000 ft; LOCATION unnamed ridge extending S from Mt. Ambler, between the headwaters of Huskey Cr. and Bradley Branch, first crossing of the ridge "nose" by Sweat Heifer Trail ca. 1.0 miles from its origin on the AT; COMMUNITY TYPE exposed opening in mature spruce-fir forest. COLLECTION No. 091H04A, on Betula lutea, a group of 5 trunks from 2-5" dbh; 091H22B, on Betula lutea fallen branch; 091H13C, on Betula lutea. REPEAT COLLECTION No. 091H10A', on Betula lutea.

SITE 92: ELEVATION 5300 ft; LOCATION Richland Mtn. Ridge extending S from state-line ridge E of Charlies Bunion, in mesic saddle along abandoned ridgeline trail SW of intersection of Richland Mtn. Trail and Grassy Branch Trail; COMMUNITY TYPE high elevation deciduous dominated by Betula lutea. COLLECTION No. 092H02A, on Betula lutea, branches; 092H08B, Betula lutea, branches; 092H06C, on Betula lutea; 092H10D, on Acer rubrum; 092H15F, on Prunus pensylvanica; 092H02E, on Fagus americana.

SITE 93: ELEVATION 4900 ft; LOCATION Hughes Ridge, in narrow saddle gap on W side of Hughes Ridge Trail ca. 9 miles from origin at Smokemont Chapel, and S of Taywa Cr. Trail intersection, COMMUNITY TYPE mid-elevation deciduous gap dominated by Acer in heath ridgeline. COLLECTION No. 093H03A, on Acer rubrum; 093H03B, on Acer rubrum.

SITE 94: ELEVATION 4600 ft; LOCATION Hughes Ridge, NE of Becks Bald, along the Hughes Ridge Trail just N of the junction with the Chasteen Creek Trail, ca. 6.7 from the trail origin at the Smokemont Chapel in the Smokemont Campground; COMMUNITY TYPE closed oak forest on a mesic ridge. COLLECTION No. 094H12A, on Acer rubrum 7" dbh, in a clump of eight boles; 094H47B, on Acer rubrum; 094H04C, on Betula lenta.

SITE 95: ELEVATION 4500 ft; LOCATION Hyatt Ridge, SW of Hyatt Bald, at point where Hyatt Ridge Trail skirts the SW slopes of small knob, ca. 0.2 miles N of Low Gap at intersection of Enloe Cr. Trail; COMMUNITY TYPE mid-elevation deciduous forest dominated by Acer. COLLECTION No. 095H04A, on Acer rubrum; 095H02B, on Acer rubrum; 095H03C, on Acer rubrum.

SITE 96: ELEVATION 4200 ft; LOCATION unnamed ridge extending S of Hyatt Bald, on broad, low ridgeline just S of Hyatt Ridge Trail's last crossing of stream SE of Low Gap, ca. 1 mile from origin at Straight Fork Road, COMMUNITY TYPE mid-elevational, second growth deciduous forest dominated by Acer. COLLECTION No. 096H06A, on Betula lutea.

SITE 97: ELEVATION 5500 ft; LOCATION Chiltoes Mtn. Ridge, just N of summit, in narrow gap between knobs,along Spruce Mountain Trail ca. 3 miles from origin at Pauls Gap on the Blue Ridge Parkway Spur Road; COMMUNITY TYPE open spruce forest with many mature trees, on mesic, rounded ridge. COLLECTION No. 097H02A, on Betula lutea, mature tree; 097H07B, on Betula lutea.

SITE 98: ELEVATION 5600 ft; LOCATION Spruce Mtn., just N of summit, at NE margin of clearing, on forested slope of summit, along Spruce Mtn. Trail to Lookout Tower; COMMUNITY TYPE high elevation deciduous forest dominated by Fagus and Betula, many fallen and damaged trees. COLLECTION No. 098H49A, on Betula lutea, low hanging branches; 098H06B, on Betula lutea, branches; 098H02C, on Betula lutea; 098H10D, on Prunus pensylvanica.

SITE 99: ELEVATION 3400 ft; LOCATION Big Fork Ridge extending NE from Cataloochee Balsam Mtn., in gap in main ridgeline, on NE margin of Big Fork Ridge Trail ca. 1.6 miles from origin on Cataloochee Road; COMMUNITY TYPE mid-elevation deciduous forest dominated by Acer rubrum on xeric, narrow ridgeline. COLLECTION No. 099H02A, on Acer rubrum; 099H01B, on Betula lutea; 099H14C, on Quercus sp.

SITE 100: ELEVATION 3400 ft; LOCATION Den Ridge extending NW from Cataloochee Divide Ridge, just N of gap on main ridgeline on S slope of small knob along the Booger Man Trail ca. 2 miles from origin on Caldwell Fork Trail; COMMUNITY TYPE closed pine-oak forest on xeric, rounded ridgeline. COLLECTION No. 100H01A, on Acer rubrum; 100G04B, on Betula lenta; 100H04C, on fallen log; 100H29D, on fallen branches.

SITE 101: No collections made.

SITE 102: No collections made.

SITE 103: No collections made.

SITE 104: ELEVATION 2000 ft; LOCATION unnamed ridge extending N from Boring Ridge, in narrow gap where Rabbit Cr. Trail reaches ridgeline, ca. 1 mile from origin at Abrams Falls parking area in Cades Cove, COMMUNITY TYPE closed pine stand with mid-elevation hardwoods. COLLECTION No. 104H01A, on Oxydendron arboreum.

SITE 105: No collections made.

SITE 106: ELEVATION 3600 ft; LOCATION Leadbetter Ridge, extending N from McCampbell Knob on the state-line ridge, where Russell Field Trail reaches a gap in the ridgeline in an abrupt left turn, ca. 1.5 miles from its origin at the Anthony Cr. Trail; COMMUNITY TYPE closed oak-hickory forest on a narrow xeric ridgeline. COLLECTION No. 106H12A, on Acer rubrum; 106H12B, on Acer rubrum;

106H10C, on Acer sp., standing dead tree; 106H20D, on Oxydendron arboreum; 106H26E, on Quercus sp.

SITE 107: ELEVATION 3300 ft; LOCATION Bote Mtn. Ridge, NE of Cold Water Knob, on W side Bote Mtn. Road where trail leaves the ridgeline to skirt E slope of knob, ca. 1 mile SE of Sandy Gap and intersection with Lead Cove Trail; COMMUNITY TYPE open pine ridge with interspersed hardwoods, on narrow, xeric ridgeline. COLLECTION No. 107H18A, on Acer rubrum; 107H03B, Acer rubrum; 107H08C, Acer rubrum.

SITE 108: ELEVATION 5000 ft; LOCATION Deerhobble Ridge extending NE from Defeat Ridge, along unmaintained Defeat Ridge Trail ca. 1 mile from origin on AT at Thunderhead Mtn., at point where trail follows narrow ridgeline before turning W and descending the ridge slope, COMMUNITY TYPE, closed high elevation deciduous stand dominated by Fagus, on mesic ridge. COLLECTION No. 108H02A, on Fagus americana; 108H02B, on Prunus sp.

SITE 109: ELEVATION 5100 ft; LOCATION Brier Ridge, extending N from Brier Knob on the state-line ridge, between Thunderhead and Mt. Davis, along the AT ca. 2 miles east of the summit of Thunderhead Mtn. at the point where the trail passes along the S slope of Brier Knob, on the northwest face of the summit ca. 40 ft from the crest, COMMUNITY TYPE beech garden with well-spaced mature trees over seepy, exposed rock. COLLECTION No. 109H41A, on Betula lutea, mature tree with burl on S side.

SITE 110: No collections made.

SITE 111: ELEVATION 5000 ft; LOCATION state-line ridge just E of Cold Spring Knob, on N side of AT where trail climbs steeply on E slope of Cold Spring Knob, ca. 0.2 miles W of intersection with Miry Ridge Trail; COMMUNITY TYPE moderately open, high elevation deciduous forest dominated by Acer with many mature trees. COLLECTION No. 111H02A, on Betula lutea; 111H03B*, on Betula lutea; 111H18C, on Halesia carolina.

SITE 112: ELEVATION 4800 ft LOCATION Miry Ridge just SW of Ben Parton Lookout, on N slope of small knob along Miry Ridge Trail ca. 1.0 mile S of intersection with Lynn Camp Prong Trail; COMMUNITY TYPE margin of beech gap in high elevation deciduous forest. COLLECTION No. 112H46A', on Betula lutea, mature tree >20" dbh; 112H06B', on Fagus americana.

SITE 113: ELEVATION 5000 ft; LOCATION Goshen Ridge, extending N from the state-line ridge between Mt. Buckley and Double Spring Gap, in a broad saddle where Goshen Prong Trail enters the ridgetop, ca. 0.9 miles N to NW from its origin at the AT; COMMUNITY TYPE heavily damage spruce and hardwood forest with dense and tangled understory of Rhododendron and Rubus. COLLECTION No. 113H08A, on Betula lutea; 113H10B, on fallen Prunus pensylvanica.

SITE 114: No collections made.

SITE 115: ELEVATION 6000 ft; LOCATION Mt. Collins just SW of Meigs Post on summit, on S side of AT in open area, ca. 0.2 miles SE of junction with Sugarland Mtn. Trail; COMMUNITY TYPE closed spruce-fir stand with interspersed hardwoods, many mature trees. COLLECTION No. 115H01A, on Betula lutea; 115H15B, on Betula lutea; 115H19C, on Acer spicatum; 115H06C, on Acer spicatum. REPEAT COLLECTION No. 115H07A', on Betula lutea; 115H14B', on Betula lutea, branch; 115H21C', on Betula lutea; 115H16D', on Betula lutea; 115H02E', on branches; 115H24F', on Acer spicatum.

SITE 116: ELEVATION 5500 ft; LOCATION Fork Ridge, extending S of Mt. Collins on the state-line ridge, where Fork Ridge Trail descends away from the ridge crest, ca. 0.6 miles from its origin at the Clingmans Dome Road and ca. 0.2 miles S of massive boulders, just E of a saddle gap formerly used as a campsite; COMMUNITY TYPE high elevation deciduous gap in spruce-fir forest with moderately open canopy. COLLECTION No. 116H65A, on Betula lutea, mature tree with broken top; 116H36B*, on Betula lutea.

SITE 117: ELEVATION 4500 ft; LOCATION Short Beech Ridge extending S from Thomas Ridge, along W side of unnamed "Quiet Walkway" in small gap, ca. 0.3 miles from origin on Newfound Gap Road (441) SE of Newfound Gap; COMMUNITY TYPE mid-elevational deciduous forest dominated by Acer, on mesic, shaded ridgeline. COLLECTION No. 117H25A, on Acer rubrum; 117H08C, on Betula lenta.

SITE 118: ELEVATION 5000 ft; LOCATION Beetree Ridge extending SW of Thomas Ridge, on the summit of the knife edge ridge, just N of point where Thomas Divide Trail reaches the ridgeline in sharp left turn, ca. 0.7 miles from origin on Newfound Gap Road; COMMUNITY TYPE closed birch garden on mesic ridge. COLLECTION 118H03A, on Acer rubrum; 118H09B*, on Acer rubrum.

SITE 119: No collections made.

SITE 120: ELEVATION 3200 ft; LOCATION Richland Mtn. Ridge, extending S form Charlie's Bunion on the state-line ridge, in a narrow gap where unmaintained trails continue N and NW from the Smokemont Loop Trail ca. 1.0 mile from its origin at the Bradley Fork Trail; COMMUNITY TYPE mixed hardwood dominated by maple. COLLECTION No. 120H01A, on Acer rubrum, a group of 3 trees, 5-8" dbh; 120H01B, on Betula lenta.

SITE 121: ELEVATION 5000 ft; LOCATION Chiltoskie Ridge, on S slopes of knob above unmaintained trail where it descends the ridge nose to Stillwell Cr. ca. 0.5 miles SW of origin on Balsam Mtn. Road; COMMUNITY TYPE open oak forest on xeric, rounded ridgeline. COLLECTION No. 121H02A, on Acer rubrum; 121H01B*, on Acer rubrum.

SITE 122: ELEVATION 5700 ft; LOCATION Spruce Mtn. Ridge between Horsecreek Gap and Cataloochee Balsam summit, in narrow ridgeline NE of Cataloochee Balsam summit, on N side of

COMMUNITY TYPE spruce-fir with many dead fir. COLLECTION No. 122H04A, on Betula lutea, mature tree; 122H29B, on Betula lutea fallen branches; 122H08C, on Prunus pensylvanica.

SITE 123: ELEVATION 5500 ft; LOCATION Spruce Mtn. Ridge, SE of Cataloochee Balsam summit, on E side of Spruce Mtn. Trail on narrow rounded ridge, ca. 1 mile N of origin at Polls (Pauls) Gap on the Blue Ridge Parkway Spur Road; COMMUNITY TYPE moderately open high elevation deciduous forest dominated by Betula with many downed trees, on mesic ridgeline. COLLECTION No. 123H06A, on Betula lutea; 123H03B*, on Betula lutea; 123H30C, on Prunus pensylvanica.

SITE 124: ELEVATION 4000 ft; LOCATION Big Fork Ridge extending NE from Cataloochee Balsam on the Spruce Mtn. Ridge, on narrow ridgeline just E of switchback where Rough Fork Trial leaves ridgeline ca. 4 miles from origin at Polls (Pauls) Gap on the Blue Ridge Parkway Spur Road; COMMUNITY TYPE second growth, mid-elevation deciduous forest dominated by Acer. COLLECTION No. 124H05A, on Acer rubrum; 124H50B, on Acer rubrum.

SITE 125: No collections made.

SITE 126: No collections made.

SITE 127: ELEVATON 2800 ft; LOCATION Hannah Mtn. Ridge extending N from Mt. Lanier, on the E slopes of the ridge above Hannah Mtn. Trial just SW of the point where it circles a small knob on the ridge and descends to Flint Gap, ca. 3 miles from origin at Sams Gap on Parsons Branch Road; COMMUNITY TYPE moderately open pine-oak forest. COLLECTION No. 127H12A, on Acer rubrum; 127H07B, on Oxydendron arboreum.

SITE 128: No collections made.

SITE 129: ELEVATION 3100 ft; LOCATION Gregory Ridge extending N of Gregory's Bald on the state-line ridge, along Gregory Ridge Trail just N along ridgeline from point where trail reaches the ridge crest, ca. 2.5 miles from origin at turnaround on Forge Cr. Road; COMMUNITY TYPE moderately open, pine-oak stand on xeric ridge. COLLECTION No. 129H06A, on Acer rubrum.

SITE 130: ELEVATION 4500 ft; LOCATION Mollies Ridge, extending W from the state-line ridge between Russell Field and Doe Knob, along the AT ca. 2.2 miles SW from Russell Field, where Mollie's Ridge diverges from the state-line ridge just W of trail shelter; COMMUNITY TYPE high elevation deciduous forest dominated by birch on mesic ridge. COLLECTION No. 130H02A, on Acer rubrum 5" dbh; 130H05B, on Halesia carolina.

SITE 131: ELEVATION 4300 ft; LOCATION Leadbetter Ridge, just W of McCampbell Ridge, between the two sections of Russell Field in a broad flat saddle gap just NW of the spring, along the Russell Field Trail ca. 3.3 miles from its origin at the Anthony Cr. Trail; COMMUNITY TYPE open birch garden

between rhododendron tunnels. COLLECTION No. 131H04A, on Betula lutea branches; 131H01B, on Betula lutea; 131H22C, on Prunus pensylvanica.

SITE 132: ELEVATION 4800 ft; LOCATION Mt. Squires Ridge, just W of Spence Field on the state-line ridge, along the AT ca. 0.2 miles NW from junction with Bote Mtn. Road at Spence Field; COMMUNITY TYPE over-grown section of grassy bald dominated by oak. COLLECTION No. 132H02A, on Betula lutea with many low hanging branches; 132H03B, on Betula lutea; 132H15C, on Acer rubrum.

SITE 133: ELEVATION 5100 ft; LOCATION Rocky Top Ridge, just W of summit on the state-line ridge, where the AT passes N of a small outcrop before ascending steeply to the summit, ca. 2 miles from junction with Bote Mtn. Road; COMMUNITY TYPE open beech forest with mature birch trees on the slopes. COLLECTION No. 133H02A, on Betula lutea; 133H34B, on Betula lutea; 133H02C, on Betula lutea; 133H08D, on exposed rock under Betula lutea.

SITE 134: ELEVATION 5000 ft; LOCATION Thunderhead Mtn. Ridge, between Beechnut Gap and the summit, in a broad, flat saddle at the point where an alternate path leaves the N side of the AT, ca. 0.6 E of the summit of Thunderhead Mtn.; COMMUNITY TYPE beech forest with mature birch. COLLECTION No. 134H02A, on Betula lutea with two boles diverging from the base to form a broad "V" shape; 134H04B*, on Betula lutea.

SITE 135: ELEVATION 4900 ft; LOCATION Derrick Knob on state-line ridge, just W of summit on the E edge of Derrick Knob Trail Shelter clearing, along Appalachian Trail ca. 0.3 miles W of intersection with Greenbrier Ridge Trail; COMMUNITY TYPE beech garden with many mature trees. COLLECTION No. 135H06A, on Betula lutea.

SITE 136: ELEVATION 4700 ft; LOCATION state-line ridge SW of Hemlock Knob, SE of the AT in a narrow gap ca. 1 mile NE of AT intersection with the Greenbrier Ridge Trail, COMMUNITY TYPE beech gap, with many mature trees. COLLECTION No. 136H02A, on Betula lutea.

SITE 137: ELEVATION 5300 ft; LOCATION Welch Ridge extending S from Silers Bald, in narrow gap between small knobs, on W side of Welch Ridge Trail, ca. 0.5 miles from origin at AT at Silers Bald; COMMUNITY TYPE moderately open, high elevation deciduous forest dominated by Fagus, with many mature trees and stnading dead Betula lutea. COLLECTION No. 137H42A, on Betula lutea, mature tree; 137H02B, on Betula lutea.

SITE 138: ELEVATION 5500 ft; LOCATION Double Spring Gap on the state-line ridge W of Mt. Buckley, on E slopes of small knob at edge of clearing just NW of trail shelter, along the Appalachian Trial ca. 4 miles from Forney Ridge Parking Area; COMMUNITY TYPE beech gap in spruce forest.

COLLECTION No. 138H04A, on Betula lutea; 138H17B, on Betula lutea; 138H07C, on Betula lutea branches; 138H05D, on Fagus americana; 138H31E, on Acer spicatum.

SITE 139: ELEVATION 6100 ft; LOCATION state-line ridge just W of Mt. Buckley, along the Appalachian Trail where trail descends to Double Springs Gap and turns slightly to the N, ca. 1 mile W of junction with the Forney Ridge Trail; COMMUNITY TYPE closed spruce-fir forest on mesic slope. COLLECTION No. 139H10A, on Betula lutea 12" dbh adjacent to mature spruce; 139H21B, on Betula lutea; 139H16C, on Betula lutea.

SITE 140: ELEVATION 6400 ft; LOCATION Mt. Love on state-line ridge, on N edge of large clearing, possibly abandoned campsite, along Appalachian Trial ca. 1 mile NE of Clingmans Dome Tower; COMMUNITY TYPE clearing in spruce-fir with many saplings and shrubs. COLLECTION No. 140H56A, on Betula lutea branches.

SITE 141: ELEVATION 5300 ft; LOCATION Noland Divide Ridge, N of Roundtop Knob, narrow gap on the ridgeline just N of Round Top Knob, along Noland Divide Trail ca. 2 miles from origin on Clingmans Dome Road near Webb Overlook; COMMUNITY TYPE moderately open high elevation deciduous gap in spruce-fir forest. COLLECTION No. 141H05A, on Betula lutea; 141H04C, on Betula lutea. REPEAT COLLECTION No. 141H08A', on Betula lutea; 141H08B', on Betula lutea; 141H04C', on fallen branch; 141H63D', on Prunus pensylvanica; 141H40E', on Prunus pensylvanica, fallen bole.

SITE 142: ELEVATION 3700 ft; LOCATION Fork Ridge, extending SE from Mt. Collins on the state-line ridge, N of a knob where the Fork Ridge Trail crosses the W slope before entering a saddle in a series of small knobs, ca. 4 miles from its origin on the Clingmans Dome Road; COMMUNITY TYPE pine-oak stand with dense heath understory. COLLECTION No. 142H05A, on Acer rubrum; 142H06B, on Acer rubrum; 142H04D, on Quercus sp.; 142H18E, on Oxydendron arboreum; 142H02F, on Betula lenta.

SITE 143: ELEVATION 4700 ft; LOCATION Tuskee Gap on Thomas Divide Ridge, along the Thomas Divide Trail ca. 3.5 miles from origin on Newfound Gap Road S of Newfound Gap, COMMUNITY TYPE high elevation deciduous forest dominated by Betula lutea in mesic gap. COLLECTION No. 143H05A, on Acer rubrum.

SITE 144: ELEVATION 4500 ft; LOCATION unnamed ridge, extending E form Newton Bald, E of Newton Bald Trial on narrow ridgeline where trail ascends steeply to summit, ca. 3.5 from origin at Smokemount Camping Area; COMMUNITY TYPE closed, mid-elevation deciduous forest dominated by Acer on mesic ridgeline. COLLECTION No. 144H 06A, on Acer rubrum; 144H20B, on Acer rubrum; 144H10C, on Acer rubrum.

SITE 145: ELEVATION 2700 ft; LOCATION Richland Mtn. Ridge, extending SW from Charlies Bunion on the state-line ridge, along unmarked, unmaintained trail where the trail climbs steeply and

crosses a ridge nose on the west slopes of the main ridge, ca. 0.5 miles N of origin on the Smokemont Nature Loop; COMMUNITY TYPE moderately open oak ridgeline with dense heath understory. COLLECTION No. 145H03A, on Acer rubrum; 145H01B, on Pinus strobus.

SITE 146: ELEVATION 5250 ft; LOCATION Heintooga Ridge, just S of Heintooga Overlook, just S of Flat Cr. Trail intersection marked with trail sign, ca. 0.1 miles from origin at Heintooga Overlook Parking Are; COMMUNITY TYPE beech garden in high elevation deciduous forest. COLLECTION No. 146H07A, on Betula lutea; 146H02B, on Acer rubrum; 146H08C, on Faqus americana.

SITE 147: No collections made.

SITE 148: No collections made.

SITE 149: ELEVATION 2700 ft; LOCATION Bunker Hill summit WNW of Parsons Bald, NW margin of clearing for lookout tower, along Bunker Hill Road ca. 2 miles NW of origin on Parsons Branch Road; COMMUNITY TYPE moderately open pine-oak forest on xeric, rounded knob. COLLECTION No. 149 H04A, on Acer rubrum.

SITE 150: ELEVATION 3500 ft; LOCATION Hannah Mtn. Ridge NW of Gregory Bald, on an exposed ridge point just S of narrow gap where Gregory Bald Trail first reaches the ridgeline, ca. 2.5 miles from origin on Parsons Branch Road; COMMUNITY TYPE moderately open p ne forest with hardwoods. COLLECTION No. 150H04A, on Acer rubrum; 150H06B, on Oxydendron arboreum; 150H04C, on Magnolia sp.; 150H02D, on Carya sp.

SITE 151: ELEVATION 4100 ft; LOCATION Gregory Ridge extending NW form Gregory's Bald, on main ridgeline along Gregory Ridge Trail ca. 4 miles from origin at turnaround on Froge Cr. Road and ca. 1 mile S of Rich Gap; COMMUNITY TYPE mid-elevation deciduous forest dominated by Acer on mesic, broad saddle gap on ridgeline. COLLECTION No. 151H07A, on Acer rubrum; 151H12B, on Acer rubrum; 151H12C, Betula lenta.

SITE 152: ELEVATION 4500 ft; LOCATION Doe Knob on state-line ridge, between Gregory's Bald and Russell Field where Twenty Mile Ridge extends S, along abandoned trail across the summit, just E of junction of Gregory's Bald Trail and the AT; COMMUNITY TYPE open oak forest on xeric and exposed knob on the margin of a overgrown grassy bald. COLLECTION No. 152H01A, on Quercus rubra var. borealis; 152H15B, on Prunus pensylvanica.

SITE 153: ELEVATION 4500 ft; LOCATION Big Grill Ridge, extending SE from Devils Tater Patch on the state-line ridge, along the AT ca. 1.8 miles SW of junction with Russell Field Trail, at a point ca. 100 yds S of the summit of Devil's Tater Patch; COMMUNITY TYPE closed deciduous forest dominated by oak. COLLECTION No. 153H01A, on Acer rubrum; 153H10B*, on cer rubrum; 153H08C, on Acer rubrum.

SITE 154: No collections made.

SITE 155: ELEVATION 4400 ft; LOCATION Jenkins Ridge, S of De Armond Bald, between Cherry Knob and Haw Gap, on steep S slope of ridge where Jenkins Ridge Trail descends to narrow gap, ca. 3.5 miles from origin at the AT at Spence Field; COMMUNITY TYPE mid-elevation deciduous forest dominated by Acer on xeric ridgeline. COLLECTION No. 155H20A, on Acer saccharum; 155H06B, on Acer saccharum; 155H07C, on Acer saccharum.

SITE 156: ELEVATION 2500 ft; LOCATION Bone Valley Homesite, edge of clearing along the Big Flats Branch, on the Bone Valley Trail ca. 1.7 miles from origin at Hazel Cr. Trail; COMMUNITY TYPE second growth dominated by pine with an assortment of native and cultivated species. COLLECTION No. 156H04A, on Prunus cerasus (cultivar); 156H02B, on Liriodendron tulipfera.

SITE 157: No collections made.

SITE 158: ELEVATION 4700 ft; LOCATION Welch Ridge N of Mt. Glory, in narrow gap just N of Mt. Glory summit along Welch Ridge Trail, ca. 4.5 miles from origin on AT at Silars Bald; COMMUNITY TYPE closed oak forest on xeric ridge. COLLECTION No. 158H02A, on Quercus rubra var. borealis; 158H02B*, on Betula lutea; 158H03C, on Quercus rubra var. borealis.

SITE 159: ELEVATION 4700 ft; LOCATION Welch Ridge SW of Mule Gap, in a broad saddle in ridge along Welch Ridge Trail just N of intersection with Jonas Cr. Trail, ca. 2.2 miles from origin on AT at Silars Bald, Community type closed mid-elevation deciduous forest dominated by oak on mesic ridgeline. COLLECTION No. 159H04A, on Acer rubrum; 159H05B*, Acer rubrum; 159H02C, on Acer rubrum; 159H03D, on Acer rubrum.

SITE 160: No collections made.

SITE 161: ELEVATION 5200 ft; LOCATION Forney Ridge N of Buckhorn Bald, N side of Forney Ridge Trial on the crest of a narrow ridge, just E of point where trail crosses narrow ridge spur and turns sharply south, ca. 3 miles from origin at Forney Ridge Parking Area on Clingmans Dome Road; COMMUNITY TYPE high elevation deciduous forest dominated by Fagus. COLLECTION No. 161H02A, on Betula lutea; 161H02B, on Betula lutea; 161H01C, on Betula lutea; 161H03D, on Betula lutea.

SITE 162: ELEVATION 5700 ft; LOCATION Forney Ridge NW of Andrew's Bald, on N edge of bald where Forney Ridge Trail enters forest, ca. 1.5 miles from origin at Forney Ridge Parking Area on Clingmans Dome Road; COMMUNITY TYPE, spruce forest with interspersed high elevation deciduous gaps. COLLECTION No. 162H02A, on Betula lutea; 162H20B, on Prunus pensylvanica.

SITE 163: ELEVATION 4200 ft; LOCATION Upper Sassafras Gap on Noland Divide just N of Sassafras Knob, just E of gap at head of Pole Road Creek Trail along Noland Divide Trail, ca. 8.3 miles from origin on Clingmans Dome Road near Webb Overlook; COMMUNITY TYPE open, mid-elevation

deciduous forest dominated by Acer, on xeric, narrow ridge. COLLECTION No. 163H04A, on Acer rubrum; 163H20B, on Acer rubrum.

SITE 164: ELEVATION 3500 ft; LOCATION Sunkota Ridge just N of Martins Gap, at N end of the narrow gap on E side of Sunkota Ridge Trail just N of intersection with Indian Cr. Trail; COMMUNITY TYPE open, mie-elevation deciduous forest dominated by Acer in pine oak ridge. COLLECTION No. 164H03A, on Acer rubrum; 164H03B*, on Acer rubrum; 164H05C, on Oxydendron arboreum; 164H07D, on Sassafras albidum.

SITE 165: ELEVATION 4700 ft; LOCATION Sunkota Ridge extending SW from Thomas Divide, on S facing ridge spur as Sunkota Ridge Trail skirts S slopes of small knob, ca. 0.5 miles SW of intersection with Thomas Divide Trail; COMMUNITY TYPE open oak forest with heath understory. COLLECTION No. 165H19A, on Acer rubrum; 165H12B, on group of ten Acer rubrum boles, 2-6" dbh; 165H12B, on Acer rubrum.

SITE 166: ELEVATION 4700 ft; LOCATION Newton Ridge extending S from Newton Bald, along E side of Mingus Cr. Trail just N of steep descent down S slope of ridge, ca. 1 mile from origin on Newton Bald Trail; COMMUNITY TYPE open, mid-elevation deciduous forest dominated by Acer. COLLECTION No. 166H05A, on Acer rubrum.

SITE 167: ELEVATION 2100 ft; LOCATION unnamed ridge, just N of Mingus Mill Parking Area, ca. 20 yds along manway to slave cemetery, at edge of cemetery marked by uncarved stones; COMMUNITY TYPE second growth forest dominated by maple and oak. COLLECTION No. 167H05A, on Acer rubrum.

SITE 168: No collections made.

SITE 169: ELEVATION 4600 ft; LOCATION Parsons Bald on ridge extending SW from Gregory's Ridge, on isolated trees in center of bald along Wolf Ridge Trail, ca. 0.5 miles from origin on Gregory's Bald Trail at Sheep Pen Gap; COMMUNITY TYPE grassy bald. COLLECTION No. 169H20A, on Prunus pensylvanica, low hanging branches; 169H07B, on Betula lutea branches, at N margin of bald.

SITE 170: ELEVATION 4400 ft; LOCATION Rye Patch on Long Hungry Ridge extending S from the state-line ridge, at SW end of clearing, S of Long Hungry Ridge Trail where it turns sharply E and leaves the ridgeline, ca. 1 miles from origin on Gregorys Bald Trail at Rich Gap; COMMUNITY TYPE over-grown grassy meadow. COLLECTION No. 170H05A, Quercus sp., low hanging branches.

SITE 171: ELEVATION 4300 ft; LOCATION Twentymile Ridge just S of Greer Knob, on the SW side of AT where it reaches the ridgeline after skirting the W slopes of Greer Knob, ca. 1 mile S of intersection with Gregory's Bald Trail at Doe Knob; COMMUNITY TYPE 171H07A, on Oxydendron arboreum; 171H04B, on Quercus rubra var. borealis; 171H03C, on Quercus rubra var. borealis.

SITE 172: No collections made.

SITE 173: No collections made.

SITE 174: ELEVATION 3050 ft; LOCATION Jenkins Ridge just N of Pickens Gap, on the W slope of a small knob, above Jenkins Ridge Trail where it skirts the E slope of this knob, ca. 0.2 miles NE of intersection with Sugar Fork Trail at Pickens Gap; COMMUNITY TYPE open pine stand on xeric ridgeline. COLLECTION No. 174H01A, on Acer saccharum.

SITE 175: ELEVATION 2300 ft; LOCATION Hall Homesite along Bone Valley Cr, W margin of open grassy area, W of first stream crossing along Bone Valley Trail, ca. 0.4 miles from origin on Hazel Cr. Trail at Bone Valley Campsite; COMMUNITY TYPE second growth hardwood forest dominated by tulip poplar. COLLECTION No. 175H05C, on Betula lenta; 175H02A, on Acer saccharum.

SITE 176: ELEVATION 2400 ft; LOCATION old homesite on flood plain of Hazel Creek NE of Bone Valley Campsite, on SE side of stream in large, flat homesite area along Hazel Cr. Trail ca. 6.5 miles NE of origin at the mouth of Hazel Cr. on Fontana Lake; COMMUNITY TYPE second growth forest dominated by tulip poplar. COLLECTION No. 176H01B, on Oxydendron arboreum; 176H02A, on Carya sp.

SITE 177: ELEVATION 4900 ft; LOCATION Welch Ridge SW of Bearwallow Bald, SE side of Welch Ridge Trail on margin of grassy bald, ca. 6 miles SW of origin on AT at Silars Bald, just N of intersection with Jump-Off Ridge Trail; COMMUNITY TYPE mid-elevation deciduous forest dominated by Quercus rubra var. borealis on mesic, rounded ridge. COLLECTION No. 177H07A, on Betula lutea, mature tree with half of lower bole missing, remaining bole liginocolous; 177H04B, on Betula lutea.

SITE 178: No collections made.

SITE 179: ELEVATION 4000 ft; LOCATION Forney Ridge S of Board Camp Gap, rim of narrow gap at terminus of Forney Ridge Trail ca. 6.8 SW of origin at Forney Ridge Parking Area on Clingmans Dome Road, just N of intersection with Bee Gum Branch Trial; COMMUNITY TYPE closed oak forest on xeric ridge. COLLECITON No. 179H03A, on Acer rubrum; 179H03B, on Quercus sp.; 179H01C, on Quercus sp.

SITE 180: ELEVATION 4000 ft; LOCATION Forney Ridge NE of Board Camp Gap, S slope of large knob along Forney Ridge Trail, ca. 5.5 miles SW of origin at Forney Ridge Parking Area on Clingmans Dome Road, just N of intersection with Spring House Branch Trail; COMMUNITY TYPE moderately open, mid-elevation deciduous forest dominated by Fagus on xeric ridge nose. COLLECTION No. 180H02A, on Acer rubrum; 180H14B, on Acer rubrum; 180H10C, on Quercus sp.

SITE 181: ELEVATION 4400 ft; LOCATION Noland Divide just S of Coburn Knob, on S slopes of Coburn Knob where Noland Divide Trail crosses small ridge nose, ca. 6.5 miles from origin on Clingmans Dome Road near Webb Overlook; COMMUNITY TYPE mid-elevation deciduous forest dominated by Acer on xeric ridge. COLLECTION No. 181H09A, on Acer rubrum; 181H05B, on Acer rubrum.

SITE 182: ELEVATION 4200 ft; LOCATION Noland Divide SW of Lower Sassafras Gap, on S slope of gap between two small knobs, along Noland Divide Trail ca. 4.5 miles SW of origin on Clingmans Dome Road near Webb Overlook; COMMUNITY TYPE open oak stand on xeric ridgeline. COLLECTION No. 182H04A, on Acer rubrum; 182H06B, on Acer rubrum.

SITE 183: ELEVATION 3300 ft; LOCATION Sunkota Ridge S of Martins Gap, E side of lower Sunkota Ridge Trail in a narrow gap between two knobs, ca. 1.5 NE of intersection with unnamed trail which connects Jenkins Place with Indian Creek Trail; COMMUNITY TYPE closed oak forest in xeric gap. COLLECTION No. 183H02A, on Acer rubrum; 183H07B, on Oxydendron.

SITE 184: ELEVATION 4200 ft; LOCATION Thomas Ridge SW of Deeplow Gap, SW of a summit in gap in ridgeline along Thomas Divide Trail ca. 4.9 miles NE of origin on Deep Creek Road; COMMUNITY TYPE second growth, closed oak-hickory forest on xeric ridge. COLLECTION No. 184H02A, on Acer rubrum; 184H01B, on Acer rubrum; 184H10C, on Acer rubrum.

SITE 185: No collections made.

SITE 186: No collections made.

SITE 187: ELEVATION 3800 ft; LOCATION Shuckstack Ridge just SE of Little Shuckstack, on ridge spur of Little Shuckstack where AT skirts the S slopes of knob, ca. 2.5 miles from trailhead on paved road at Fontana Dam; COMMUNITY TYPE closed oak hickory forest on xeric ridge. COLLECTION No. 187H01A, on Oxydendron arboreum; 187H05B, on Oxydendron arboreum; 187H03C, on Betula lenta.

SITE 188: No collections made.

SITE 189: No collections made.

SITE 190: ELEVATION 1900 ft; LOCATION in flood plain of the Horseshoe of Hazel Creek, old homesite, E end of bridge at creek crossing along Hazel Creek Trail, ca. 2 miles from origin at the mouth of Hazel Creek at Fontana Lake; COMMUNITY TYPE opening in second growth forest dominated by tulip poplar. COLLECTION No. 190H02A, on Acer rubrum.

SITE 191: No collections made.

SITE 192: ELEVATION 3000 ft; LOCATION unnamed ridge extending W from Welch Ridge along Cold Spring Branch, homesite area, S side of stream just E of the first stream crossing of Cold Spring

Branch Trail, ca. 1.5 miles from origin on Hazel Creek Trail; COMMUNITY TYPE second growth, mid-elevation deciduous forest dominated by Acer. COLLECTION No. 192H01A, on Betula lenta; 192H01B, on shrub cultivar.

SITE 193: ELEVATION 4400 ft; LOCATION Cold Spring Gap of Welch Ridge just S of High Rocks, E of gap in last switchback of Cold Spring Branch Trail, ca. 3.9 miles from origin on Hazel Creek Trail at terminus in gap; COMMUNITY TYPE open mid-elevation forest dominated by oak. COLLECTION No. 193H04A, on Halesia carolina; 193H04B, on Acer spicatum.

SITE 194: No collections made.

SITE 195: ELEVATION 2300 ft; LOCATION Forney Ridge S of junction with Tunnel Ridge, S slopes of small knob along the unmaintained lower section of Forney Ridge Trail at intersection with bridle path; COMMUNITY TYPE closed oak-hickory forest on xeric ridge. COLLECTION No. 195H03A, on Oxydendron arboreum; 195H03B, on Oxydendron arboreum.

SITE 196: No collections made.

SITE 197: Site not entered.

SITE 198: Site not entered.

SITE 199: Site not entered.

SITE 200: ELEVATION 2300 ft; LOCATION Tunnel Ridge SE of North Shore Road Tunnel, SE slope of small knob, along unnamed bridle path which originates at terminus of North Shore Road; COMMUNITY TYPE open oak-hickory stand on narrow, xeric ridgeline. COLLECTION No. 200H05A, on Oxydendron arboreum; 200H03B, on Prunus cerasus, cultivar on low elevation homesite.

SITE 201: ELEVATION 4000 ft; LOCATION Cove Mtn. just E of summit, N rim of gap at jeep trail intersection with Cove Mtn. trail, COMMUNITY TYPE mid-elevation forest dominated by Acer. COLLECTION 201H55A', on Acer rubrum; 201H56B', on Oxydendron arboreum; 201H88C', on Oxydendron arboreum.

APPENDIX 2

COLLECTIONS

COLLECTIONS OF HYPOGYMNIA PHYSODES FOR ANALYSIS

COLLECTION NO.[1]	PHOROPHYTE SPECIES	ELEVATION (FT)
001 H 11 A	Quercus sp.	2800
002 H 01 A	Betula lutea	4900
002 H 05 B	Fagus americana	
002 H 09 C	Prunus pensylvanica	
003 H 10 A	Quercus sp.	2500
003 H 05 B	Quercus sp.	
003 H 02 C	Prunus pensylvanica	
004 H 04 A	Quercus sp.	1900
004 H 07 B*	Quercus sp.	
004 H 12 C	Quercus sp.	
005 H 07 A	Quercus sp.	2200
005 H 02 B	Quercus sp.	
005 H 07 C	Rhododendron	
006 H 07 A	Betula lenta	4800
006 H 20 B	Prunus pensylvanica	
006 H 01 C	Rhododendron	
007 H 30 A	Prunus pensylvanica	4400
007 H 11 B	Prunus pensylvanica	
007 H 02 C	Betula lutea, fallen branch	
008 H 05 A	Acer rubrum	4500
008 H 25 B	Betula lutea	
008 H 01 C	Betula lutea, fallen	
008 H 01 D	Prunus pensylvanica	
009 H 11 A	Betula lutea	4800
009 H 05 B	Betula lutea	
009 H 06 C	Acer rubrum	
009 H 01 D	Betula lutea, fallen branch	
009 H 04 E	Ragus americana, fallen br.	
010 H 01 A	Acer rubrum	2700
010 H 02 B	Acer rubrum	
010 H 06 C	Acer, fallen bole	
010 H 01 D	Kalmia latifolia	

[1]Collection No.
001 H 11 A
| | | | |---substrate code, A-primary collection from tagged tree; B-secondary collection; etc.
| | | |---no. of individuals in collection (01-99)
| | |---species code, H-Hypogymnia physodes
|---collection cell no. (001-201)

011 H 01 A	Quercus sp.	2400
011 H 01 B	Rhododendron	
012 H 01 A	Quercus sp.	2600
012 H 02 B*	Quercus rubra	
012 H 06 C	Quercus rubra	
012 H 01 D	Quercus sp.	
012 H 01 E	Quercus sp., fallen branch	
012 H 02 F	Quercus sp., fallen bole	
013 H 06 A	Quercus rubra	2000
014 H 05 A	Acer rubrum	4500
014 H 25 B	Acer rubrum	
014 H 01 C	Betula lutea	
016 H 04 A	Betula lutea, fallen branch	3400
016 H 03 B	fallen branch	
017 H 15 A	Betula lutea, branches	6000
017 H 11 B	Betula lutea, branches	
017 H 05 C	Betula lutea	
018 H 06 A	Betula lutea, branches	5200
018 H 10 B	Rhododendron	
018 H 02 C	Prunus pensylvanics	
018 H 01 D	Fagus americana	
018 H 05 E	Betula lutea	
018 H 25 F	Betula lutea, branches	
019 H 21 A	Betula lutea	4900
019 H 01 B	Betula lutea, fallen branch	
019 H 12 C	Betula lutea	
019 H 10 D	Prunus pensylvanica, fallen branch	
019 H 14 E	Prunus pensylvanica, fallen bole	
021 H 20 A	Betula lutea	5100
021 H 11 B	Betula lutea, fallen	
021 H 06 C	Fagus americana	
022 H 01 A	Acer rubrum	2700
022 H 02 B	Oxydendron arboreum	
022 H 02 C	Oxydendron arboreum	
023 H 01 A	Magnolia sp.	3000
023 H 01 B	Quercus sp.	
023 H 05 C	Rhododendron	
023 H 10 D	Oxydendron arboreum	
023 H 02 E	Rhododendron	
023 H 02 F	fallen branches	
024 H 01 A	Acer rubrum, dwarfed	4900
024 H 10 B	Rhododendron	

025 H 01 A	Oxydendron arboreum	2000
025 H 01 B	Quercus sp.	
026 H 02 A	Quercus sp.	2800
026 H 02 B*	Quercus sp.	
026 H 17 C	Quercus sp., fallen branch	
026 H 17 C	Quercus sp., fallen branch	
028 H 19 A	Betula lutea, branches	5800
028 H 03 B	Betula lutea, branches	
028 H 10 C	Acer rubrum	
029 H 02 A	Betula lutea	5900
029 H 09 B*	Betula lutea	
029 H 14 C	Betula lutea, fallen	
030 H 01 A	Betula lutea	6000
030 H 01 B	Betula lutea	
031 H 08 A	Betula lutea, branches	5700
031 H 07 B	Betula lutea, branches	
031 H 04 C	Betula lutea	
032 H 03 A	Betula lutea	5300
032 H 54 B	Betula lutea, fallen	
033 H 09 A	Betula lutea	5700
033 H 13 B	Betula lutea	
033 H 06 C	Betula lutea	
033 H 12 D	fallen branches	
034 H 02 A	Oxdendron arboreum	1900
034 H 01 B	Oxdendron arboreum	
034 H 02 C	Pinus sp.	
035 H 01 A	Quercus sp.	2300
035 H 01 B	Acer rubrum, fallen	
035 H 01 C	Kalmia latifolia	
035 H 01 D	Quercus sp.	
036 H 08 A	Quercus rubra	3700
036 H 03 B	Quercus alba	
036 H 03 C	Quercus rubra	
037 H 03 A	Acer rubrum	2800
037 H 10 B	Kalmia latifolia	
037 H 01 C	Prunus sp.	
038 H 02 A	Acer rubrum	2900
038 H 03 B	Quercus sp.	
039 H 02 A	Acer rubrum	2400
039 H 02 B	Quercus sp.	

040 H 07 A	Oxydendron arboreum	3600
040 H 05 B	Prunus pensylvanica, fallen	
040 H 06 C	Prunus pensylvanica, fallen	
041 H 16 A	Betula lutea	4800
041 H 28 B	Prunus pensylvanica	
042 H 02 A	Betula lutea	5800
042 H 08 B	Betula lutea, fallen	
043 H 10 C	Prunus pensylvanica, fallen	
043 H 04 D	Picea rubra	
044 H 12 A	Betula lutea, branches	5600
044 H 40 B	Betula lutea	
044 H 03 C	Prunus pensylvanica	
044 H 02 D	Rhododendron	
045 H 06 A	Betula lutea	6000
045 H 07 B	Betula lutea	
045 H 08 C	Betula lutea	
045 H 24 D	Betula lutea, branches	
046 H 10 A	Betula lutea	6300
046 H 14 B	Betula lutea	
046 H 06 C	Betula lutea	
046 H 01 D	Betula lutea	
046 H 02 E	Betula lutea	
047 H 12 A	Betula lutea	6000
047 H 10 B	Betula lutea	
047 H 02 C	Betula lutea	
048 H 01 A	Betula lutea	5000
048 H 04 B	Acer rubrum	
049 H 06 A	Betula lutea, branches	5500
049 H 06 B*	Betula lutea, branches	
049 H 13 C	Prunus pensylvanica, fallen	
050 H 04 A	Betula lutea	5500
050 H 10 B	Betula lutea, fallen br.	
050 H 01 C	Betula lutea	
050 H 01 D	Prunus pensylvanica	
051 H 01 A	Betula lutea	4200
051 H 01 B*	Betula lutea	
051 H 14 C	Prunus pensylvanica, fallen br.	
051 H 01 D	Betula lutea, fallen br.	
052 H 02 A	Acer rubrum	3800
052 H 07 B	Acer sp.	
052 H 04 C	Oxydendron arboreum	
052 H 02 D	Oxydendron arboreum	
056 H 01 A	Quercus sp.	2000

057 H 01 A	Quercus sp.	2400
057 H 01 B	Quercus sp.	
058 H 08 A	Aesculus octandra	4600
058 H 05 B	Acer rubrum	
058 H 07 C	Rhododendron	
059 H 01 A	Quercus sp.	2500
060 H 05 A	Acer rubrum	3400
060 H 01 B	Oxydendron arboreum	
060 H 08 C	Prunus pensylvanica	
061 H 11 A	Prunus pensylvanica	4400
061 H 01 B	Oxydendron arboreum	
061 H 08 C	Prunus pensylvanica	
062 H 03 A	Betula lutea	4800
062 H 05 B	decorticated log	
062 H 03 C	twigs	
062 H 02 D	twigs	
063 H 17 A	Betula lutea, fallen branch	5200
063 H 04 B	fallen branches	
063 H 02 C	Betula lutea, fallen bole	
063 H 07 D	Acer sp.	
063 H 10 E	branches	
063 H 13 F	Rhododendron	
064 H 04 A	Betula lutea	5700
064 H 07 B*	Betula lutea	
064 H 03 C	branches	
064 H 01 D	Betula lutea	
065 H 20 A	Betula lutea	5500
065 H 06 B*	Betula lutea	
065 H 04 C	branches	
066 H 20 A	Betula lutea	5300
066 H 17 B	Betula lutea, branches	
067 H 05 A	Betula lutea	5300
067 H 03 B	Betula lutea	
068 H 04 A	Betula lutea	5800
068 H 35 B*	Betula lutea	
069 H 09 A	Betula lutea	5100
069 H 03 B	Betula lutea, branches	
069 H 03 B	Prunus pensylvanica	
070 H 04 A	Acer spicatum	4500

071 H 02 A	Betula lutea	5000
071 H 01 B*	Betula lutea	
071 H 01 C	Betula lutea	
072 H 11 A	Acer rubrum	4000
072 H 03 B	Acer rubrum	
072 H 50 C	Oxydendron arboreum	
073 H 05 A	Betula lenta	3000
073 H 06 B	Oxydendron arboreum	
073 H 01 C	fallen branch	
073 H 01 D	Betula lenta	
073 H 02 E	Liriodendron tulipifera	
074 H 01 A	Betula lenta	3900
074 H 05 B*	Betula lenta	
074 H 03 C	Betula lenta	
076 H 02 A	Quercus sp.	2000
076 H 01 B	Quercus sp.	
077 H 01 A	Acer rubrum	2100
077 H 01 B*	Acer rubrum	
077 H 04 C	Acer rubrum	
078 H 02 A	Quercus sp.	3100
078 H 17 B	Quercus sp.	
079 H 28 A	Quercus sp.	3500
079 H 12 B	Quercus sp.	
079 H 06 C	Quercus sp.	
079 H 02 D	Quercus sp.	
079 H 03 E	Quercus sp.	
079 H 02 F	Quercus sp.	
080 H 05 A	Quercus sp.	3300
080 H 03 B	Quercus sp.	
080 H 03 C	Quercus sp.	
081 H 02 A	Acer rubrum	2700
081 H 10 B	Rhododendron	
081 H 05 C	fallen branch	
084 H 01 A	Fagus americana	4400
084 H 08 B	Prunus pensylvanica	
085 H 01 A	Betula lutea	4400
085 H 02 B	Fagus americana, fallen bole	
085 H 04 C	Prunus pensylvanica, fallen bole	
088 H 20 A	Betula lutea	5400
088 H 18 B	Betula lutea	
089 H 12 A	Betula lutea	5600
089 H 20 B	fallen logs	

090 H 11 A	Betula lutea	5300
090 H 41 B	Betula lutea	
091 H 04 A	Betula lutea	5000
091 H 22 B	Betula lutea, fallen branch	
091 H 13 C	Betula lutea	
092 H 02 A	Betula lutea, branches	5300
092 H 08 B	Betula lutea, branches	
092 H 06 C	Betula lutea	
092 H 10 D	Acer rubrum	
092 H 15 F	Prunus pensylvanica	
092 H 02 E	Fagus americana	
093 H 03 A	Acer rubrum	4900
093 H 03 B	Acer rubrum	
094 H 12 A	Acer rubrum	4600
094 H 47 B	Acer rubrum	
094 H 04 C	Betula lenta	
095 H 04 A	Acer rubrum	4500
095 H 02 B	Acer rubrum	
095 H 03 C	Acer rubrum	
096 H 06 A	Betula lutea	4200
097 H 02 A	Betula lutea	5500
097 H 07 B	Betula lutea	
098 H 49 A	Betula lutea, branches	5600
098 H 06 B	Betula lutea, branches	
098 H 02 C	Betula lutea	
098 H 10 D	Prunus pensylvanica	
099 H 02 A	Acer rubrum	3400
099 H 01 B	Betula lutea	
099 H 14 C	Quercus sp.	
100 H 01 A	Acer rubrum	3400
100 H 04 B	Betula lenta	
100 H 05 C	fallen log	
100 H 29 D	fallen branches	
104 H 01 A	Oxydendron arboreum	2000
106 H 12 A	Acer rubrum	3600
106 H 12 B	Acer rubrum	
106 H 10 C	Acer sp., standing dead	
106 H 20 D	Oxydendron arboreum	
106 H 26 E	Quercus sp.	
107 H 18 A	Acer rubrum	3300
107 H 03 B	Acer rubrum	
107 H 08 C	Acer rubrum	

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108 H 02 A	Fagus americana	5000
108 H 02 B	Prunus, sp.	
109 H 41 A	Betual lutea	5100
111 H 02 A	Betual lutea	5000
111 H 03 B*	Betual lutea	
111 H 18 C	Halesia carolina	
113 H 08 A	Betula lutea	5100
113 H 10 B	Prunus pensylvanica, fallen	
115 H 01 A	Betual lutea	6000
115 H 15 B	Betual lutea	
115 H 19 C	Acer spicatum	
115 H 06 D	Acer spicatum	
116 H 65 A	Betula lutea	5500
116 H 36 B*	Betula lutea	
117 H 25 A	Acer rubrum	4500
117 H 08 C	Betula lenta	
118 H 03 A	Acer rubrum	5000
118 H 09 B*	Acer rubrum	
120 H 01 A	Acer rubrum	3200
120 H 01 B	Betula lenta	
121 H 02 A	Acer rubrum	5000
121 H 01 B*	Acer rubrum	
122 H 04 A	Betula lutea	5700
122 H 29 B	Betula lutea, fallen branch	
122 H 08 C	Prunus pensylvanica	
123 H 06 A	Betula lutea	5500
123 H 03 B*	Betual lutea	
123 H 30 C	Prunus pensylvanica	
124 H 05 A	Acer rubrum	4000
124 H 50 B	Acer rubrum	
127 H 12 A	Acer rubrum	2800
127 H 07 B	Oxydendron arboreum	
129 H 06 A	Acer rubrum	3100
130 H 02 A	Acer rubrum	4400
130 H 05 B	Halesia carolina	
131 H 04 A	Betula lutea, branches	4300
131 H 01 B	Betula lutea	
131 H 22 C	Prunus pensylvanica	

132 H 02 A	Betula lutea	4800
132 H 03 B	Betula lenta	
132 H 15 C	Acer rubrum	
133 H 02 A	Betula lutea	5100
133 H 34 B	Betula lutea	
133 H 02 C	Betula lutea	
133 H 08 D	exposed rock under Betula root	
134 H 02 A	Betula lutea	5000
134 H 04 B*	Betula lutea	
135 H 06 A	Betula lutea	4900
136 H 02 A	Betula lutea	4700
137 H 42 A	Betula lutea	5300
137 H 02 B	Betula lutea	
138 H 04 A	Betula lutea	5500
138 H 17 B	Betula lutea	
138 H 07 C	Betula lutea, branch	
138 H 05 D	Fagus americana	
138 H 31 E	Acer spicatum	
139 H 10 A	Betula lutea	6100
139 H 21 B	Betula lutea	
139 H 16 C	Betula lutea	
140 H 56 A	Betula lutea	6400
141 H 05 A	Betula lutea	5300
141 H 04 B	Betula lutea	
142 H 05 A	Acer rubrum	3700
142 H 06 B	Acer rubrum	
142 H 04 C	Quercus, sp.	
142 H 18 E	Oxydendron arboreum	
142 H 02 F	Betula lenta	
143 H 05 A	Acer rubrum	4700
144 H 06 A	Acer rubrum	4500
144 H 20 B	Acer rubrum	
144 H 10 C	Acer rubrum	
145 H 03 A	Acer rubrum	2700
145 H 01 B	Pinus strobus	
146 H 07 A	Betula lutea	5250
146 H 02 B	Acer rubrum	
146 H 08 C	Fagus americana	
149 H 04 A	Acer rubrum	2700

150 H 04 A	Acer rubrum	3500
150 H 06 B	Oxydendron arboreum	
150 H 04 C	Magnolia, sp.	
150 H 02 D	Carya, sp.	
151 H 07 A	Acer rubrum	4100
151 H 12 B	Acer rubrum	
151 H 12 C	Betula lenta	
152 H 01 A	Quercus rubra var borealis	4500
152 H 15 B	Prunus pensylvanica	
153 H 01 A	Acer rubrum	4500
153 H 10 B*	Acer rubrum	
153 H 08 C	Acer rubrum	
155 H 20 A	Acer saccharum	4400
155 H 06 B	Acer saccharum	
155 H 07 C	Acer saccharum	
156 H 04 A	Prunus cerasus (or cultivar)	2500
156 H 02 B	Liriodendron tulipfera	
158 H 02 A	Quercus rubra var. borealis	4700
158 H 02 B*	Betula lutea	
158 H 03 C	Quercus rubra var. borealis	
159 H 04 A	Acer rubrum	4700
159 H 05 B*	Acer rubrum	
159 H 02 C	Acer rubrum	
159 H 03 D	Acer rubrum	
161 H 02 A	Betula lutea	5200
161 H 02 B	Betula lutea	
161 H 01 C	Betula lutea	
161 H 03 D	Betula lutea	
162 H 02 A	Betula lutea	5700
162 H 20 B	Prunus pensylvanica	
163 H 04 A	Acer rubrum	4200
163 H 20 B	Acer rubrum	
164 H 03 A	Acer rubrum	3500
164 H 03 B*	Acer rubrum	
164 H 05 C	Oxydendron arboreum	
164 H 07 D	Sassafras albidum	
165 H 19 A	Acer rubrum	4700
165 H 12 B	Acer rubrum	
166 H 05 A	Acer rubrum	4700
167 H 05 A	Acer rubrum	2200

169 H 20 A	Prunus pensylvanica, branches	4600
169 H 07 B	Betula lutea, branches	
170 H 05 A	Quercus sp., branches	4400
171 H 07 A	Oxydendron arboreum	4300
171 H 04 B	Quercus rubra var. borealis	
171 H 03 C	Quercus rubra var. borealis	
174 H 01 A	Acer saccharum	3050
175 H 05 C	Betula lenta	2300
175 H 02 A	Acer saccharum	
176 H 01 A	Oxydendron arboreum	2400
176 H 02 B	Carya sp.	
177 H 07 A	Betula lutea	4900
177 H 04 B	Betula lutea	
179 H 03 A	Acer rubrum	4000
179 H 03 B	Quercus sp.	
179 H 01 C	Quercus sp.	
180 H 02 A	Acer rubrum	4000
180 H 14 B	Acer rubrum	
180 H 10 C	Quercus sp.	
181 H 09 A	Acer rubrum	4400
181 H 05 B	Acer rubrum	
182 H 04 A	Acer rubrum	3300
182 H 06 B	Acer rubrum	
183 H 02 A	Acer rubrum	
183 H 07 B	Oxydendron arboreum	
184 H 02 A	Acer rubrum	4200
184 H 01 B	Acer rubrum	
184 H 10 C	Acer rubrum	
187 H 01 A	Oxydendron arboreum	3800
187 H 05 B	Oxydendron arboreum	
187 H 03 C	Betula lenta	
190 H 02 A	Acer rubrum	1900
192 H 01 A	Betula lenta	3000
192 H 01 B	Shrub, cultivar	
193 H 04 A	Halesia carolina	4400
193 H 04 B	Acer spicatum	

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195 H 03 A	Oxydendron arboreum	2300
195 H 03 B	Oxydendron arboreum	
200 H 05 A	Oxydendron arboreum	2300
200 H 03 B	Prunus cerasus	

REPEAT COLLECTIONS OF HYPOGYMNIA PHYSODES FOR ANALYSIS

COLLECTION NO.	PHOROPHYTE	ELEVATION (FT.)	LOCATION
012 H 19 A'	Quercus sp.	2600	original site
012 H 08 B'	Oxydendron arboreum		''
012 H 03 C'	Acer rubrum		''
023 H 01 A'	Oxydendron arboreum	3000	original site
023 H 07 B'	Acer rubrum		''
023 H 24 C'	Oxydendron arboreum		new site
023 H 04 C'	Acer rubrum		''
038 H 03 A'	Acer rubrum	3000	new site 1
038 H 07 B'	Oxydendron arboreum		''
038 H 01 C'	Acer rubrum		new site 2
038 H 16 D'	Oxydendron arboreum		''
038 H 12 E'	Oxydendron arboreum, dead		''
039 H 01 A'	Oxydendron arboreum	2600	new site
039 H 05 B'	Quercus sp.		''
039 H 02 C'	Quercus sp.		''
039 H 02 D'	Magnolia sp.		original site
060 H 01 A'	Quercus alba	3400	original site
060 H 03 B'	Quercus alba		''
060 H 04 C'	Quercus sp.		''
060 H 11 D'	Oxydendron arboreum		''
060 H 12 E'	Quercus sp.		new site
060 H 08 F'	Oxydendron arboreum		''
060 H 04 G'	Quercus sp.		''
060 H 07 H'	Oxydendron arboreum		''
061 H 21 A'	Prunus pensylvanica	4400	original site
061 H 02 B'	Prunus pensylvanica		''
061 H 03 C'	Betula lutea		''
061 H 04 D'	Betula lutea		new site 1
061 H 22 E'	Prunus pensylvanica		''
062 H 05 A'	Betula lutea	5000	new site 1
062 H 04 B'	Branches		''
062 H 12 C'	Betula lutea		''
062 H 04 D'	Betula lutea		new site 2
062 H 08 E'	Betula lutea, fallen bole		original site
062 H 31 F'	Prunus pensylvanica		new site 3
064 H 50 A'	Betula lutea, branches	6000	new site
064 H 06 B'	Betula lutea		''
064 H 07 C'	Prunus pensylvanica		''
064 H 20 D'	Prunus pensylvanica		original site
064 H 06 E'	Betula lutea		''
065 H 20 A'	Betula lutea	6000	new site

080 H 02 A'	Oxydendron arboreum	3300	original site
080 H 61 B'	Oxydendron arboreum		''
080 H 05 C'	Oxydendron arboreum		''
080 H 01 D'	Jugulans sp.		new site
084 H 41 A'	Betula lenta	4400	new site
085 H 03 A'	Betula lenta, branch	4600	new site
085 H 27 D'	Acer rubrum		''
085 H 06 C'	Acer rubrum		original site
085 H 17 D'	Prunus pensylvanica, fallen		''
089 H 50 A'	Betula lutea	5600	original site
089 H 04 B'	Betula lutea, fallen branch		new site
089 H 16 C'	Betula lutea		''
090 H A'	Betula lutea	5500	new site
091 H A'	Betula lutea	5500	new site
112 H 46 A'	Betula lutea	4800	new site
112 H 06 B'	Fagus americana		''
115 H 07 A'	Betula lutea	6000	new site 1
115 H 14 B'	Betula lutea, branch		''
115 H 21 C'	Betula lutea		''
115 H 16 D'	Betula lutea		new site 2
115 H 02 E'	Branches		''
115 H 24 F'	Acer spicatum		''
141 H 08 A'	Betula lutea	5500	new site 1
141 H 08 B'	Betula lutea		''
141 H 04 C'	Fallen branch		''
141 H 63 D'	Prunus pensylvanica		new site 2
141 H 40 E'	Prunus pensylvanica, fallen		''
201 H 55 A'	Acer rubrum	4000	new site 1
201 H 56 B'	Oxydendron arboreum		''
201 H 88 C'	Oxydendron arboreum	3800	new site 2

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COLLECTIONS OF HYPOCOMIUM SPLENDENS FOR ANALYSIS

COLLECTION NO.	SITE LOCATION	ELEVATION (FT)
064 HYLO A	Walker Camp Prong Headwaters	5600
065 HYLO A	The Jump-Off Trailhead	6100
089 HYLO A	Mt. Mingus, along AT	5500
090 HYLO A	AT W of Sweat Heifer Trail Junction	6000
091 HYLO A	Mt. Ambler, along AT	5800
091 HYLO B	Mt. Kepler, AT W of Boulevard Junction	6100
114 HYLO A (misnumbered should be listed for section 139)	North Face of Clingman's Dome	6400
115 HYLO A	Mt. Collins, along AT	6000
140 HYLO A	Clingman's Dome, plot 305	6500
140 HYLO B	Rock outcrops, Mt. Love	6200
140 HYLO C	Mt. Love	6400
140 HYLO D	Clingman's Dome, along AT east	6400
141 HYLO A	Noland Ridge, near junction with Service Road	5500
141 HYLO B	Noland Ridge, just north of Roundtop Knob	5000

APPENDIX 3

PRESENTATION ABSTRACT

MAPPING ELEMENTAL CONCENTRATIONS IN GREAT SMOKY MOUNTAINS NATIONAL PARK WITH LICHENS

Paula T. DePriest, James P. Bennett, and Larry P. Gough

Paper presented, Eleventh Annual Scientific Research Meeting, The Uplands Areas of the Southeast Region National Park Service, Gatlinburg, TN, May 24, 1985.

Hypogymnia physodes (L.) Nyl., a foliose lichen, is being used to map the concentrations of elements associated with anthropogenic pollution in the Great Smoky Mountains National Park. This species is known to accumulate pollutants in concentrations positively correlated with the ambient level of those pollutants; and therefore, provides a relative measure of air quality. European mapping studies and laboratory fumigations have indicated that this species is moderately tolerant, and can be an effective monitor in areas of elevated pollution.

A grid of 200 cells, each 3×3 km^2, was drawn over a map of the Great Smoky Mountains National Park. H. physodes was collected in 159 (79%) of the cells between February and October 1984. Collection sites were located on ridgelines between 1500 and 6500 ft elevations. The preferred substrate was Betula lutea. Other hardwood species, Acer rubrum, Oxydendron arboreum, and Quercus sp. were used when B. lutea was not present or did not bear H. physodes. Repeat collections were made in the first ten sites in the spring of 1985, roughly one year later. The specimens were examined and mechanically cleaned of bark and other materials.

Analysis for 23 elements is currently being conducted at the U.S. Geological Survey in Denver. Of the 159 cells collected, 84 cells provided over 2 g of material, the amount required for analysis of all the elements. Of these elements, 22 are heavy metals and will be analysed using inductively coupled argon plasmospectrophotometry. Sulfur will be measured by complex of lichen material in a Leco furnace, oxidizing the elemental sulfur to sulfur dioxide.

BIBLIOGRAPHY

Addison, P.A. and K.J. Puckett. 1980. Deposition of atmospheric pollutants measured by lichen elemental content in the Athabasea oil sand areas. Can. J. Bot. 58:2323-2334.

Ahmadjian, V. 1982. The nature of lichens. Natural History 91:30-37.

Arvidsson, L. and M. Lindstrom. 1980. Forandringar i lavfloran i botaniska tradgarden i Goteburg. Svensk. Bot.Tidskr. 73:133-143.

Arvidsson, L. and L. Skoog. 1984. Svaveldioxens inverban pa lavfloran i Goteborgsomradet. [Effect of sulphur dioxide air pollution on the distribution of lichens in the Goteborg area, SW Sweden.] Svensk Bot. Tidskr. 78:137-144.

Barkman, J.J. 1963. De epiphyten-flora en vegetatie van Midden-Limburg (Belgie). Verh. K. ned. Akad. Wet. Tweed. sect. 54(4):1-46.

Barkman, J.J. 1958. Phytosociology and ecology of cryptogamic epiphytes. Van Gorcum, Assen.

Brown, D.H. and T.N. Hooken. 1977. The significance of acidic lichen substances in the estimation of chlorophyll and phaeophytn in lichens. New Phytol. 78:617-624.

Case, J.W. and H.R. Krouse. 1980. Variations in sulphur content and stable sulphur isotope composition of vegetation near a SO_2 source at Fox Creek, Alberta, Canada. Oecologia [Berlin] 44:248-257.

Case, J.W. 1984. The influence of three sour gas processing plants on the ecological distribution of epiphytic lichens in the vicinity of Fow Creek and Whitecourt, Alberta, Canada. Water, Air, and Soil Pollution 14:45-68.

Deruelle, S. 1977. Influence de la pollution atmospherique sur la vegetation lichenique des arbes Isoles dans la region de Mantes (Yvelines). Rev. Bryol. Lichenol. 43,2:137-158.

DeSloover, J. and F. L. Beams. 1968. Mapping of atmospheric pollution on the basis of lichen sensitivity. In: R. Misra and B. Gopal, eds. Proceedings of the Symposium on Recent Advances in Tropical Ecology, pp. 42-56.

DeWitt, T. 1976. Epiphytic Lichens and Air Pollution in the Netherlands. Cramer, Vaduz.

Dey, J.P. 1975. The fruticose and foliose lichens of the high-mountain areas of the southern Appalachians. Dissertation. Durham, NC: Duke University.

Dey, J.P. 1978. Frutiose and foliose lichens of the high-mountain areas of the southern Appalachians. Bryologist 81:1-93.

Erdman, J.A. and L.P. Gough. 1977. Variation in the element content of Parmelia chlorochroa Tuck from the Powder River Basin of Wyoming and Montana. Bryologist 80:292-303.

Felfoldy, L. 1942. A varosi Levego hatasa az epiphyton-zuzmovegetaciora Debrecenben. Acta Geobot. Hung. 4:332-349.

Ferry, B.W., M.S. Baddeley, and D.L. Hawksworth, eds. 1973. Air pollution and lichens. Toronto: University of Toronto Press.

Folkeson, L. 1979. Interspecies calibrations of heavy-metal concentrations in nine deposition measurements. Water, Air, Soil Pollution 11:253-260.

Gilbert, O.L. 1970a. A biological scale for the estimation of sulphur dioxide pollution. New Phytol. 69:629-634.

Gilbert, O.L. 1 970b. Further studies on the effects of sulphur dioxide on lichens and bryophytes. New Phytol. 69:605-627.

Gough, L.P. and J.A. Erdman. 1977. Influence of a coal-fired power plant on the element content of Parmelia chlorochroa. Bryologist 80:492-501.

Goward, T. and W.B. Schofield. 1983 (1984). The lichens and bryophytes of Burns Bog, Fraser Delta, Southwestern British Columbia [Canada]. Syesis 16(0):53-70.

Grindon, L.H. 1859. The Manchester Flora. London.

Hawksworth, D.L. 1971. Lichens as litmus for air pollution: a historical review. Intern. J. Environ. Studies 1:281-296.

Hawksworth, D.L. 1973. Mapping Studies. In: B.W. Ferry, M.S. Baddeley and D.L. Hawksworth, eds. Air Pollution and Lichens, pp. 38-76. London: Athlone Press.

Hawksworth, D.L. and F. Rose. 1970. Qualitative scale for estimating sulphur dioxide air pollution in England and Wales using epiphytic lichens. Nature (London), 227:45-48.

Hawksworth, D.L. and F. Rose, 1970. Qualitative scale for estimating sulphuric dioxide air pollution in England and Wales using epiphytic lichens. Nature 227:145-148.

Haynes, F.N. and D.I. Morgan-Huwes. 1970. Lichenologist 4:362-368.

Hocking, D., P. Kuchar, J.A. Plambeck and R.A. Smith. 1978. The impact of gold smelter emissions on vegetation and soils of a sub-arctic forest-tundra transition ecosystem. J. Air Poll. Cont. Assoc. 28:133-137.

Holopainen, T.H. 1983. Ultrastructual changes in epiphytic lichens, Bryoria capillaris and Hypogymnia physodes, growing near a fertilizer plant and a pulp mill in central Finland. Ann. Bot. Fenn. 20:169-185.

Holopainen, T.H. 1984a. Cellular injuries in epiphytic lichens transplanted to air polluted areas. Nord. J. Bot. 4:393-408.

Holopainen, T.H. 1 984b. Types and distribution of ultrastructural symptoms in epiphytic lichens in several urban and industrial environments in Finland. Ann. Bot. Fenn. 21:213-230.

Horntvedt, R. 1975. Epiphytic macrolichens on scots pine to air pollution from industry in Odda, Western Norway. Reports of the Norwegian Forest Research Institute. 31:384-604.

Johnsen, I. and U. Sochting. 1973. Influence of air pollution on the epiphytic lichen and bark properties of deciduous trees in Copehagen area. Oikos. 24:344-351.

Johnson, D.W. 1979. Air pollution and the distribution of corticolons lichens in Seattle, Washington. Northwest Sci. 53:257-263.

Kauppi, M. 1980. Fluorescence microscopy and microfluorometry for the examination of pollution damage in lichens. Ann. Bot. Fenn. 17:163-173.

Kauppi, M. and A. Mikkonen. 1980. Floristic versus single species analysis in the epiphytic lichens as indicators of air pollution in a boreal forest region, Northern Finland. Flora. 169:255-281.

Kershaw, K.A. 1964. Preliminary observations on the distributions and ecology of epiphytic lichens in Wales. Lichenologist 2:263-276.

Knabe, W. 1982. Monitoring of air pollution by wildlife, plants and plant exposure: suitable bioindicators for different emission types. In: L. Stenberg and H.J. Jager, eds. Monitoring of air pollution by plants: Methods & Problems. Junk. 59-72.

Krog, H. and N. Brandt. 1975. Lav som indikatorplant ved stdiet av luftforurensninger. E utdrag a noen prosjekter ved NILU i tiden 1970. Norsk Inst. Luftforskning. 1-28.

Krouse, H.R. 1977. Sulphur isotope abundances elucidate uptake of atmospheric sulphur emissions by vegetation. Nature 265:45-60.

Laaksovirta, K. and H. Olkkonen. 1977. Epiphytic lichen vegatation and element contents of Hypogymnia physodes and pine needles examined as indicators of air pollution at Kokkola, W. Finland. Ann. Bot. Fenn. 4:112-130.

Laaksovirta, K. and H. Olkkonen. 1979. Effect of air pollution on epiphytic lichen vegatation and elemental contents of lichen and pine needles at Valkeakosi, S. Finalnd. Ann. Bot. Fenn. 16:285-296.

Laaksovirta, K., H. Olkkonen, and P. Alabuilala. 1976. Observations on the lead content of lichen and bark adjacent to a highway in southern Finland. Environ. Poll. 11:247-255.

Laaksovirta, K. and J. Sibrola. 1975. Effect of air pollution by copper, sulphuric acid and fertilizer factories on plants at Harjovalta, W. Finalnd. Ann. Bot. Fenn. 12:81-88.

Laundon, J.R. 1967. A study of the lichen flora of London. Lichenologist. 3:277-327.

LeBlanc, F. 1969. Epiphytes and air polllution. In: Air Pollution: Proceedings of the First European Congress on the Influence of Air Pollution on Plants and Animals. Wageningen, 1968:211-221. Wageningen.

LeBlanc, F. and J. DeSloover. 1970. Relation between industrialization and the distribution and growth of epiphytic lichens and mosses in Montreal. Can. J. Bot. 48:1485-1496.

LeBlanc, F. and D.N. Rao. 1966. Reaction de quelques lichens at mousses ephiphytiques a l'anhydride sulphureux dans la region de Sudbury, Ontario. Bryologist. 69:338-346.

LeBlanc, F. and D.N. Rao. 1973. Effects of sulphur dioxide on lichen and moss transplants. Ecology. 54:612-617.

LeBlanc, F. and D.N. Rao. 1975. Effects of air pollutants on lichens and bryophytes. In: J.B. Mudd and T.T. Kozlowski, eds. Responses of Plants to Air Pollution. New York: Academic Press.

LeBlanc, F., D.N. Rao, and G. Comeau. 1971. Flouride injury symptoms in epiphytic lichens and mosses. Can. J. Bot. 49:1691-1698.

LeBlanc, F., D.N. Rao, and G. Comeau. 1972a. The epiphytic vegetation of Populus balsamifera and its significance as an air pollution indicator in Sudbury, Ontario. Can. J. Bot. 50:519-528.

LeBlanc, F., D.N. Rao and G. Comeau. 1972b. Indices of atmospheric purity and fluoride pollution pattern in Arivida, Quebec. Can. J. Bot. 50:991-998.

LeBlanc, F., G. Robitaille, and D.N. Rao. 1974. Biological Responses of lichens and bryophytes to environmental pollution in the Murdochville Copper Mine Area, Quebec. J. Hattori Bot. Lab. 38:405-433.

Lodenius, M. and K. Laaksovirta. 1979. Mercury content of Hypogemnia physodes and pine needles affected by a chloralkali works at Kuusankoski, SE Finland. Ann. Bot. Fenn. 16:7-10.

Lovette, G.M. 1984. Pollutant Deposition in Mountainous Terrains. In: P.S. White, ed. The Southern Appalachian Spruce-Fir Ecosystem: Its Biology and Threats, pp. 225-235. United States Department of the Interior. National Park Service-Southeast Region Research/Resources Management Report SER-71. Uplands Field Research Laboratory, Great Smoky Mountains National Park, Gatlinburg, TN.

Lounamaa, K.J. 1956. Trace elements in plants growing wild on different rocks in Finland. A semi-quantitative spectrographic survey. Ann. Bot. Soc. [Vanamo] 29(4):1-196.

Lounamaa, K.J. 1965. Studies on the content of iron, manganese and zinc in macrolichens. Ann. Bot. Fenn. 2:127-137.

Macher, M. and L. Steubing. 1984. Lichens and forest damage in Bayerischer Wald National Park [West Germany]. Beitr. Biol. Pflanz 59(2):191-204.

Makinen, A. and P. Pakarinen. 1977. Rasbasmet allibasbeumien sevranta sammalten ja jabalien arrilla. [Summary: Comparison of some forest and bog plants in heavy metal surveys.] Ymparisto ja Terveys 81:170-180.

Morgan-Huws, D.I. and F.N. Haynes. 1973. Distribution of some epiphytic lichens around an oil refinery at Fawley, Hampshire. In: B.S. Ferry, M.S. Baddeley, and D.L. Hawksworth, eds. Air Pollution and Lichens, pp. 89-108. London: Athone Press.

Nash, T.H. 1972. Simplification of the Blue Mountain lichen communities near a zinc factory. Bryologist 75:315-324.

Nash, T.H. 1976. Lichens as indicators of air pollution. Die Naturwissenschaften. 63:364-367.

Natho, G. 1964. Die verbreitung der epixlen flechten und algen im demokratischen berlin. Wiss. Zeitschr. Humboldt-Univ. Berlin, Math-Naturwiss. Reihe 13:53-57.

Newberry, G. 1974. T he influence of a sulfate process paper mill on corticolous lichens. Bryologist. 77:561-576.

Nieboer, E. and D.H.S. Richardson. 1981. Lichens as monitors of atmospheric deposition. In: S.J. Eisenreich, ed. Atmospheric Pollutants in Natural Waters, pp. 339-388. Ann Arbor: Ann Arbor Science Publishers.

Nylander, W. 1866. Les lichens du jardin du luxembourg. Bull. Soc. Bot. Fr. 13:364-372.

O'Hare, G.P. 1974. Lichens and bark acidification as indicators of air pollution in West Central Scotland. J. Biogeogr. 1:135-146.

O'Hare, G.P. and P. Williams. 1975. Some effects of sulphur dioxide flow on lichens. Lichenologist 7:116-120.

Olkkonen, H. and K. Takala. 1975. Total sulphur content of an epiphytic lichen as an index of air pollution and the usefulness of the X-ray fluorescence method in sulphur determinations. Ann. Bot. Fenn. 12:131-134.

Olkkonen, H. and K. Takala. 1976. Biological monitoring of air pollution in the urban area of Kuopio, pp. 215-217. Proc. Second National Meeting Biophysics Biotechnol. Helsinki, Finland.

Pararinen, P. and A. Makinen. 1976. Suosammalet jakalat ja mannyn neulaset raskasmetllien Keraajina. [Summary: Comparison of Pb, Zn, and Mn contents of mosses, lichens, and pine needles in raised logs.] Suo. 27:77-83.

Pyatt, F.B. 1973. Lichens as indicators of air pollution in a steel producing town in South Wales. Environ. Pollut. 1:45-56.

Rao, D.N. and F. LeBlanc. 1967. Influence of an iron-sentering plant on the epiphytic vegetation in Wawa, Ontario. Bryologist 70:141-157.

Roberts, B.A. and L.K. Thompson. 1980. Lichens as indicators of fluoride emission from a phosphorus plant, Long Harbour, Newfoundland, Canada. Can. J. Bot. 58:2218-2228.

Rose, F. and P.W. James. 1974. Regional studies on the British lichen flora. I. The corticolous and ligicolous species of the New Forest, Hampshire. Lichenologist 6:1-72.

Rosentreter, R. and V. Ahmadjian. 1977. Effect of ozone on lichen Cladonia arbriscula and the Treborixia phycobiont of Cladina stellavis. Bryologist 80:601-605.

Schonbeck, H. 1974. N achweiss schwermetallhaltiger immissionen durch ausgewahlte pflanzliche indikatoren. Staub Reinhalt. Luft 34:214-224.

Seaward, M.R.D. 1974. Some observations on heavy metal toxicity and tolerance in lichens. Lichenology 6:158-164.

Sernanda, R. 1926. Stockholms natur. Uppsala.

Skye, E. 1968. Lichens and air pollution. A Study of cryptogramic epiphytes and environment in the Stockholm region. Acta Phytogeogr. Svecica. 52:1-123.

Skye, E. and I. Hallberg. 1969. Changes in the lichen flora following air pollution. Oikos 20:547-552.

Sochting, U. and I. Johnsen. 1974. Changes in the distribution of epiphytic lichens in the Copehagen area from 1936 to 1972. Bot. Trdskr. 69:60-63.

Solberg, Y.J. 1967. Studies on the chemistry of lichens IV. The chemical composition of some Norwegian lichen species. Ann. Bot. Fenn. 4:29-34.

Steinnes, E. and H. Krog. 1977. Mercury, arsenic and selenium fall-out from an industrial complex studied by means of lichen transplants. Oikos. 28:160-164.

Swieboda, M. and A. Kalemba. 1978. The lichen Parmelia physodes (L.) Ach. as indicator for determination of the degree of atmospheric air pollution in the area contaminated by fluorine and sulphur dioxide emission. Acta Soc. Bot. Pol. 47:25-40.

Takala, K. and H. Olkkonen. 1976. Lead content of the lichen Psuedevernia furfuracea in the urban area of Kuopio, Central Finland. In: L. Karenlampi, ed. Proc. Kuopio Meet. Plant Damage Caused by Air Pollution, pp. 64-67.

Takala, K. et. al. 1978. Fluorine content of two lichen species in the vicinity of a fertilizer factory. Ann. Bot. Fenn. 15:158-166.

Tallis, J.H. 1964. Lichens and atmospheric pollution. Advan Sci. 21:250-252.

Taylor, J.R. and M.A. Bell. 1983. Effects of SO_2 on the lichen flora in an industrial area nortwest Whatcom county, Washington. Northw. Sci. 57(3):157-166.

Vaarnea, V.V. 1934. Helsingin kaupungin puiden ja pensaiden jakalakasvisto. Ann. Bot. Soc. Zool.-Bot. Fenn. [Vanamo] 5(6):1-32.

Vick, C.M. and R. Revan. 1976. Lichens and tar spot fungus (Rhytisema acerinun) as indicators of sulphur dioxide pollution on Mesrseydide. Environ. Poll. 11:203-216.

White, P.S. 1984. The southern Appalachian spruce-fir ecosystem, an introduction. In: P.S. White, ed. The Southern Appalachian Spruce-Fir Ecosystem: Its Biology and Threats, pp. 1-21. United States Department of the Interior. National Park Service-Southeast Region Research/Resources Management Report SER-71. Uplands Field Research Laboratory, Great Smoky Mountains National Park, Gatlinburg, TN.