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# The Seasonal, Altitudinal, and Vegetational Incidence of Black Bear Scats in the Great Smoky Mountains National Park

Susie Jo Kelly Matthews
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To the Graduate Council:

I am submitting herewith a thesis written by Susie Jo Kelly Matthews entitled "The Seasonal, Altitudinal, and Vegetational Incidence of Black Bear Scats in the Great Smoky Mountains National Park." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

Michael R. Pelton, Major Professor

We have read this thesis and recommend its acceptance:

Boyd L. Dearden, Ralph W. Dimmick

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Accepted for the Council:

Vice Chancellor
Graduate Studies and Research

# THE SEASONAL, ALTITUDINAL, AND VEGETATIONAL INCIDENCE OF BLACK BEAR SCATS IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Susie Jo Kelly Matthews

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# ABSTRACT

A study was conducted in the Great Smoky Mountains National Park to determine the variability of incidence of black bear scats as a reliable index to the population density. A total of 6085.7 km were hiked along six different routes, each hiked biweekly, from June-October, 1970-1975, resulting in the collection of 697 scats. The overall incidence of scats was 0.11 scats/km. The Elkmont-Bent Arm yielded 0.21 scats/km, Sugarlands Index Route 0.18 scats/km, Tremont-Derrick Knob Index Route 0.07 scats/km, Gregory-Hannah Mountain Index Route 0.06 scats/km, and Spence-Russell Index Route 0.03 scats/km. Variability in the scats/km over the nine hiking periods was partially attributed to the behavioral activities of breeding. Other factors such as the relative scarcity and abundance of summer and fall foods, climatic conditions, and pre-hibernation activities may have also influenced variability. The number of scats/km collected prior to and after the June-October time period was less, in both cases, except for the Spence-Russell Index Route. Factors possibly causing less evidence of bear presence along this route were the high degree of hiker use (40 percent higher than the next most popular trail) and the large number of horseback riders.

Bears preferred higher elevations in the Park during

the June-October period. The highest values of scats/km occurred between elevations of 1219-1371 m. Specific vegetation types in the higher elevations were also preferred over those same types in the lower elevations. Since certain abundant and available berry crops occur only in the higher elevations, it is assumed that this accounts for the apparent preference.

When the number of scats/km were analyzed in conjunction with a combination factor of altitude-vegetation, it was found that altitude had at least a 95 percent probability of influencing the location of scats along all routes except the Spence-Russell Index Route.

Numerous factors such as fluctuations in temperature, variations in precipitation, behavioral aspects of bears, etc., may influence the incidence of scats. Taking this into consideration when attempting to establish an independent index to monitor population fluctuations, it was found that certain statistical assumptions concerning factors that influence the variability of scats incidence would need to be made if the index was to be statistically valid. As these assumptions could not be made, a less sensitive but still effective equation was determined. Used in conjunction with the number of scats collected annually, the equation can be used as a check on population fluctuations.

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# CHAPTER I

## INTRODUCTION

Of primary importance in formulating a management plan for wildlife is the necessity to determine population density. Researchers have devoted much time, effort, and resources in developing accurate methods for assessing population numbers.

Current methods are classified into five general groupings. These involve direct counts of animals, capture of marked animals, reduction of the population size and subsequently the rate of capture, selective reduction or increase, and animal signs and related objects (Overton 1971). Obviously, the most desirable method is a total count of a species. However, only in rare cases is a direct count possible. Methods involving marked animals are more commonly used. These methods require considerable resources to set traps, mark animals, reset traps, and recapture the animals. Another general method, involving reduction of the population size and thus the rate of capture, is based on the principle that the rate of successful capture decreases as the population decreases; in this instance as in the above, the time and resources required are considerable. The method of selective reduction or increase, also known as the dichotomy method or change in composition, is more complex than the previous methods discussed. The structure of the population is first modeled into recognizable classes of animals and time. A population estimate is derived through use of various mathematical equations. In addition to the mathematical complexity, the main limitation of this method is that the exact numbers of animals at a specific time are not usually known. More frequently used is the measurement of sign or evidence of the presence of the species in question. Major factors that persuade researchers to utilize this last method are lack of funds, equipment, and personnel.

Animal signs, calls, or other indications of a species' presence are often used as indicators of population trends or as indexes to the relative abundance of a species. Depending on the species, the use of animal signs can yield a total count on one extreme, and on the other, indexes that are very difficult to calibrate (i.e., calls) (Overton 1971). Overton stated that, at best, this technique can be considered a double sample which he defines as an extensive count of the sign with an extensive analysis of the relationship between the counted variable and the animal. Watt (1968) felt that although measuring an animal population by the number of signs left per animal has a great many possible sources of error, in some circumstances it may prove to be useful as an independent check on other methods of estimating the same populations.

As for statistical properties and limitations encountered in using animal signs as an index to populations, Overton (1971) stated that they are identical to those statistical properties and limitations encountered in other types of index counts of animals.

Numerous papers concerning the use of animal signs as an index to population density have been published. One of the earliest was by McClure (1939) using dove calling activity. Use of the auditory index has also been extended to species such as ruffed grouse (Petraborg et al. 1953, Hungerford 1953), woodcock (Kozicky et al. 1954), Gambel quail (Smith and Gallizioli 1965), chukar partridge (Williams 1961), turkeys and even squirrels (Overton 1971). Track counts have also been used in the same manner (Overton 1971).

The pellet count technique has been used for numerous species. Not only has it been utilized as an index to population level but in some cases it has been calibrated to produce an estimate of the population number; most widely documented are those studies pertaining to deer, elk, and other ungulates (Bennett et al. 1940, Eberhardt and Van Etten 1956, Van Etten and Bennett 1965, Neff 1968, Batcheler 1975). The pellet count technique has also been used as an index to population trends for rabbits (Taylor and William 1956) and for red and fallow deer, goats, and brushtail opossum (Riney 1957). Conspicuously absent from the literature is mention of the pellet (or feces) count technique and its use for carnivores.

While the literature contains numerous articles on black bear (Ursus americanus), little can be found on practical, yet accurate methods of estimating population densities. Davenport (1953), in his research on agricultural depredation by bears, stated that he could find no accurate method for estimating population densities of bears. He resorted to estimating their numbers from kill figures, hunter estimates and sign. Spencer (1961) remarked that, "No wholly satisfactory method has been devised for censusing black bear." Some previous techniques used direct counts (Barnes and Bray 1967), multiple capture (Erikson and Petrides 1964), annual harvest data (Carpenter 1973), and radioactive feces tagging (Pelton and Marcum 1974). Only one researcher reported using black bear sign. Spencer (1961) used cruise lines; these were random cruises of known mileages made on foot and by canoe during which all signs (scats, tracks, marking posts, and stump workings) were noted. With the above information, in conjunction with kill estimates and visual observations, he was able to estimate population densities and trends.

Pelton (1972) indicated that bears in their daily movements seem to utilize trails and also tend to defecate on these trails. It was suggested that by hiking trails and collecting scats the data obtained could be used as an indirect estimation of population density or population trends. The present study attempted to determine the feasibility of using scats as an index to trends in black bear populations by (1) delineating the seasonal, altitudinal, and vegetative distribution of scats of black bears in the Great Smoky Mountains National Park (Park or GSMNP), and (2) determining the degree of variability of the incidence of scats on Index Routes by date and location.

CHAPTER II

# DESCRIPTION OF STUDY AREA

## Location and Physiography

The study area is located at the southern extreme of the Appalachian Mountains in the Blue Ridge Province. Within the southern section of this province is the Unaka Mountain Range which includes the Great Smoky Mountains National Park.

The Park encompasses 2072 $km^2$ and is located in sections of southeastern Tennessee and northwestern North Carolina. On the Tennessee side this includes parts of Blount, Cocke, and Sevier Counties and on the North Carolina side it includes sections of Swain and Haywood Counties.

Large sections of the Park's boundaries are also shared with the Cherokee National Forest, the Nantahala National Forest, the Pisgah National Forest, and the Cherokee Indian Reservation. The Little Tennessee River and Fontana Lake also border sections of the Park's boundary.

Excluding maintenance roads, which are closed to public vehicles, only two major paved roads are located in the Park; U. S. Highway 441 bisects the Park running north to south between Gatlinburg, Tennessee, and Cherokee, North

Carolina and Tennessee Highway 73 which connects Park Headquarters at Sugarlands and Cades Cove (Figure 1).

The topography of the Park is dominated by the crest of mountains which run northeast to southwest. For much of its length the altitude does not drop below 1524 m. Elevations range from a low of 266.4 m at the Abram's Creek-Little Tennessee River junction to a high of 2024.5 m at Clingman's Dome. The slopes of these rugged mountains tend to be steeper and more barren on the Tennessee side than those on the North Carolina side. Whittaker (1956) estimated that less than 10 percent of the land surface in the Park has less than a 10 degree slope.

Narrow V-shaped stream valleys penetrate the steep mountain slopes. These stream valleys drain into six major rivers; these are the Big and Little Pigeon Rivers, Tuckaseegee River, Oconaluftee River, Little River, and Little Tennessee River (King and Stupka 1950). There are no permanent lakes or ponds in the Park although numerous springs exist. Occasional ponding will occur in the cove areas where valleys are flat and broad, but this is only a seasonal phenomenon.

## Climate

Outside of the tropical areas of the world there are few places that can claim the vegetative diversity that

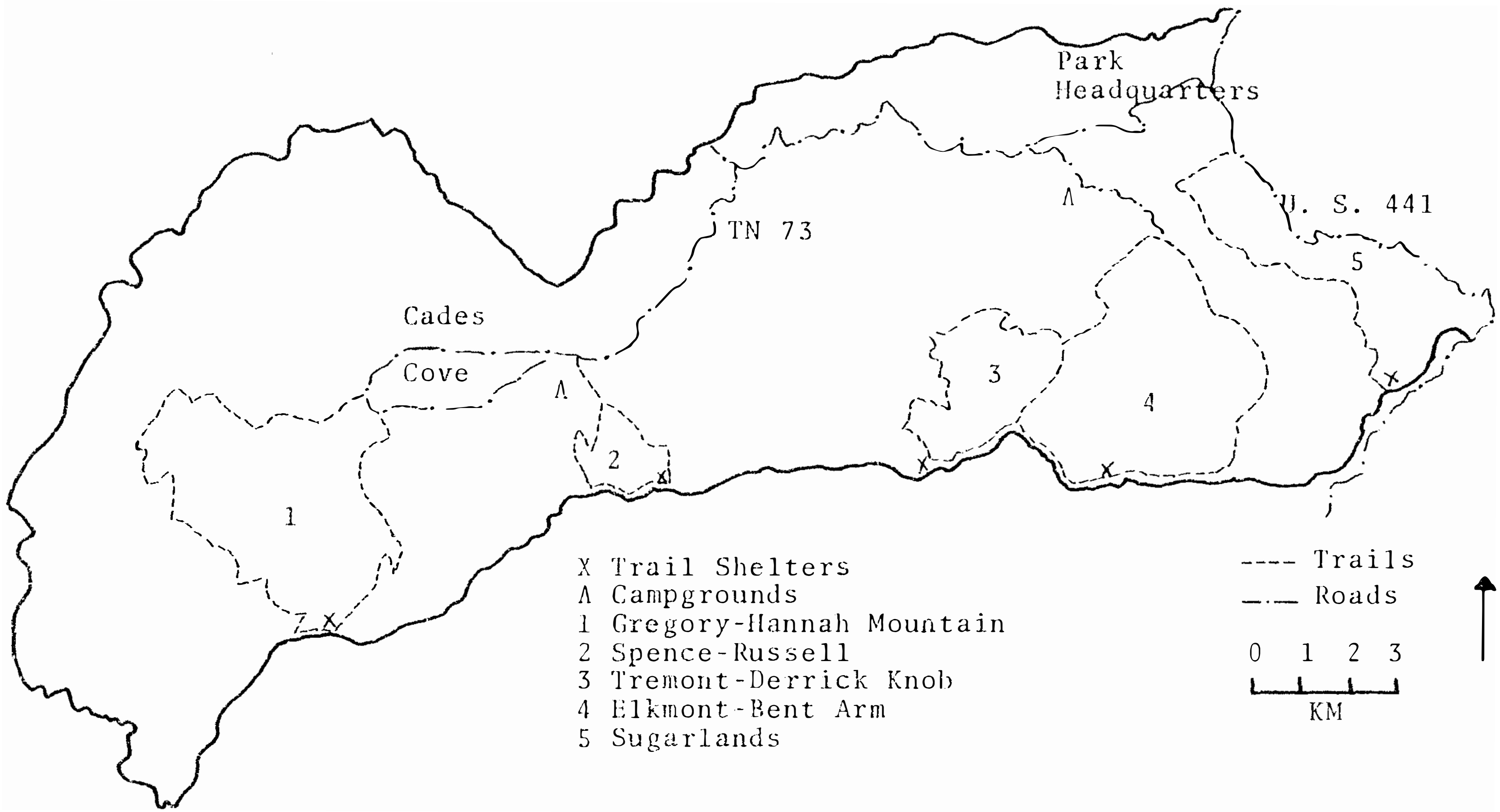


Figure 1. Map of the northwestern quarter of the Great Smoky Mountains National Park and Index Routes.

exists in the Great Smoky Mountains. A prime factor of this phenomenon is the climate. On an altitude-latitude equivalent the Great Smoky Mountains climate and vegetation most nearly resembles what one would experience if one would travel from east Tennessee to northeastern Maine and adjacent New Brunswick.

Temperature and precipitation change noticeably with an increase in altitude. Shanks (1954a) found precipitation amounts to have increased by 50 percent at the lower level of the spruce-fir forest (1372-1524 m) when compared to the amount that falls at the base of the mountain range (approximately 457 m). The mean annual precipitation ranges from 127-152 cm at the lower elevations to 229 cm at elevations over 1829 m (Shanks 1954a, Murless and Stallings 1974). The driest month of the year is usually September, with the wettest being July and August. Temperatures can be expected to decrease 1.20° C with every gain of 304 m in altitude. Temperatures in the spruce-fir forest (1372-1524 m) can be expected to be 5.6°-8.3° C cooler than those at the base of the mountains or in adjacent valleys. The average July temperatures range from 23.6° C in Gatlinburg at the base of the mountains to 14.7° C at Newfound Gap. In January the mean temperature in Gatlinburg is 3.9° C and at Newfound Gap, -5.2° C.

Vegetation

The vegetation of the Great Smoky Mountains National Park is considered to be one of the most diversified and unique in North America. The Blue Ridge Province has been continually occupied by plant life for perhaps 200 million years while other geographical regions of the country have been glaciated, flooded, and/or exposed to various forms of great climatic and physical changes (Cain 1937). Thus, the Great Smoky Mountains area acted as a haven and redistribution center for countless species that had been obliterated in other geographical regions. Due to its diversity and subsequent complexity, a thorough description of the flora of this area has proven to be a difficult task. The most thorough description of the vegetation of the area was accomplished by Whittaker (1956). He established vegetation patterns, vegetation types, and their distributional relations.

Shanks (1954b) established a physiographic site-elevation-moisture category into which all dominant tree species could be placed (Figure 1). Shanks' six categories include cove hardwood, northern hardwood, hemlock, spruce-fir, closed oak, and the combination of open oak-pine and balds (Figure 2 and Table 1).

Cove hardwood forests are characteristic of cove areas and sheltered slopes up to elevations of 1372 m. Deep, well drained soils are prerequisite to this forest type.

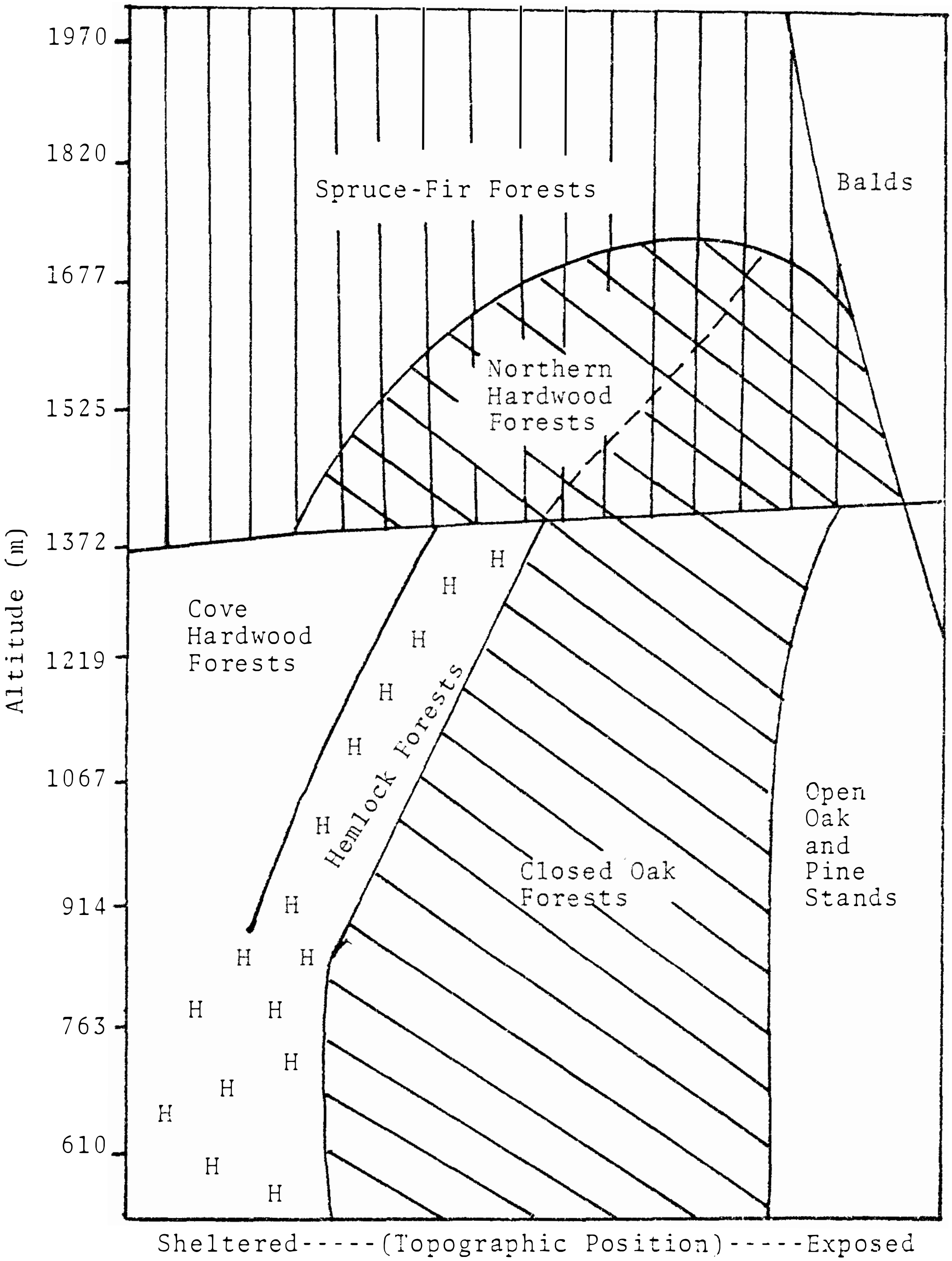


Figure 2. Vegetation pattern of the Great Smoky Mountains (Shanks 1954b).

TABLE 1

VEGETATION TYPES AND THEIR DOMINANT SPECIES IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

| Vegetation Type | Dominant Species |
|---|---|
| Cove hardwood | Canopy Trees |
| | Basswood (*Tilia heterophylla*) |
| | Beech (*Fagus grandifolia*) |
| | Buckeye (*Aesculus octandra*) |
| | Hemlock (*Tsuga canadensis*) |
| | Silver bell (*Halesia carolina* var. *monticola*) |
| | Sugar maple (*Acer saccharum*) |
| | Yellow birch (*Betula allegheniensis*) |
| | Yellow poplar (*Liriodendron tulipifera*) |
| | Small Trees and Shrubs |
| | Alternate-leaf dogwood (*Cornus alternifolia*) |
| | Bear huckleberry (*Gaylussacia ursina*) |
| | Hearts-A-Bustin (*Euonymus americanus*) |
| | Mountain laurel (*Kalmia latifolia*) |
| | Service berry (*Amelanchier laevis*) |
| | Witch Hazel (*Hamamelis virginiana*) |
| Hemlock | Canopy Trees |
| | Beech |
| | Hemlock |
| | Silver bell |
| | Yellow birch |
| | Yellow poplar |
| | Small Trees and Shrubs |
| | Alternate-leaf dogwood |
| | Mountain laurel |
| | Rhododendron (*Rhododendron maximum*) |
| | Purple rhododendron (*R. catawbiense*) |
| Northern hardwood | Canopy Trees |
| | Beech |
| | Yellow birch |
| | Fire cherry (*Prunus pensylvanica*) |
| | Buckeye |

TABLE 1 (continued)

| Vegetation Type | Dominant Species |
|---|---|
| | Small Trees and Shrubs |
| | Striped maple (*Acer pensylvanicum*) |
| | Hydrangea (*Hydrangea arborescens*) |
| | Dog hobble (*Leucothoe editorum*) |
| | Canada blackberry (*Rubus canadensis*) |
| | Rhododendron |
| | Purple rhododendron |
| Spruce-fir | Canopy Trees |
| | Fraser fir (*Abies fraseri*) |
| | Red spruce (*Picea rubens*) |
| | Mountain ash (*Sorbus americana*) |
| | Small Trees and Shrubs |
| | Striped maple |
| | Rhododendron (*Rhododendron carolina*) |
| | High-bush blueberry (*Vaccinium simulatum*) |
| | Mountain cranberry (*V. alnifolium*) |
| | Red-berried elder (*Sambucus pubens*) |
| Closed oak | Canopy Trees |
| | Red oak (*Quercus rubra*) |
| | White oak (*Q. alba*) |
| | Black oak (*Q. velutina*) |
| | Sourwood (*Oxydendron arboreum*) |
| | Pignut hickory (*Carya glabra*) |
| | Mockernut hickory (*C. tomentosa*) |
| | Sweet birch (*Betula lenta*) |
| | Small Trees and Shrubs |
| | Flowering dogwood (*Cornus florida*) |
| | Bear huckleberry |
| | High-bush blueberry |
| | Mountain laurel |
| | Rhododendron |
| | Flame azalea (*Rhododendron calendulceum*) |

TABLE 1 (continued)

| Vegetation Type | Dominant Species |
|---|---|
| Open oak-pine | Canopy Trees<br>Virginia pine (*Pinus virginiana*)<br>Pitch pine (*P. ridgida*)<br>Table mountain pine (*P. pungens*)<br>Scarlet oak (*Quercus coccinea*)<br>Chestnut oak (*Q. prinus*)<br>White oak<br><br>Small Trees and Shrubs<br><br>Mountain laurel<br>High-bush blueberry<br>Rhododendron<br>Deerberry (*Vaccinium stamineum*) |
| Heath balds | Mountain laurel<br>Rhododendron<br>Flame azalea<br>Blueberries |
| Grass balds | Blueberries<br>Blackberries (*Rubus* sp.)<br>Mountain oatgrass (*Danthonia compressa*) |

Sources: Shanks 1954b, Whittaker 1956.

Eight tree species, six dominant and two subdominant, coexist in the cove hardwood forest with each constituting 10-20 percent of the forest canopy. These species include hemlock (Tsuga canadensis), silver bell (Halesia carolina var. monticola), buckeye (Aesculus octandra), basswood (Tilia heterophylla), sugar maple (Acer saccharum), yellow birch (Betula allegheniensis), yellow poplar (Liriodendron tulipifera), and beech (Fagus grandifolia). Whittaker (1956) found that these eight species, in various percentage combinations, make up 80-90 percent of the cove hardwood forest canopy. Below this canopy, a variety of small trees and shrubs make up a broad, but not dense, layer. The herbaceous layer is by far the richest to be found among the six forest types with over a hundred species to be identified during the spring alone (Whittaker 1956, Cain 1937).

Sheltered stream valleys, up to elevations of 914 m, and those areas along the more exposed ridges, up to 1372 m, are dominated by eastern hemlock. The more important associates of hemlock are silver bell, yellow birch, and occasionally yellow poplar and/or beech (Whittaker 1956). The hemlock association is dense and dark, providing very little herb stratum. The acidic soil conditions found under many hemlock forests partially explains this phenomenon. The small tree and shrub layer is often occupied by dense thickets of rhododendron (Rhododendron sp.)

and/or combinations of numerous heath species, all of which thrive in acidic soil conditions. Whittaker (1956) noted that at lower elevations stands are mixed with hardwoods, have less heath, and a more abundant herbaceous layer. At higher elevations stands are densest with a thick growth of heaths and little or no herb layer. At the lowest elevations the hemlock forest merges with the cove hardwood forests and hemlock becomes only one of the dominant species.

Located at altitudes of 1372 m and above is the northern hardwood forests, dominated by beech and yellow birch. Sometimes referred to as the beech orchards, this forest type is characterized by its open understory with a collection of herbs, sedges and ferns, small trees, and shrubs. Undergrowth is slight if not altogether absent. Whittaker (1956) suggests that the short and stunted appearance of the dominant tree species as well as the obviously open understory may be attributed to the extreme climatic conditions at this altitude.

The spruce-fir forests are located primarily at altitudes of 1372 m and above. The dominant tree species are Fraser fir (*Abies fraseri*) and red spruce (*Picea rubens*). Pure stands of Fraser fir may be found above 1829 m. The only other tree species of major importance in this association is mountain ash (*Sorbus americana*).

Depending on the exposure of the slope, undergrowth varies from a 90 percent coverage of moss and oxalis on north-facing slopes to 60 percent or less coverage on south-facing slopes with almost 100 percent coverage by rhododendron on ridges. While undergrowth is sparse in this forest type, mosses and lichens abound, covering the ground and trees liberally.

The next forest type described is a combination of Whittaker's chestnut-oak heath, red oak-chestnut and white oak-chestnut forest types. Shanks (1954b) has called this group of species the closed oak forest. Species of this association are located on intermediate to dry slopes and are dominated primarily by oaks and, prior to the destruction of the chestnuts by the chestnut blight, by chestnuts and oaks. Some of the dominant tree species today are red oak (Quercus rubra), white oak (Q. alba), chestnut oak (Q. prinus), black oak (Q. velutina), sourwood (Oxydendron arboreum), pignut hickory (Carya glabra), mockernut hickory (C. tomentosa), and sweet birch (Betula lenta). The understory is dominated by heaths but is not usually a continuous stratum. Common to this layer of the forest canopy are mountain laurel (Kalmia latifolia), rhododendron (Rhododendron maximum), flame azalea (R. calendulaceum), sweet shrub (Calycanthus fertilis), and hydrangea (Hydrangea arborescens).

The last classification, a combination of two types, open oak-pine and heath balds, is composed of those species common to the dry exposed and often rocky ridges and slopes. At lower elevations, Virginia pine (Pinus virginiana) and scarlet oak (Quercus coccinea) are dominant. These forests are comparatively open with only 70 percent tree coverage, 10-40 percent shrub coverage, and 2-10 percent herb coverage. Above the Virginia pine-scarlet oak grouping (617-975 m) the pitch pine (Pinus ridgida) is dominant. Often found with this species are scarlet oak and chestnut oak. This association is similar to the previous as it is also relatively open, but differs in that the shrub layer is denser; the coverage being 40-70 percent. Herb cover is low at 5-20 percent coverage. Above 975 m is the third group of pines. Dominated by table mountain pine (Pinus pungens) tree coverage is 70-80 percent with scarlet oak, pitch pine and chestnut oak appearing as codominants at lower elevations. Shrub coverage is high at 60-90 percent, dominated by mountain laurel (Whittaker 1956). Herb coverage is again low at 5-20 percent.

The most distinctive and controversial type of vegetation to be found in the mountains are the balds. Found at higher elevations along ridges and mountain tops, balds are either grassy or heath covered. Grassy balds, believed to be the result of fire and/or grazing, are dominated by mountain oat grass (Danthonia compressa). The heath balds occur between 1219 m and the uppermost peaks. At lower elevations mountain laurel is the dominant heath while at higher elevations catawba rhododendron (*Rhododendron catawbiense*) dominates.

# CHAPTER III

## MATERIALS AND METHODS

In 1970, five different hiking routes totaling 130.0 km were established in the northwestern quarter of the Park to collect black bear scats. These routes consist of trails previously established by the National Park Service. All five routes are located west of U. S. Highway 441 and north of the Appalachian Trail and the North Carolina state line (Figure 1, page 8).

### Description of Routes

The easternmost route, Sugarlands, is 17.2 km in length, ranges in elevation from 573 m to 1810 m, and is characterized by three general vegetation types: spruce-fir, open oak-pine and balds, and closed oak forests. This route begins at the Spruce-Fir Nature Trail on the Clingman's Dome Road and ends on U. S. Highway 441 (Figure 1 and Appendix E).

The Elkmont-Bent Arm Route lies west of the Sugarlands Route, is 32.8 km in length, ranges in elevation from 792 m to 1709 m, and is characterized by two general vegetation types: closed oak and northern hardwoods forests. This route begins on the Little River Gravel Road at the Cucumber Gap trail head and terminates on the

Little River Gravel Road at the Goshen Prong trail head (Figure 1, page 8, and Appendix E).

Sharing approximately 4.8 km with the Elkmont-Bent Arm Route is the Tremont-Derrick Knob Route. It is 24.8 km in length, ranges in elevation from 792 m to 1578 m, and is characterized by closed oak and northern hardwoods forests. The Tremont-Derrick Knob Index Route begins at the Panther Creek trail head and terminates at the end of the Davis Ridge Trail (Figure 1 and Appendix E).

The Spence-Russell Route is 20.1 km in length, ranges in elevation from 590 m to 1548 m, and is characterized by five general vegetation types: hemlock, closed oak, northern hardwoods, cove hardwoods, and open oak-pine and balds. This route begins in the Cades Cove Picnic Ground at the Anthony Creek trail head, makes a loop via the Appalachian Trail and returns to the original starting point (Figure 1 and Appendix E).

On the western edge of the Park is the Gregory-Hannah Mountain Index Route. It is 33.1 km long, ranges in elevation from 522 m to 1508 m and is characterized by four general vegetation types: closed oak, open oak-pine and balds, cove hardwoods, and northern hardwoods. The route begins at the Gregory Ridge trail head at the end of Forge Creek Road and terminates in the Abrams Falls parking area at the west end of Cades Cove (Figure 1 and Appendix E).

## Collection of Scats

Between 1 October and 15 May routes were hiked on an irregular basis. Between 15 May and 1 October all routes were hiked biweekly, during which time all routes were hiked within a two- to four-day period. Scats collected during these periods were used in other studies on food habits (Beeman 1971), radioactive tagging of feces (Marcum 1974, Eagar 1977) and movement studies (Eubanks 1976).

Scats of black bear were collected and records were maintained on the exact date and location of each; any remaining scats were always brushed from the trail to prevent collecting the same material at a later date. Information regarding weather conditions, time of day, condition of the scat, the number and type (day or overnight) of hikers met along the routes, and any other pertinent data were recorded on Index Route Data Sheets (Appendix A). Scats were frozen upon return to the lab. Scats collected around trail shelters in proximity to Index Routes were not included in the data analysis.

## Analysis of the Data

The number of scats collected from one route cannot be directly compared to the number collected from another since routes are of unequal lengths. For comparative purposes it was necessary to convert the number of scats collected to a figure indicating a per unit effort; this was accomplished by transforming all figures into a scats/km value (to convert any scats/km value to km/scat, divide the number one by the scats/km value).

The major portion of the analysis concerned data collected from 1 June through 1 October, a period of time consisting of nine biweekly hikes. Prior to the summer season hiking period of 1 June - 1 October, Index Routes were cleared of scats during the 15 May hiking period. This was to insure that scats collected on 1 June would be no more than two weeks old. Any scats found were included in the pre-summer season data. The remainder of the analysis utilized data collected from 1 October through 1 June, a series of irregular hikes. Influencing this decision was early work by Pelton (1972), who found that black bear activity in the Park increases appreciably after May and decreases sharply after September, and the fact that only during the time from 1 June - 1 October were all routes hiked regularly and all information recorded. Data collected on a regular basis cannot be statistically analyzed in conjunction with data collected on an irregular basis, however, a comparison can be made between the summer periods (1 June - 1 October) and the pre- and post-summer season periods (1 October - 1 June) when each set of data is described on a scat per kilometer basis (Appendix F).

Locations for each scat collected between 1 June - 1 October were recorded as accurately as possible in terms of distance from a trail head, trail junction, stream crossing, or other landmark. These locations were then marked on USGS topographic maps to determine the altitude (to the nearest 12.2 m contour interval) for each scat.

Using the classification system formulated by Shanks (1954b), in addition to personal observation, each scat was categorized into a specific vegetation type. Individual scat locations could then be identified using route name, date of collection (year, month, and day), altitude, and vegetation type. This information was then coded to facilitate use of a computer for subsequent analysis of variance testing (Barr and Goodnight 1976).

Altitudinal classifications were arbitrarily set at 152.4 m intervals beginning at 457.2 m and progressing to 1676+ m. Each class was numbered consecutively, resulting in nine different altitude classes (Appendix B). An altitudinal description of (1) individual routes and (2) all routes combined are presented in Table 2; this table includes the distance each route covers within the respective altitude class and the percentage of the total length of the route which occupies each altitude class.

Vegetative characteristics for each route are similarly described (Table 3). Six vegetative classes were used: cove hardwoods, closed oak, open oak-pine and

TABLE 2

ALTITUDINAL DESCRIPTION OF INDEX ROUTES IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

| Altitude (m) | Index Routes: Sugarlands | | Elkmont-Bent Arm | | Tremont-Derrick Knob | | Spence-Russell | | Gregory-Hannah Mountain | | Overall Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | KM | % | KM | % | KM | % | KM | % | KM | % | KM | % |
| 457- 609 | 0.5 | 2.7 | --- | --- | --- | --- | --- | --- | 5.8 | 15.3 | 6.3 | 4.7 |
| 610- 762 | 1.0 | 5.5 | 0.2 | 0.6 | --- | --- | 5.4 | 25.5 | 12.4 | 32.6 | 19.0 | 14.4 |
| 763- 913 | 1.3 | 7.1 | 4.3 | 13.7 | 2.3 | 9.1 | 2.6 | 12.3 | 8.2 | 21.6 | 18.7 | 13.9 |
| 914-1066 | 2.1 | 11.5 | 4.8 | 15.3 | 3.1 | 12.2 | 1.8 | 8.5 | 3.4 | 8.9 | 15.2 | 11.3 |
| 1067-1218 | 1.3 | 7.1 | 2.9 | 9.2 | 2.9 | 11.4 | 3.8 | 17.9 | 3.2 | 8.4 | 14.1 | 10.5 |
| 1219-1371 | 4.5 | 24.6 | 3.7 | 11.8 | 5.5 | 21.7 | 3.4 | 16.0 | 2.1 | 5.5 | 19.2 | 14.3 |
| 1372-1524 | 1.3 | 7.1 | 4.3 | 13.7 | 9.7 | 38.2 | 3.4 | 16.0 | 2.9 | 7.6 | 21.6 | 16.1 |
| 1525-1676 | 3.2 | 17.5 | 8.4 | 26.8 | 1.9 | 7.5 | 0.8 | 3.8 | --- | --- | 14.3 | 10.6 |
| 1677+ | 3.1 | 16.9 | 2.8 | 8.9 | --- | --- | --- | --- | --- | --- | 5.9 | 4.4 |

TABLE 3

VEGETATION TYPES FOUND ALONG INDEX ROUTES IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

| Vegetation Type | Index Routes | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sugarlands | | Elkmont-Bent Arm | | Tremont-Derrick Knob | | Spence-Russell | | Gregory-Hannah Mountain | | Total | |
| | KM | % | KM | % | KM | % | KM | % | KM | % | KM | % |
| Cove Hardwood | --- | --- | --- | --- | --- | --- | 3.0 | 40.0 | 4.5 | 60.0 | 7.5 | 5.6 |
| Closed Oak | 3.4 | 6.8 | 17.8 | 35.9 | 14.8 | 29.8 | 4.4 | 8.9 | 9.2 | 18.5 | 49.6 | 37.2 |
| Open Oak-Pine and Balds | 6.9 | 22.5 | --- | --- | --- | --- | 3.5 | 11.4 | 20.3 | 66.1 | 30.7 | 23.0 |
| Northern Hardwoods | --- | --- | 15.8 | 48.5 | 10.2 | 31.3 | 5.4 | 16.6 | 1.2 | 3.7 | 32.6 | 24.4 |
| Hemlock | --- | --- | --- | --- | --- | --- | 5.3 | 100.0 | --- | --- | 5.3 | 4.0 |
| Spruce-Fir | 7.7 | 100.0 | --- | --- | --- | --- | --- | --- | --- | --- | 7.7 | 5.8 |
| Total km | 18.0 | | 33.6 | | 25.0 | | 21.6 | | 35.2 | | 133.4 | |

balds, northern hardwoods, hemlock, and spruce-fir. The inclusive vegetation types and the distance that each route covers within each vegetation type are also included.

A combination factor of altitude class and vegetation type was determined for each scat location. The relationship between this combination factor and the resultant scats/km for each was analyzed through the use of a regression procedure (Sokal and Rohlf 1969).

# CHAPTER IV

# RESULTS AND DISCUSSION

## I. INCIDENCE OF SCATS DURING PRE- AND POST-SUMMER SEASONS

Index Routes were hiked on a regular basis from 15 May through 1 October and on an irregular basis between 1 October and 15 May, 1970-1975. The period of time from 1 June - 1 October will be referred to as the summer season and the time spans from 1 January - 1 June and from 1 October - 1 January will be referred to as pre- and post-summer seasons, respectively.

Scats/km for the pre- and post-summer season were less than those for the summer season except in the case of the Spence-Russell Index Route. The pre- and post-summer season values were 0.03 scats/km and 0.06 scats/km, respectively for this route (Figure 3).

There are numerous factors which may influence the low incidence of scats during the pre-summer season. Bears may be located away from the Index Routes, and their movements may be restricted to smaller areas than at other times during the year. The availability of natural foods is less during the spring and the bears may still be subsisting off fat stores (rather than feeding and thus defecating) until later in the season at which time food

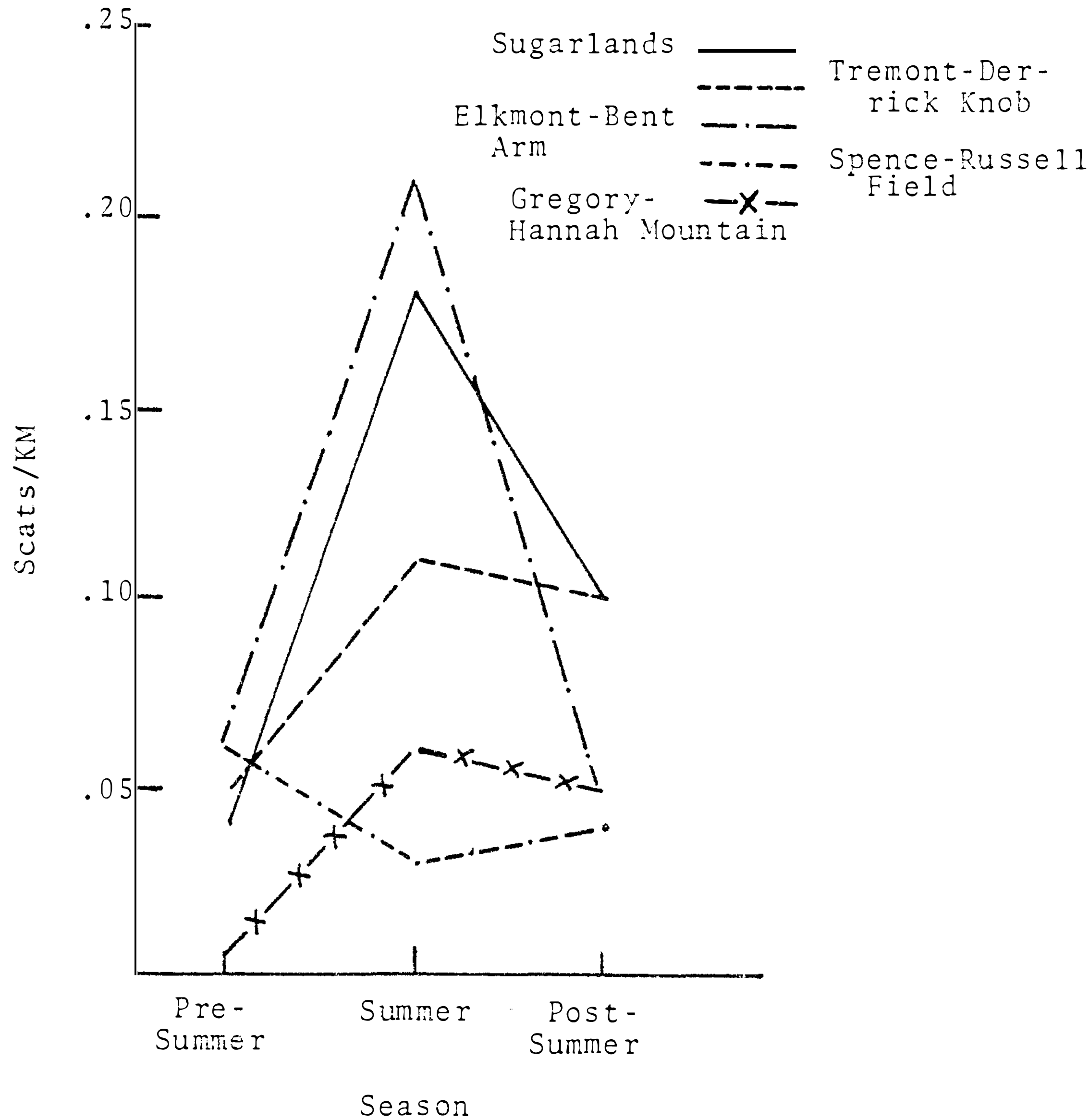


Figure 3. Comparison of scats/km values for pre-summer, summer, and post-summer seasons over six years (1970-1975) in the Great Smoky Mountains National Park.

sources are more plentiful. Associated with the above is the possibility that the dormant condition of the gastro-intestinal tract after the winter season may deter food intake during the early part of the spring.

Factors that may influence the fluctuation of incidence of scats during the fall should be noted. It is suspected that some specific food sources (i.e., mast) may occur away from the routes during the fall. Beeman (1975) noted that several of the bears he had radiotracked left their normal home ranges during early fall and returned prior to denning. Decreased feeding activities prior to denning obviously result in less defecation. During the denning period no scats are found because no defecation occurs (Folk et al. 1972). In his study on the defecation rates of captive brown bears fed ad libatum Roth (1977) also found that in winter the defecation rate approaches zero, particularly for pregnant females. Leaf cover in the fall was also found to hinder the location of scats. In years of early leaf fall the number of scats collected appeared to decrease more quickly than in years of later leaf fall indicating the difficulty of locating scats because of leaves.

It appears that some factor or combination of factors are causing less evidence of the presence of bears along the Spence-Russell Index Route suggesting that bears utilize this route more frequently during the pre- and post-summer season than during the summer season. Due to the popularity of the Anthony Creek Trail and the upper section of the Bote Mountain Road (both major sections of the Spence-Russell Index Route) hiker intensity is suspected as having some influence on the differences between scats/km for the summer season and those for the pre- and post-summer seasons. A total of 73 overnight hikers, 36.4 percent of all overnight hikers encountered on all Index Routes during the 1975 summer season, were met along the Spence-Russell Index Route (Table 4). Marsh (1973) found that between early June and mid-September the Anthony Creek Trail was more heavily used than any of the other trails which make up sections of the Index Routes. Whether the presence of larger numbers of people alone causes the bears to avoid this route during the summer season or whether hikers and horseback riders have trampled the scats into the mud or whether bears have simply quit using this route for some other reason (e.g., dominance of one or more animals over others, climatic conditions, establishment of other game trails, etc.) is unknown. Figure 3 illustrates that bears appear to use the route less during the summer season.

## II. INCIDENCE OF SCATS DURING SUMMER SEASON

Between 1 June and 1 October, 1970-1975, 697 scats were collected by hiking 6085.7 km of Index Routes (Table 5).

TABLE 4

HIKER USE OF INDEX ROUTES DURING THE 1975 SUMMER SEASON DETERMINED BY NINE ALL-DAY COUNTS

| Index Route | Number of Hikers Day | Number of Hikers Overnight | Total Number | % of Grand Total |
|---|---|---|---|---|
| Sugarlands | 10 | 36 | 46 | 7.3 |
| Elkmont-Bent Arm | 28 | 85 | 113 | 18.0 |
| Tremont-Derrick Knob | 15 | 73 | 88 | 14.0 |
| Spence-Russell | 69 | 174 | 243 | 38.8 |
| Gregory-Hannah Mountain | 27 | 110 | 137 | 21.9 |
| Grand Total | 149 | 478 | 627 | 100.0 |

TABLE 5

SUMMARY OF THE NUMBER OF SCATS COLLECTED ALONG INDEX ROUTES IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK, 1970-1975

| Index Route | KM | Hiking Periods June 1 | June 15 | July 1 | July 15 | Aug. 1 | Aug. 15 | Sept. 1 | Sept. 15 | Oct. 1 | Total Scats | Total KM | Scats |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sugarlands | 17.2 | 23 | 5 | 21 | 13 | 15 | 29 | 23 | 17 | 9 | 155 | 877.2 | 0.18 |
| Elkmont-Bent Arm | 32.8 | 45 | 35 | 37 | 23 | 25 | 48 | 55 | 33 | 31 | 332 | 1607.2 | 0.21 |
| Tremont-Derrick Knob | 24.8 | 23 | 7 | 7 | 7 | 4 | 15 | 11 | 12 | 6 | 92 | 1240.0 | 0.07 |
| Spence-Russell | 20.1 | 4 | 4 | 3 | 0 | 5 | 4 | 8 | 3 | 1 | 32 | 964.8 | 0.03 |
| Gregory-Hannah Mountain | 35.1 | 10 | 5 | 10 | 10 | 9 | 15 | 11 | 7 | 9 | 86 | 1396.5 | 0.06 |
| Total scats | | 105 | 56 | 78 | 53 | 58 | 111 | 108 | 72 | 56 | 697 | | |
| Total km | 130.0 | 676.5 | 724.8 | 729.4 | 684.5 | 659.7 | 689.6 | 709.3 | 654.6 | 557.3 | | 6085.7 | |
| Scats/km | | 0.16 | 0.08 | 0.11 | 0.08 | 0.09 | 0.16 | 0.15 | 0.11 | 0.10 | | | 0.15 |

During this five-year period the Elkmont-Bent Arm Index Route yielded 332 scats, Sugarlands 155, Tremont-Derrick Knob 92, Gregory-Hannah Mountain 86, and Spence-Russell 32. The overall trend between years shows an increase in the raw number of scats collected between 1970 and 1971. This increase is likely explained by the fact that during 1970 the Gregory-Hannah Mountain Index Route was not hiked. From 1971 through 1975 the number of scats collected steadily declined (Figure 4) suggesting that bear activity along Index Routes was also decreasing.

To enable comparisons to be made among the routes, the number of scats collected along each route was converted to a scats/km value. Despite the conversion, the Elkmont-Bent Arm Index Route still produced the highest scats/km at 0.21. Sugarlands produced 0.18 scats/km, Tremont-Derrick Knob 0.07, Gregory Hannah Mountain 0.06, and Spence-Russell 0.03 scats/km (Table 5).

The inclusive scats/km value for all Index Routes over all years was 0.11 scats/km (or 9.1 km/scat). Marcum (1974) estimated the density of black bear for 1973 to be 1 bear/2.7 km$^2$. The scats/km value for 1973 was 0.12 (8.3 km/scat). Eagar (1977) determined the density of black bears to be 1 bear/3.03 km$^2$ for 1974 and 1 bear/2.77 km$^2$ for 1975; scats/km values were 0.09 and 0.08, respectively during this period. Study areas during the period when all three estimates were derived were the same. Future

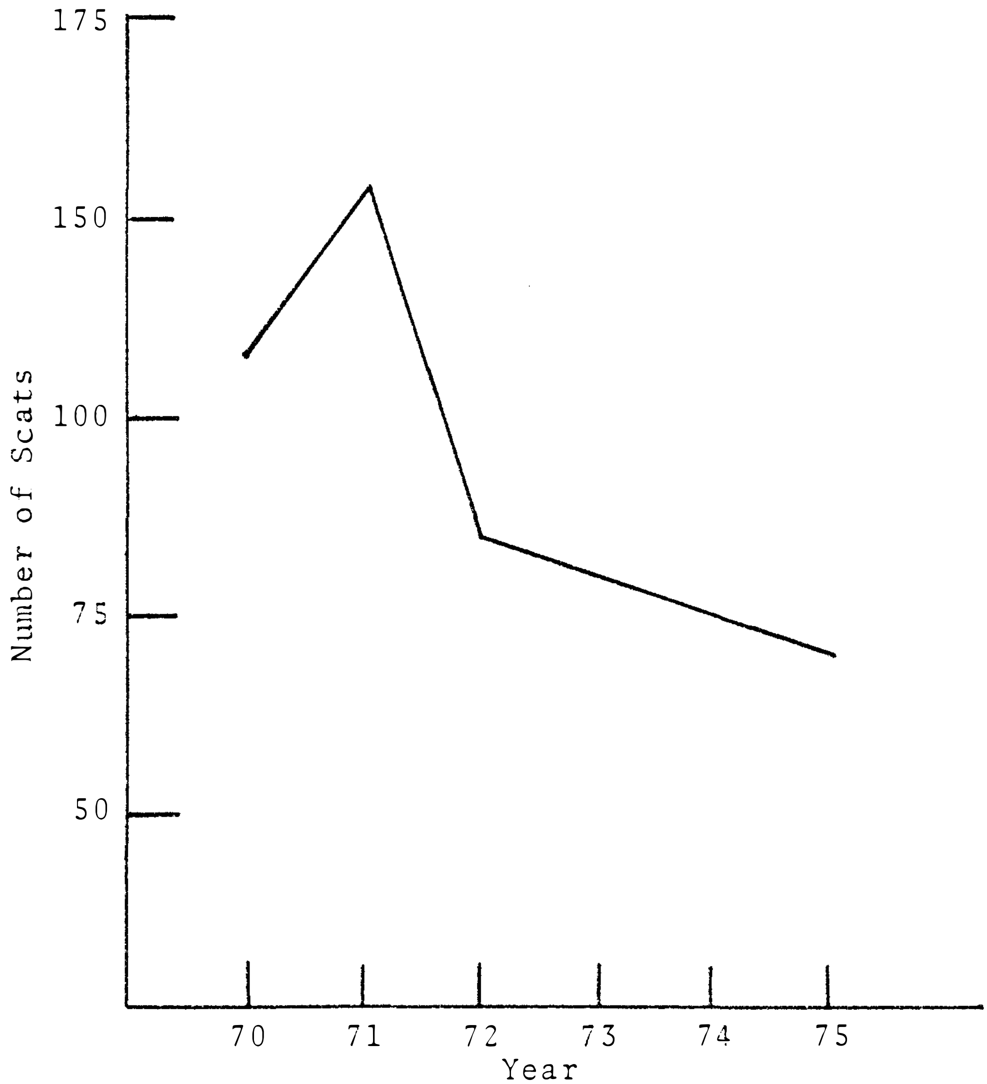


Figure 4. Total number of scats collected in the Great Smoky Mountains National Park, 1970-1975.

comparative studies from other sections of the black bear's range in North America would be interesting and useful.

Evaluation of the scats/km on a yearly basis showed that a marked decrease occurred between 1970-1975. The scats/km value for 1975 is 43 percent of the value for 1970. In other words, the number of scats/km collected in 1975 was 57 percent smaller than the number of scats/km collected in 1970 (Figure 5).

It appears that the 1973 scats/km figure is greater than it should be according to the overall linear appearance (Figure 5), however it is also possible that the 1972 figure is artificially lower than normally expected. If this is the case it is likely explained by the scarcity of mast in 1972, which apparently caused greater movements of bears (Beeman and Pelton 1977).

LaFollette (1974) also recorded several instances in which bears traveled greater than usual distances when their natural food supply was depleted or nonexistent. Thus the decrease in incidence of scats along Index Routes is a result of a greater percentage of the bear population moving out of their normal summer and/or fall home ranges (and in some cases the Park) foraging for more substantial food supplies. It was found that scat incidence did vary among vegetation types depending on the hiking date. For example, as incidence in the open oak-pine and balds vegetation type decreased (1-15 September), incidence in

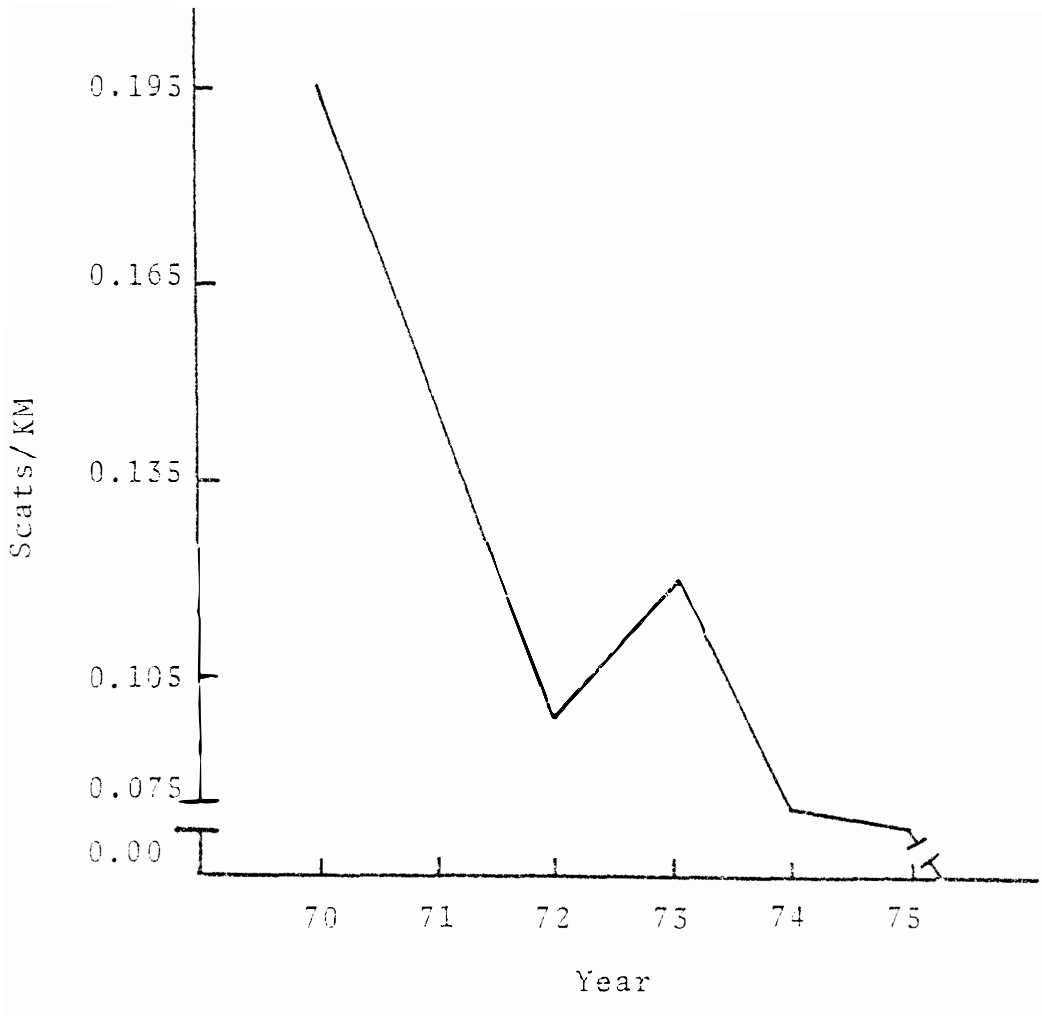


Figure 5. Yearly scats/km values from 1970-1975 in the Great Smoky Mountains National Park.

the northern hardwoods type increased, suggesting a shift in feeding, possibly from oak to beech and buckeye mast (Figure 6).

Distribution of Scats within Hiking Periods

In order to analyze the variability in scats/km among hiking periods, an analysis of variance procedure was performed. The results show that variability among scats/km over the nine hiking periods has a probability of occurring 75 percent of the time (Appendix G).

Between 1 June and 15 June (1970-1975) the number of scats/km drops from 0.16 to 0.08 (Figure 7). Since all routes were cleaned two weeks prior to the first hiking, this decline cannot be attributed to scats remaining from earlier months. It is felt that although black bear breeding activities were found to peak in July, this behavior, which begins in June (Beeman 1975), may explain the decrease in the number of scats collected during late June, perhaps signaling the onset of the breeding season. Roth (1977) also noted a temporary decrease in the defecation rate of brown bears from April to June and suggests that the cause may be the apparent lack of appetite in bears, particularly males, during the breeding season.

The increased incidence of scats between 1 August and 15 August is likely explained by maturing berry crops. Beeman (1971) found that blueberries (*Vaccinium* sp.),

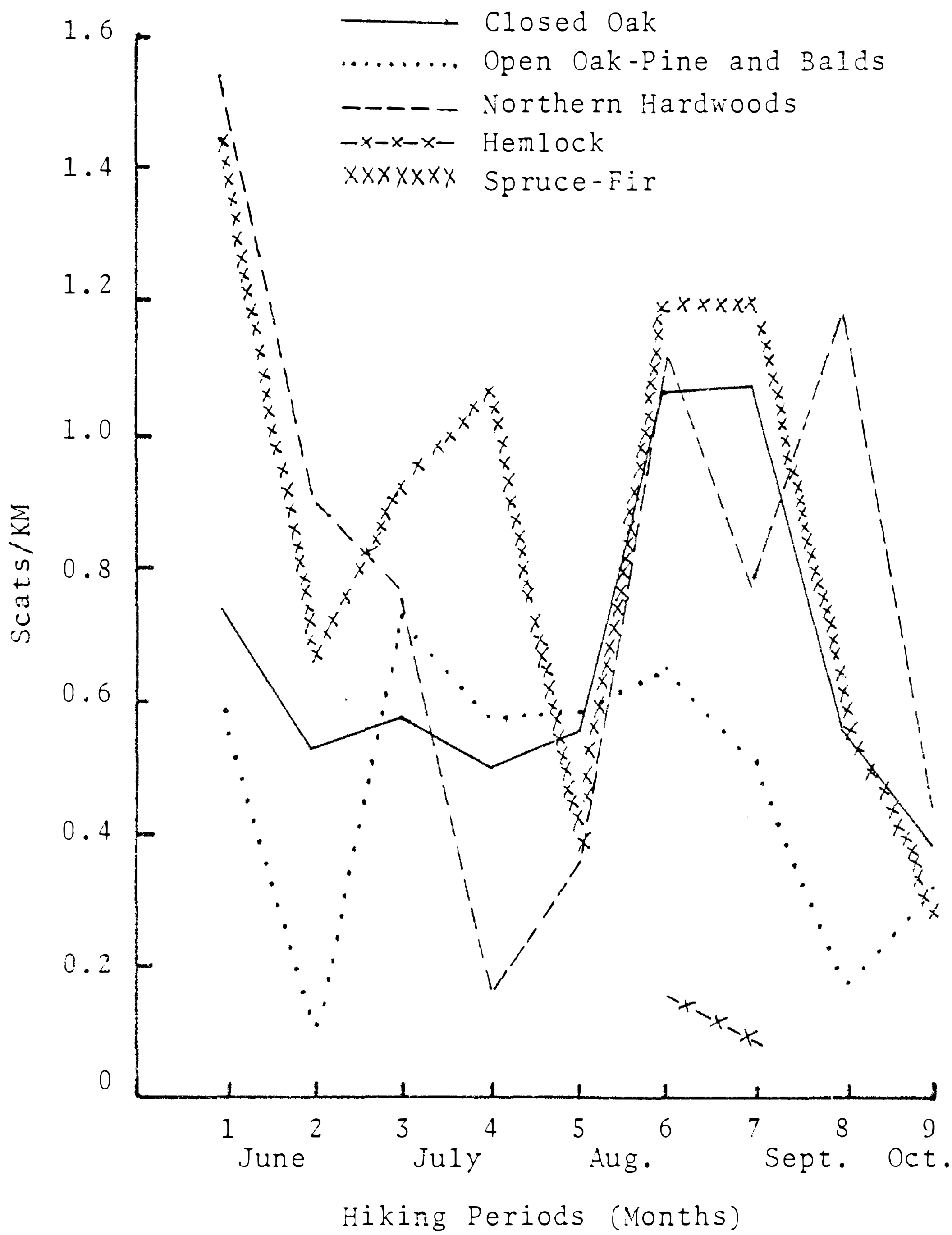


Figure 6. Scats/km within vegetation types in the Great Smoky Mountains National Park, 1970-1975.

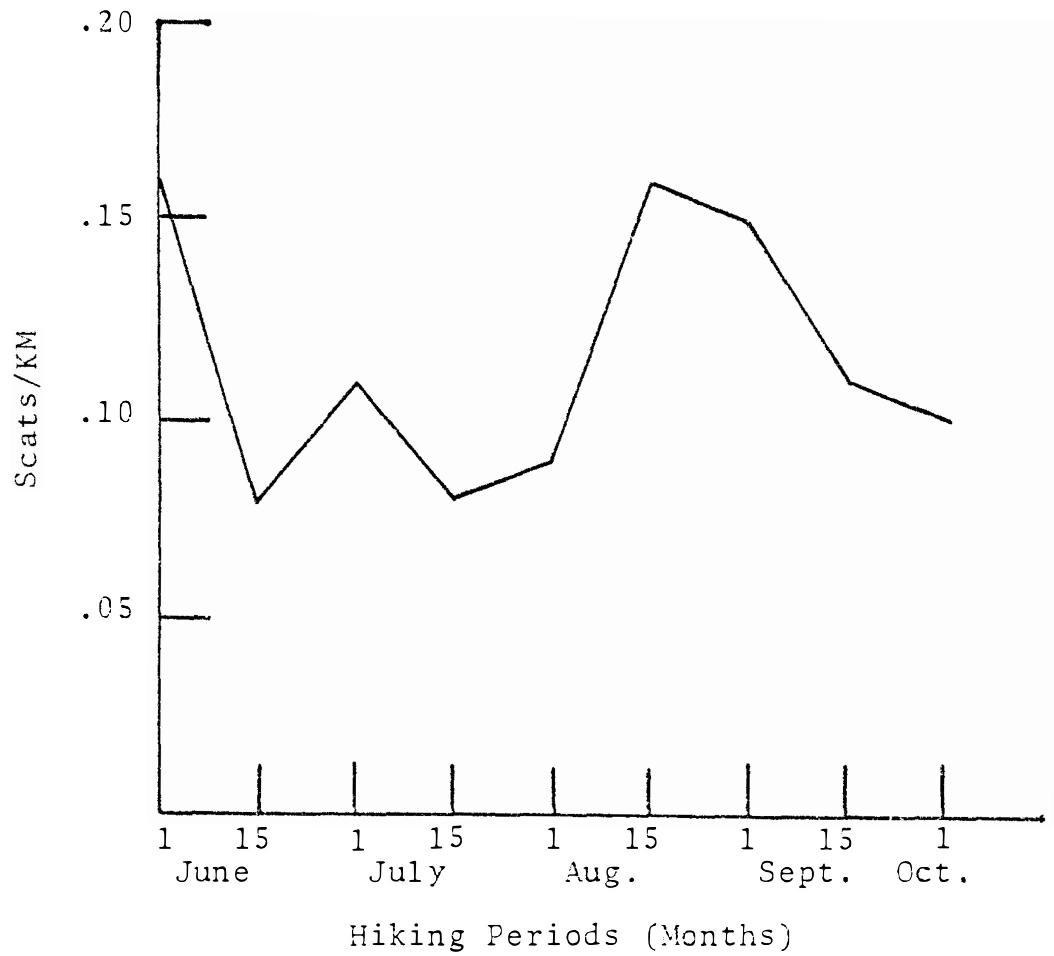


Figure 7. Relationship between scats/km and the nine hiking periods, June-October 1970-1975, from the Great Smoky Mountains National Park.

blackberries (*Rubus* sp.), and huckleberries (*Gaylussacia* sp.) accounted for 39 percent of the summer food volume of black bears (1 July through 30 August) in the Park. Between 1 September and 15 October black cherry (*Prunus serotina*) accounted for 60 percent of the food volume while blackberries made up 35 percent and blueberries 13 percent. Pelton (1970) also noted that August is the month that black bears are most actively engaged in foraging for food in the Park. It is during this late summer-early fall period that bears gain more weight than at other times of the year (Beeman and Pelton 1977).

The continuous decline in incidence of scats/km from 1 September until 1 October (1970-1975) can probably be accounted for by movements of bears out of the study area, away from Index Routes, or to lower elevations for the purpose of foraging for fall foods prior to denning activities (Lindzey and Meslow 1976, Beeman 1975). Leaf fall, particularly when it occurs in early autumn, probably intensifies the decline in scats collected.

## Distribution of Scats within Altitudinal Classes

In a preliminary study, Pelton (1972) found that 56.9 percent of the scats collected along Index Routes were found at elevations of 1372 m and above. With 33.4 percent of the total kilometers above 1372 m and with such a large percentage of the scats found at the higher elevations, it was felt that altitude might prove to be a major factor affecting the distribution of the black bear population in the Park.

Sections of Index Routes between 1372-1524 m were most productive in terms of the overall number of scats collected (Appendix H). However, when comparing the scats/km values, the highest value, 8.2 scats/km, fell in the 1219-1371 m altitude range (Table 6). The scats/km values in the different altitude classes were quite variable (Figure 8) and suggested that altitude may affect location of scats. A Chi square test indicates the difference in scats/km among the Index Routes is significant at the 97.5 percent confidence level; altitude classification and route classification for scats/km are not independent of each other.

An analysis of variance with regression was performed to further explore the effect of altitude on the location of scats. The results of the linear regression show that the variable, scats/km, varies in a way that can be described by a linear equation: $Y = -0.8 + 1.16X$, where $X$ is altitude and $Y$ is the value of scats/km. The information in Figure 9 can therefore be used, within set confidence levels, in predicting the expected number of scats/km for any altitude level in the study area. This information may be of value in the future as a tool for

TABLE 6

SCATS/KM COLLECTED WITHIN ALTITUDINAL CLASSES ALONG INDEX ROUTES IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK, 1970-1975

| | Index Routes | | | | |
|---|---|---|---|---|---|
| Altitude Classes (m) | Sugarlands | Elkmont-Bent Arm | Tremont-Derrick Knob | Spence-Russell | Gregory-Hannah Mountain |
| 457- 609 | *- | - | - | - | 0.3 |
| 610- 762 | 3.0 | 0.0 | - | 0.4 | 1.9 |
| 763- 913 | 3.9 | 3.5 | 0.4 | 0.4 | 5.4 |
| 914-1066 | 4.8 | 7.9 | 1.0 | 1.7 | 0.9 |
| 1067-1218 | 13.1 | 11.0 | 2.1 | 0.8 | 0.9 |
| 1219-1371 | 12.2 | 17.6 | 4.7 | 2.4 | 1.9 |
| 1372-1524 | 13.9 | 19.3 | 5.0 | 3.5 | 1.7 |
| 1525-1676 | 7.8 | 7.9 | 2.6 | 3.8 | - |
| 1677+ | 3.5 | 10.4 | - | - | - |

*- denotes that the altitude class does not appear along the respective Index Route.

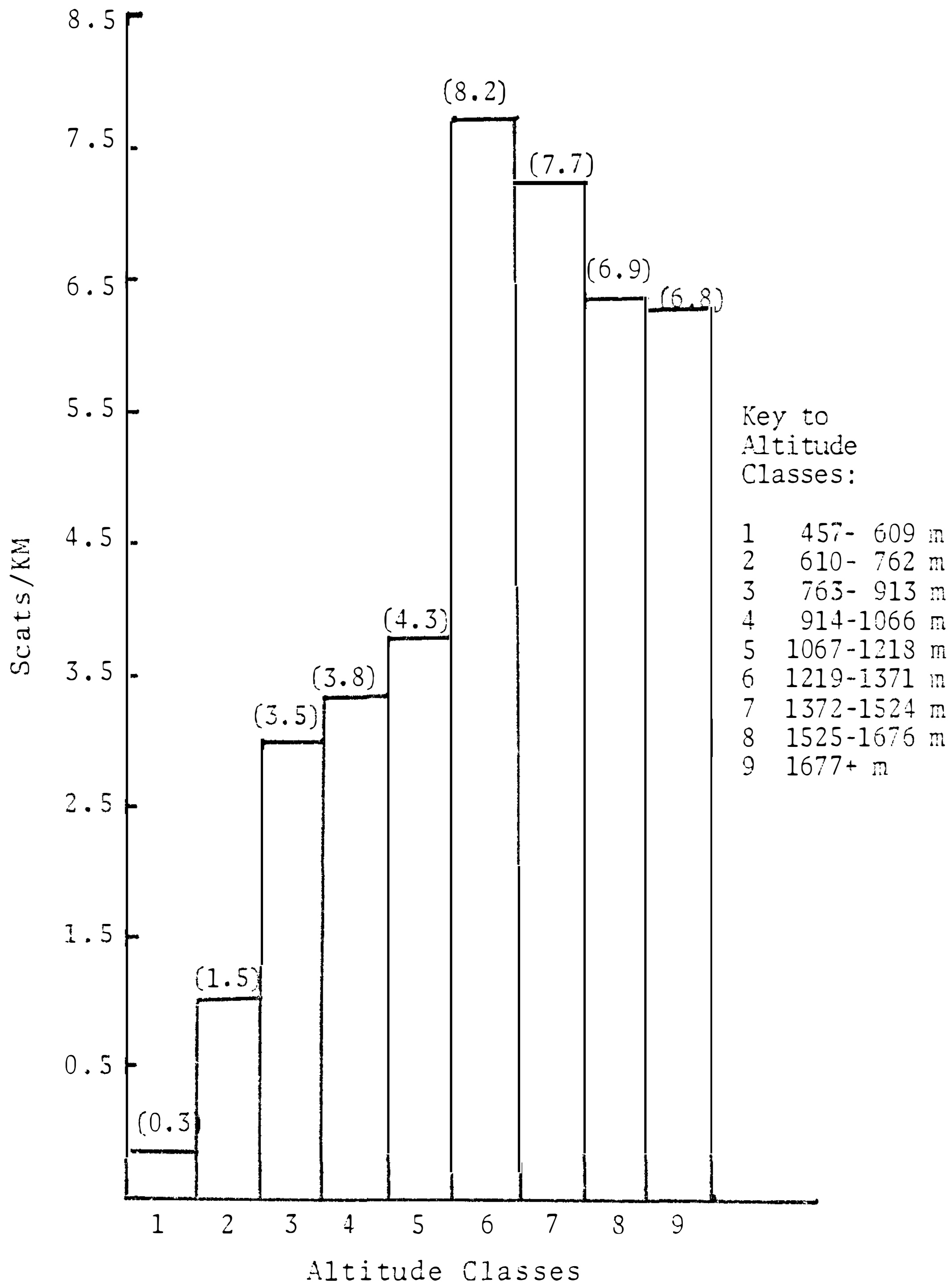


Figure 8. Relationship between scats/km and altitudinal classes in the Great Smoky Mountains National Park, 1970-1975.

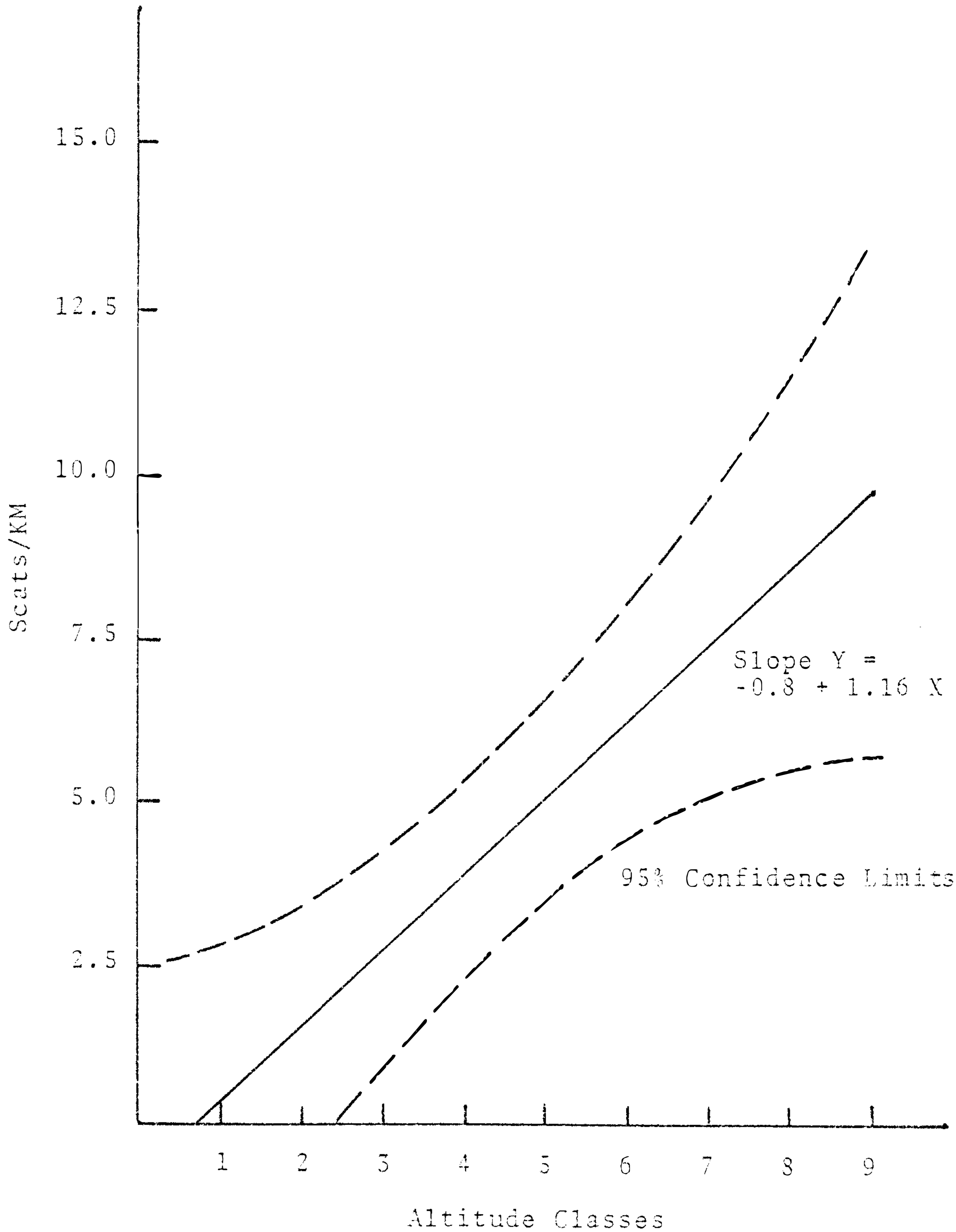


Figure 9. Regressional relationship between scats/km and altitude classes in the Great Smoky Mountains National Park, 1970-1975.

predicting intensity of bear use of certain areas within the Park.

## Distribution of Scats within Vegetation Types

Vegetation patterns are closely related to altitude in the Park. Viewing the diversity of vegetation types to be found along the Index Routes and realizing that black bears seem to frequent specific altitude classes, it was assumed that food preferences have an influence on the seasonal distribution of the population and thus their sign (scats). For the purposes of this study, food preferences of the bear population in the Park were viewed in terms of vegetation types.

The spruce-fir vegetation type yielded 8.1 scats/km. The northern hardwoods type accounted for 7.3 scats/km, closed oak for 5.8 scats/km, open oak-pine and balds for 4.3 scats/km, and hemlock for 0.3 scats/km. No scats were found in the cove hardwoods vegetation type.

When classified according to vegetation types, the overall scats/km values indicate that more scats occur in some vegetation types than in others. The spruce-fir vegetation type produced the highest number of scats/km. It is felt that the high incidence of scats in this vegetation type does not reflect the true value of this type as a natural feeding area for bears; few natural sources of summer foods are found in this type. At high elevations bears have few choices in moving from one area to another; they, in essence, are forced to utilize the spruce-fir type in going to and from areas of summer foods (berry crops). The spruce-fir type represents only 5.7 percent of the total kilometers covered by the five Index Routes. The northern hardwoods vegetation type accounted for 24.4 percent of the total mileage and 7.3 scats/km were collected along its length. The third most productive vegetation type, closed oak forest, resulted in 5.8 scats/km. This vegetation type represents 37.2 percent of the total distance hiked. The open oak-pine and balds vegetation type accounted for 23.0 percent of the total distance hiked and produced the fourth highest scats/km (4.3 scats/km). Lastly, the hemlock and cove hardwoods vegetation types, when combined, represents 9.6 percent of the total mileage, accounted for only 0.6 percent of the total scats collected (Appendix C).

Due to the effects of altitude on vegetation types within the Park, it was necessary to delineate the interactions between these two factors (altitude and subsequent vegetation type) and the resultant scats/km value.

## Distribution of Scats within Altitude-Vegetation Types

It is obvious that one vegetation type can span one or more altitude classes and vice versa. In order to analyze the distribution of scats in relation to the possible influencing factors of the combination of altitude and vegetation types, classifications were established to describe all possible combinations of altitude and vegetation types (Table 7). An analysis of variance procedure was performed. The results showed that there existed a very high probability (at or above the 95 percent confidence level) that the combination of altitude and its resultant vegetation type did significantly affect the location of bear scats on all routes but one, Spence-Russell.

Taking each vegetation type individually and studying the resulting pattern produced by the scats/km value and the altitude levels, specific relationships are evident (Figure 10).

In the cove hardwood vegetation type (1), regardless of the altitude level, no scats were found. Of the 133.4 km of Index Routes, only 5.6 percent passes through this vegetation type; it is conceivable that the low incidence of the vegetation type may partially account for the lack of scats collected. Eubanks (1976) also found relatively low incidence of scats in this vegetation type as compared to the incidence in the oak vegetation types. Mast producing species in this type include beech, buckeye, and dogwood.

Due to the complexity of the mesophytic forest, it is possible that areas of cove hardwood may have been classified as one of the oak forest types. This error in

TABLE 7

ALTITUDINAL-VEGETATION TYPE BREAKDOWN BY INDEX ROUTE IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK, 1970-1975

| Route | Altitude (m) | Vegetation Type | KM | No. Scats | Scats/KM |
|---|---|---|---|---|---|
| Sugarlands | 457- 609 | Closed oak | 0.5 | 0 | 0 |
| | 610- 762 | Closed oak | 1.0 | 3 | 3.0 |
| | 763- 913 | Closed oak | 1.3 | 5 | 3.8 |
| | 914-1066 | Closed oak | 0.5 | 0 | 0 |
| | 914-1066 | Open oak-pine and balds | 1.5 | 10 | 6.7 |
| | 1067-1218 | Open oak-pine and balds | 1.3 | 17 | 13.1 |
| | 1219-1371 | Open oak-pine and balds | 4.0 | 47 | 11.8 |
| | 1219-1371 | Spruce-fir | 0.6 | 8 | 13.3 |
| | 1372-1524 | Spruce-fir | 1.3 | 20 | 15.4 |
| | 1525-1676 | Spruce-fir | 3.2 | 23 | 7.2 |
| | 1677+ | Spruce-fir | 3.1 | 11 | 3.5 |
| | | | 18.3 | 144 | $\bar{X}$ = 7.1 |
| Elkmont-Bent Arm | 610- 762 | Closed oak | 0.2 | 0 | 0 |
| | 763- 913 | Closed oak | 4.4 | 15 | 3.4 |
| | 914-1066 | Closed oak | 4.8 | 38 | 7.9 |
| | 1067-1218 | Closed oak | 2.7 | 32 | 11.9 |
| | 1219-1371 | Closed oak | 2.6 | 61 | 23.5 |
| | 1219-1371 | Northern hardwood | 1.0 | 4 | 4.0 |
| | 1372-1524 | Closed oak | 2.7 | 64 | 23.7 |
| | 1372-1524 | Northern hardwood | 3.9 | 19 | 4.9 |
| | 1525-1676 | Northern hardwood | 8.4 | 66 | 7.9 |
| | 1677+ | Northern hardwood | 2.6 | 29 | 11.2 |
| | | | 33.3 | 328 | $\bar{X}$ = 9.84 |
| Tremont-Derrick Knob | 763- 913 | Closed oak | 2.3 | 1 | 0.4 |
| | 914-1066 | Closed oak | 3.2 | 3 | 0.9 |
| | 1067-1218 | Closed oak | 2.8 | 6 | 2.1 |
| | 1219-1371 | Closed oak | 4.5 | 17 | 3.8 |
| | 1219-1371 | Northern hardwood | 1.0 | 2 | 2.0 |
| | 1372-1524 | Closed oak | 2.2 | 18 | 8.2 |
| | 1372-1524 | Northern hardwood | 8.4 | 37 | 4.4 |
| | 1525-1676 | Northern hardwood | 1.7 | 5 | 2.9 |
| | | | 26.1 | 89 | $\bar{X}$ = 3.09 |

TABLE 7 (continued)

| Route | Altitude (m) | Vegetation Type | KM | No. Scats | Scats/KM |
|---|---|---|---|---|---|
| Spence-Russell | 610- 762 | Hemlock | 3.4 | 2 | 0.6 |
| | 610- 762 | Cove hardwood | 2.2 | 0 | 0 |
| | 763- 913 | Closed oak | 1.4 | 0 | 0 |
| | 763- 913 | Hemlock | 1.3 | 1 | 0.8 |
| | 914-1066 | Closed oak | 0.7 | 2 | 2.9 |
| | 914-1066 | Hemlock | 0.7 | 1 | 1.4 |
| | 1067-1218 | Closed oak | 1.3 | 0 | 0 |
| | 1067-1218 | Open oak-pine and balds | 2.7 | 3 | 1.1 |
| | 1219-1371 | Closed oak | 1.7 | 2 | 1.2 |
| | 1219-1371 | Open oak-pine and balds | 0.7 | 0 | 0 |
| | 1219-1371 | Northern hardwood | 1.1 | 6 | 5.5 |
| | 1372-1524 | Closed oak | 0.2 | 0 | 0 |
| | 1372-1524 | Northern hardwood | 3.1 | 12 | 3.9 |
| | 1525-1676 | Northern hardwood | 0.9 | 3 | 3.3 |
| | | | 21.4 | 32 | $\bar{X}$ = 1.48 |
| Gregory-Hannah Mountain | 457- 609 | Cove hardwood | 0.7 | 0 | 0 |
| | 457- 609 | Closed oak | 0.9 | 1 | 1.1 |
| | 457- 609 | Open oak-pine and balds | 4.1 | 1 | 0.2 |
| | 610- 762 | Cove hardwood | 2.3 | 0 | 0 |
| | 610- 762 | Closed oak | 4.4 | 15 | 3.4 |
| | 610- 762 | Open oak-pine and balds | 5.4 | 8 | 1.5 |
| | 763- 913 | Cove hardwood | 1.4 | 0 | 0 |
| | 763- 913 | Open oak-pine and | 7.2 | 44 | 6.1 |
| | 914-1066 | Closed oak | 1.1 | 3 | 2.7 |
| | 914-1066 | Open oak-pine and balds | 1.4 | 0 | 0 |
| | 1067-1218 | Closed oak | 1.3 | 2 | 1.5 |
| | 1067-1218 | Open oak-pine and balds | 1.4 | 1 | 0.7 |
| | 1219-1371 | Closed oak | 1.3 | 1 | 0.8 |
| | 1219-1371 | Open oak-pine and balds | 0.4 | 1 | 2.5 |
| | 1219-1371 | Northern hardwoods | 0.9 | 2 | 2.2 |
| | 1372-1524 | Closed oak | 1.3 | 0 | 0 |
| | 1372-1524 | Open oak-pine and balds | 1.3 | 1 | 0.8 |
| | 1372-1524 | Northern hardwoods | 0.3 | 4 | 13.3 |
| | | | 37.1 | 84 | $\bar{X}$ = 2.04 |

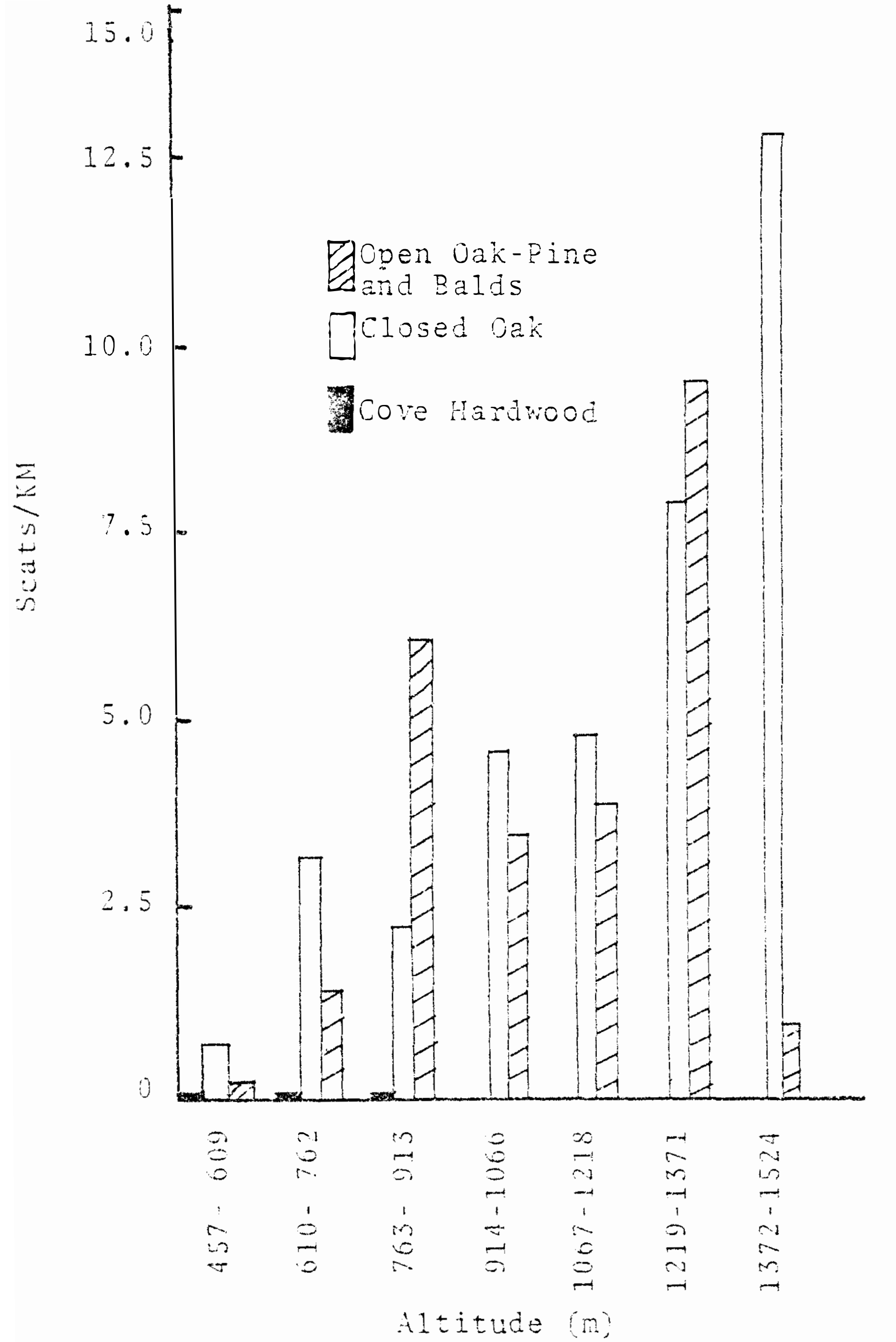


Figure 10. Relationship of scats/km within vegetation classifications in the Great Smoky Mountains National Park, 1970-1975.

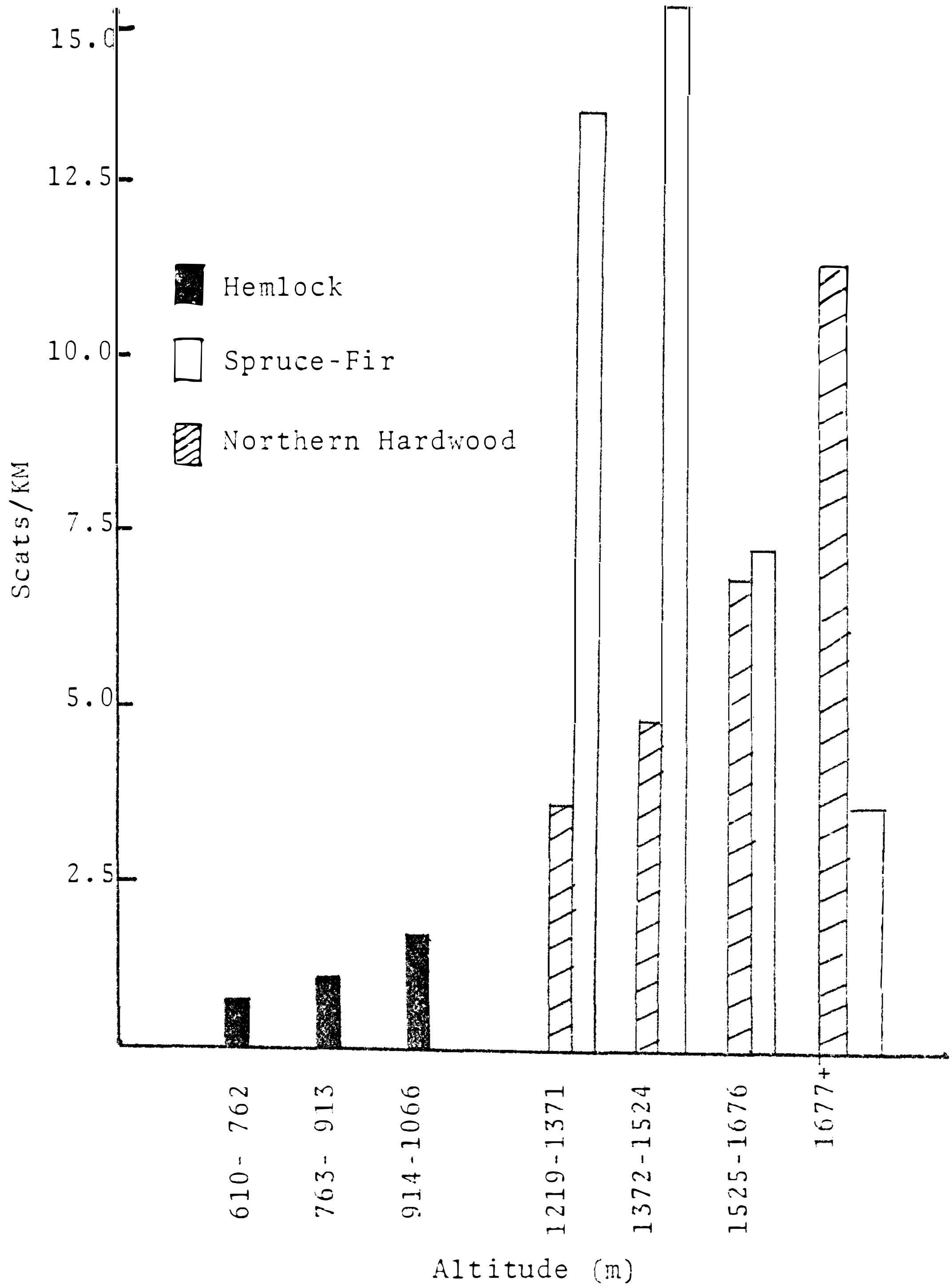


Figure 10 (continued)

classification may contribute to the lack of scats found in the cove hardwood forest type. One other possible reason for the lack of scats in this type may be historical in nature. It is known that the logging and clearing of slopes in the Park reached its peak in the late 1920's. At this time over 60 percent of the land was at least partially cleared (LaFollette 1974). It may be that the hard mast producing species in the cove hardwoods have not begun to generate enough mast to attract bears for any period of time.

The altitudinal relationships for the closed oak vegetation type (2) indicate that the scats/km value increased with an increase in altitude. The peak value was 12.8 scats/km; the corresponding altitude was 1372-1524 m. This is felt to be particularly noteworthy as this altitude level is also the upper limit of the closed oak vegetation type (Shanks 1954b).

The open oak-pine and balds vegetation type exhibits a different pattern. Beginning at 0.2 scats/km at the lower elevations, the value increases to 6.1 scats/km, drops to 3.4 scats/km, then rises to 9.4 scats/km and finally drops to 0.8 scats/km. The sharp rise in the scats/km value from 0.2 to 6.1, between altitude levels of 610-913 m and subsequent drop to 3.4 scats/km between altitudes of 914-1066 m may be explained by the dominance of Vaccinium sp. between altitude levels of 617-913 m (Whittaker 1956).

As bears feed heavily on this species (Beeman 1971), they likely frequent the area between 763-913 m more often than others thus resulting in the scats/km value of 6.1. The scats/km value continues to rise to 9.4 scats/km at the corresponding altitude level of 1219-1371 m; at this point the scats/km value drops drastically to 0.8 scats/km at the altitude level of 1372 m. According to Shanks' diagram (Figure 2, page 11), the highest reaches of the open oak-pine vegetation type also terminates around 1372 m, probably explaining the drastic drop in the last scat/km value. The balds, however, start just below 1372 m and continue up to the highest elevations. As the scats/km value falls sharply at the 1372 m altitude level, it would appear that there is more to attract bears in the open oak-pine stands than in the bald areas, possibly food. It may be that bears prefer more open understory and availability of oak mast to the denser heath coverage of the heath balds and/or the grassy cover of the grass balds.

The altitudinal relationships found within the northern hardwoods vegetation type (4) is similar to that found for the closed oak; the number of scats/km increased with each increase in altitude. Scats first occurred within the 1219-1371 m altitude level and peaked at 11.2 scats/km in the highest altitude class, 1677+ m. Beeman (1975) suggests that it is not habitat preference but the panhandler behavior of some bears that causes them to frequent the northern hardwoods vegetation type in the summer; most of the overnight shelters along Index Routes are located in/or on the edge of the northern hardwoods vegetation type. Beeman (1975) also found that those bears in the northern hardwoods vegetation type shifted to the closed oak and cove hardwoods vegetation types in the fall.

Within the hemlock vegetation type (5) the relationship also indicates an increase in the scats/km with an increase in altitude. The extremely low scats/km values (Appendix G) show this vegetation type to be second least productive. Of the 133.2 km only 12 km or 9 percent of the Index Routes passed through the hemlock vegetation type. The hemlock type is found primarily in the lower elevations. There are few food resources for bears in this type since the understory consists primarily of rhododendron.

The spruce-fir vegetation type (6) exhibits an altogether different pattern when compared to the others. Scats/km begin to rise between 1219-1371 m and peak at 1524 m. At this point the scats/km value begins to decrease steadily. This suggests that bears do not frequent the pure fir stands of the highest altitudes of this vegetation type as often as they do the lower altitude spruce-fir segments. It may be that the particular food/foods found at this altitude level are located only in the spruce-fir segments and not in the pure fir stands. It may also be that fewer kilometers of trail exist in the pure fir stands than in the spruce-fir, causing more emphasis to be placed on these last two segments.

## Backcountry Use and Scat Incidence

Recognizing the fact that human impact can and often does adversely affect some species (Leopold 1966) and the fact that the overall number of scats collected per kilometer have decreased from 1970 through 1975 (Figure 4, page 35), I investigated the relationship between the number of scats collected per kilometer (an indication of population trend) and the number of backcountry nights (number of backpackers multiplied by the number of nights spent in the backcountry) as reported by the National Park Service (Figure 11). If Figure 11 shows any kind of relationship between the two factors it would appear to be a positive one for all years except 1973. It is felt, however, that this conclusion is incorrect.

LaFollette (1974) noted that hiker use of the Park has increased exponentially from 8000 in 1970 to 80,000 in 1973. As the popularity of backpacking has also increased in recent years, it would seem logical that a similar pattern of increase would also be evident in Park records. The determination of backcountry nights, as computed by Park personnel, is calculated from the number of camping permits

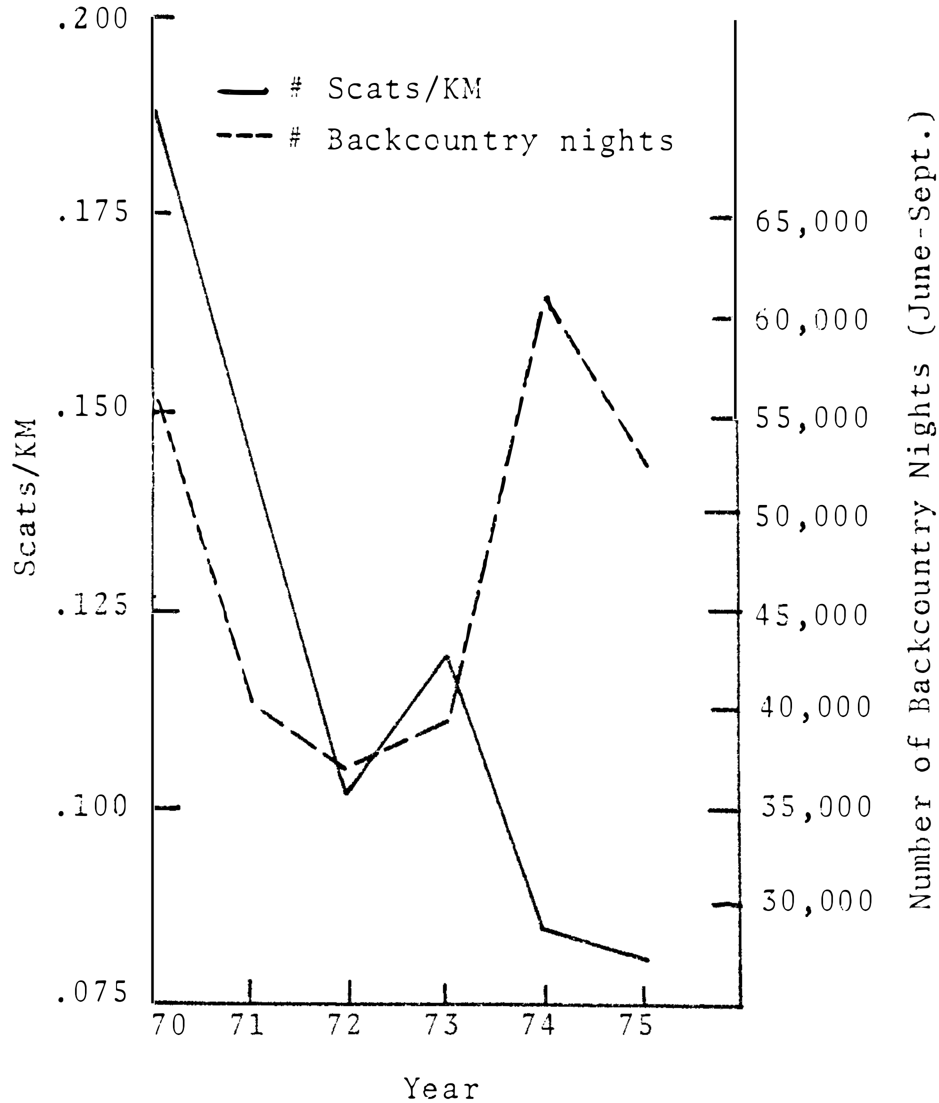


Figure 11. Relationship between the summer season scats/km values and the number of backcountry (number of backpackers multiplied by the number of nights spent out) nights for the same time period.

issued to overnight backpackers. It is probable that some neglect to apply for the permit and are thus never censused. The ratio between those with permits and those without is unknown.

Another reason for doubting a positive relationship between number of scats/km and number of backcountry nights is the results (unpublished data) of hiking an abandoned trail (same biweekly pattern as other Index Routes) located just to the east of the Spence-Russell Index Route. The abandoned route proved to be the most productive in terms of scats/km, when compared to the results of all other routes hiked in 1975. As both routes (Spence-Russell and the abandoned trail) traverse similar topography and vegetation, it appears that some factor may influence the number of scats/km, possibly the degree of human utilization. It should be noted that the Anthony Creek Trail, a major portion of the Spence-Russell Index Route, is one of the more popular trails in the Park. Marsh (1973) noted that during the period between early June and late July, the Anthony Creek Trail had an average of 24 people passing his checkpoint every three hours. Between the end of July and mid-September this figure increased to a mean of 34 per three-hour period. Marsh also tabulated similar counts on two other trails, Elkmont and Gregory Ridge, which are major segments of two other Index Routes, Elkmont-Bent Arm and Gregory-Hannah Mountain. Using the same time periods mentioned above, he found Elkmont to produce 5 and 0 persons, respectively, per three-hour period and Gregory Ridge to produce 6 and 1 persons, respectively, per three-hour period. Additional data collected during the 1975 summer season also showed that the combination of trails which make up the Spence-Russell Index Route was used by a greater number of hikers than any of the other Index Routes (Table 4, page 32). All of the above points to the high degree of popularity and consequently the high degree of human utilization encountered on the Spence-Russell Index Route. It is suspected that the large number of hikers who use the Spence-Russell Index Route may have had some influence on the resultant scats/km value and thus account for the nonsignificant outcome of the analysis of variance procedure. However, the low incidence of scats on low visitor use trails (e.g., Gregory-Hannah Mountain) cannot be attributed to hiker impact.

## Expected Frequencies of Scats

At the outset of this preliminary survey, it was hoped that an independent index could be established to monitor fluctuations in the black bear population of the Great Smoky Mountains National Park. Due to the complicated nature of the statistical aspects of the problem and the fact that numerous assumptions need to be made concerning the statistical validity of the many and varied influences on the incidence of black bear scats (i.e., temperature, precipitation, behavioral reactions among individual bears, game trails, etc.) establishing a precise and accurate index was not possible without a more in-depth analysis of the above variables.

However, with the data available and with the results of the statistical analyses performed, it is possible to determine the relative expected frequencies, which are the probabilities of the various outcomes (Snedocor 1950). Given a particular altitude-vegetation class on a given route and knowing the mean scats/km value for that route, it is possible to predict the number of times that particular route must be hiked in order to collect one or more scats within a set probability. Where p = mean number of scats/km for a route (or trail segment) and N = number of hikes, the following equation can be set up: $M = pN$. The calculated value of M is found in a table for relative expected frequencies for individual terms of the Poisson distribution. Using the mean scats/km value for the closed oak vegetation type of the Elkmont-Bent Arm Index Route between altitude levels of 1067-1218 m and assuming that this section would be hiked 10 times, the equation would be as follows:

$$M = pN$$

$$M = .2324\ (10)$$

$$M = 2.3$$

To determine the probability of the occurrence of a count of Y = 0 events on a distribution where the mean, M = 2.3, the value of 2.3 is found in the appropriate table and is .100259. In other words, if the closed oak vegetation type of the Elkmont-Bent Arm Index Route, between the altitude levels of 1067-1218 m were hiked 10 times, there is a 90 percent probability that one or more scats will be found.

Using this equation, it is possible to predict within a set probability whether one route and its subsequent altitude-vegetation type produce the number of scats expected, based on the sample mean (scats/km) from previous hikes. Although this equation cannot guarantee to be an accurate monitor of population fluctuations, it is able to provide a certain degree of probability that a certain number of scats can be expected to be collected along particular segments of Index Routes. Any deviations from the expected frequencies could indicate a fluctuation in the population level. This alone is not an accurate description of the population trends. With further measurements of extrinsic and intrinsic factors that may affect population density in conjunction with the appropriate statistical analyses, it would be possible to directly monitor population fluctuations via incidence of scats.

# CHAPTER V

## SUMMARY AND CONCLUSIONS

The purpose of this study was to determine the degree of variability of incidence of scats by date and location and to determine the feasibility of using scats as a reliable index to the population density of black bears in the Great Smoky Mountains National Park.

Seasonal distribution of scats was broken into two categories: summer season (1 June - 1 October) and post- and pre-summer season (1 October - 1 June). The scats/km values for the pre- and post-summer seasons were considerably lower than the summer season scats/km by about 25 percent. The Spence-Russell Index Route proved to be the only exception where the summer season scats/km value fell below the pre- and post-summer season scats/km values.

During the six years' time this study covers, 6085.7 km of Index Routes were hiked between 1 June and 1 October, yielding a total of 697 scats. The Elkmont-Bent Arm Index Route proved to be the most productive of all the Index Routes, yielding 0.21 scats/km. Next was Sugarlands with 0.18 scats/km, Tremont-Derrick Knob with 0.07 scats/km, Gregory-Hannah Mountain with 0.06 scats/km and Spence-Russell with 0.03 scats/km.

Between 1 June and 1 October each route was hiked approximately nine times or once every two weeks. Definite peaks and depressions in the scats/km value occur among the hiking dates. Peaks occurred in early June and from mid-August through early September. Depressions occurred from mid-June through late July and during late September and early October. It is felt that the decline noted during June and July may be an indication of the onset of the breeding period for black bears while the decline at the end of the summer season probably indicates the movement of bears away from Index Routes during early fall, foraging activities, and later the onset of winter and the initiation of hibernation activities. The productivity, in terms of scats/km, of the time period from early August through early September was about 50 percent greater than other time periods except for early June which was also approximately 50 percent more productive.

Of the nine altitudinal classes, ranging from 457-1677+ m, the class ranging from 1219-1371 m proved to be most productive, yielding 8.2 scats/km. In fact, those altitudes from 1219-1677+ m produced more scats/km than those ranging from 457-1218 m. The lower range of altitudes accounts for 31.6 percent of the total scats collected while the higher altitude range accounts for 68.4 percent of the total scats collected. Looking at the number of scats collected in conjunction with corresponding distances hiked, it turns out that over two-thirds of all scats collected along Index Routes were collected on less than half of the total mileage.

Of the six major vegetation types present in the Park, the spruce-fir vegetation type produced the highest overall scats/km value at 8.1 scats/km. It is interesting to note that only 6 percent of the total distance hiked was in the spruce-fir vegetation type. Northern hardwoods yielded 7.3 scats/km, closed oak 5.8 scats/km, open oak-pine and balds 4.3 scats/km and hemlock 0.03 scats/km. The cove hardwoods yielded no scats.

Realizing that one vegetation type can span one or more altitude classes and vice versa, an analysis of variance procedure was performed to determine if these two factors could significantly affect the number of scats collected along Index Routes. The outcome proved that there did indeed exist a probability at or above the 95 percent level of confidence that the combination of altitude and its resultant vegetation type did significantly affect the location of the bear scats on all routes except the Spence-Russell Index Route.

In order to attempt to explain the results for Spence-Russell Index Route, one factor was investigated, that of hiker intensity or simply the number of backpackers utilizing the routes. During 1975 a survey showed that 174 backpackers were met along the route during a given time period. This number is almost 40 percent larger than the next highest number of backpackers encountered along any of the other routes.

Due to the complicated nature of the statistical aspects of the problem and the fact that numerous assumptions would need to be made concerning the statistical validity of the many influences on the population density (i.e., temperature, precipitation, behavioral reactions among individual bears, etc.) establishing such an index was not feasible without a more in-depth analysis of these factors.

However, with the compiled data, a prediction equation was established. Where p = mean number of scats/km for a route or trail segment and N = number of hikes, then M = pN. Using a table for relative expected frequencies for individual terms of the Poisson distribution to determine the correct value corresponding to M, it is possible to determine if a given area is producing the number of expected scats.

It is important though that each Index Route continues to be hiked, using the results from the prediction equation only as a check on the actual results; number of scats/km. Any deviations from expected (calculated) values could indicate a fluctuation in the population level, however, this indication alone should not be considered a true or accurate monitor of the population trends without further research and continuation of monitoring of the bear population and its activities.

# CHAPTER VI

## RECOMMENDATIONS

Additional research of associated factors is needed if an independent index for monitoring population trends via scat collection is to be established. The following list of projects might be included in an extended research program.

1. Monitoring of weather conditions particularly among different vegetation types and among different altitude types; temperature, rainfall and runoff should be stressed.

2. A study of the deterioration rate of black bear scats, on and off trail, to determine if the two-week interval between collection periods is too long for proper identification of scats.

3. Reaction of bears (particularly backcountry bears as opposed to panhandlers) to hiker intensity since 95 percent of the bears trapped and released in areas of the Park are never seen again (Beeman 1975).

4. Determination of the defecation rate of black bears; with this information it would be possible to estimate population density using the following formula:

$$D(\text{animals/km}^2) = \frac{s(\text{scats})}{t(\text{days}) \cdot a(\text{km}^2) \cdot d(\text{scats/day and animal})}$$

(Neff 1968.)

5. Comparison between on-trail and off-trail incidence of scats to determine the degree of variability of incidence and relative degree of trail use by bears during seasonal movements.

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# APPENDICES

## APPENDIX A

### SUMMARY SHEET-INDEX TRAIL BLACK BEAR STUDY
### SCAT COLLECTIONS

Index Trail Hiker_______________________________Date_________
Trail___________________________Weather_____________________
Total Number of Bear Scat Collected:______________________

| Scat Number | Exact Location | Comments |
|---|---|---|
| | | |

APPENDIX B

CODING CLASSIFICATIONS

TABLE 8

CODING USED FOR VEGETATION AND ALTITUDINAL CLASSES

| Class Code | Code Definition |
|---|---|
| Altitude | Actual Values |
| 1 | 457- 609 m (1500-1999 ft) |
| 2 | 610- 762 m (2000-2499 ft) |
| 3 | 763- 913 m (2500-2999 ft) |
| 4 | 914-1066 m (3000-3499 ft) |
| 5 | 1067-1218 m (3500-3999 ft) |
| 6 | 1219-1371 m (4000-4499 ft) |
| 7 | 1372-1524 m (4500-4999 ft) |
| 8 | 1525-1676 m (5000-5499 ft) |
| 9 | 1677+ m (5500+ ft) |
| Vegetation | Vegetation Type |
| 1 | Cove hardwood |
| 2 | Closed oak |
| 3 | Open oak-pine and balds |
| 4 | Northern hardwood |
| 5 | Hemlock |
| 6 | Spruce-fir |

APPENDIX C

TOTAL SCATS COLLECTED

TABLE 9

TOTAL NUMBER OF SCATS COLLECTED ALONG EACH INDEX ROUTE AND WITHIN EACH VEGETATION TYPE IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

| Index Route | Vegetation Type | # Scats | KM | Scats/KM |
|---|---|---|---|---|
| Sugarlands | Closed oak | 8 | 3.4 | 2.4 |
| | Open oak-pine and balds | 74 | 6.9 | 10.7 |
| | Spruce fir | 62 | 7.7 | 8.1 |
| Elkmont-Bent Arm | Closed oak | 210 | 17.8 | 11.8 |
| | Northern hdwd. | 118 | 15.8 | 7.5 |
| Tremont-Derrick Knob | Closed oak | 45 | 14.8 | 3.0 |
| | Northern hdwd. | 44 | 10.2 | 4.3 |
| Spence-Russell | Cove hardwood | 0 | 3.0 | --- |
| | Closed oak | 4 | 4.4 | 0.9 |
| | Open oak-pine and balds | 3 | 3.5 | 0.9 |
| | Northern hdwd. | 21 | 5.4 | 3.9 |
| | Hemlock | 4 | 5.3 | 0.8 |
| Gregory-Hannah Mountain | Cove hardwood | 0 | 4.5 | --- |
| | Closed oak | 22 | 9.2 | 2.4 |
| | Open oak-pine and balds | 56 | 20.3 | 2.8 |
| | Northern hdwd. | 6 | 1.2 | 5.0 |
| Overall Total | Cove hardwood | 0 | 7.5 | --- |
| | Closed oak | 289 | 49.6 | 5.8 |
| | Open oak-pine and balds | 133 | 30.7 | 4.3 |
| | Northern hdwd. | 189 | 25.9 | 7.3 |
| | Hemlock | 4 | 12.0 | 0.3 |
| | Spruce-fir | 62 | 7.7 | 8.1 |
| | | 677 | 133.4 | |

## APPENDIX D

## ANOVA TABLE FOR SCATS/KM BY ALTITUDE-VEGETATION TYPE

### TABLE 10

COMPLETED ANOVA TABLE FOR SCATS/KM BY ALTITUDE-VEGETATION TYPE IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK, 1970-1975

| Source | df | SS | MS | F |
|---|---|---|---|---|
| Among classes | 8 | 272.3486 | 34.0435 | 2.5401 |
| Linear regression | 1 | 226.9609 | 226.9609 | 35.0032 |
| Deviations from regression | 7 | 45.3877 | 6.4840 | <1.00 |
| Within groups | 19 | 254.6425 | 13.4022 | |
| Total | 27 | 526.9911 | | |

APPENDIX E

# DESCRIPTION OF INDEX ROUTE LOCATIONS AND VEGETATION TYPES

## Sugarlands

This route begins at the Spruce-Fir Nature Trail on the Clingman's Dome Road. Approximately 0.8 km from its starting point is the Mt. Collins trail shelter. The first section of the Sugarland Route follows the Sugarland Mountain Trail for 14.3 km at which point it intersects the Huskey Gap Trail. The Index Route turns east at this junction and follows the east half of Huskey Gap Trail for 2.9 km where it terminates on U. S. Highway 441. The Sugarlands Route is characterized by three general vegetation types. The spruce-fir vegetation type is dominant above 1372 m. The open oak-pine and balds vegetation type is found from 914 m to 1372 m and the closed oak vegetation type is found from 573-914 m.

## Elkmont-Bent Arm

Located in the watershed of the East Prong of the Little River, this route begins at the Cucumber Gap trail head and travels west for 2 km to the Bent Arm manway which leads southward. The manway intersects Miry Ridge Trail after 6 km. Continuing southward along Miry Ridge Trail for 4.5 km, the route intersects the Appalachian Trail

(AT) at Buckeye Gap. The Index Route then proceeds east along the AT. Along this section of the AT, trail shelters are located at Silers Bald and Double Springs Gap, 4.2 km and 6.9 km east of Buckeye Gap, respectively. Goshen Prong Trail intersects the AT 7.9 km from Buckeye Gap. At this intersection the Index Route proceeds for 11.7 km (7.3 mi) along Goshen Prong Trail and then terminates on the Little River Gravel Road. Two vegetation types, closed oak and northern hardwoods, characterize this route. Closed oak forests are located predominantly at the lower elevations 792-1372 m while the northern hardwoods are located at the higher elevations between 1372-1709 m.

Tremont-Derrick Knob

Starting at the Panther Creek trail head on the Tremont Road, this route turns southward, after 3.7 km, at Jakes Gap and follows Miry Ridge Trail until it terminates at the AT. (This last section along Miry Ridge is also shared with the Elkmont-Bent Arm Index Route.) At this point the route proceeds west along the AT for 4.2 km at which point it reaches Derrick Knob. Located at Derrick Knob is the only trail shelter along this route. Here the route turns north along Davis Ridge and after 8.5 km terminates on the Tremont Road just above the originating point of the route. Similar to the Elkmont-Bent Arm route, there are two general vegetation types; closed oak and northern hardwoods. The closed oak forests are located between elevations of 792-1372 m while the northern hardwoods are situated between 1372-1578 m.

Spence-Russell

This route begins in the Cades Cove Picnic Ground at the Anthony Creek trail head. It proceeds for 5.5 km to the Bote Mountain Road where it turns south following the road for 2.6 km where it intersects the AT crossing Spencefield. At the AT the route continues westward for 3.7 km where it reaches Russell Field. Trail shelters are located at both Spencefield and Russell Field. The route turns north at Russell Field and follows Leadbetter Ridge for 5.6 km until it intersects the Anthony Creek Trail. At the junction of the two trails the route follows Anthony Creek Trail back to the route's originating point. Five vegetation types are found along this route. In the lowest elevations along sheltered streams are the hemlock forests. Moving to higher elevations, but still in sheltered situations, cove hardwood forests are found. At the same elevations as the cove hardwoods, but in more exposed sites, are the closed oak forests which in turn give way to the open oak-pine and balds vegetation type on the most exposed sites along the route. The northern hardwoods vegetation type is found above the 1372 m elevation level.

Gregory-Hannah Mountain

The first section of this route begins at the Gregory Ridge trail head on Forge Creek Road and continues for 8.0 km (5.0 mi) where it terminates at Rich Gap. The route continues along the Gregory Bald Trail for 1.1 km to the crest of Gregory Bald. After crossing Gregory Bald, the trail turns north and descends to its termination at Parson's Branch Road. The Index Route continues along Hannah Mountain Trail for 12.1 km at which point it intersects Scott Gap on the Rabbit Creek Road. Here the route turns east, follows Rabbit Creek Road for 11.3 km, and terminates in the Abrams Falls parking area at the west end of Cades Cove. The route is characterized by four general vegetation types. Cove hardwoods are located in sheltered areas between 522-1372 km. Closed oak forests, found at the same elevations as cove hardwoods but in more exposed sites, give way to the open oak-pine and balds on the most exposed ridges and gaps. The northern hardwoods are found above the 1372 m elevation level.

## APPENDIX F

## SCATS COLLECTED BETWEEN 15 OCTOBER AND 1 JUNE

### TABLE 11

### DATES AND NUMBER OF SCATS COLLECTED BETWEEN 15 OCTOBER AND 1 JUNE

| Index Route | Scats Collected | Means |
|---|---|---|
| Sugarlands | | |
| 5- 3-70 | 2 | Post-summer season 0.10 scats/km |
| 5-16-70 | 1 | Pre-summer season 0.04 scats/km |
| 5-30-70 | 1 | |
| 10-18-70 | 3 | |
| 10-31-70 | 1 | |
| 11-13-70 | 0 | |
| 11-15-70 | 1 | |
| 4- 3-71 | 0 | |
| 4-17-71 | 0 | |
| 4-31-71 | 0 | |
| 10-18-71 | 2 | |
| 10-29-71 | 1 | |
| 5-28-72 | 1 | |
| 10-15-74 | 4 | |
| | 17 | |
| Tremont-Derrick Knob | | |
| 4- 4-70 | 0 | Post-summer season 0.10 scats/km |
| 5-30-70 | 2 | Pre-summer season 0.05 scats/km |
| 10-18-70 | 3 | |
| 11-12-70 | 3 | |
| 12- 9-70 | 4 | |
| 4- 3-71 | 0 | |
| 4-17-71 | 0 | |
| 5-16-71 | 3 | |
| 5-29-71 | 0 | |
| 10-17-71 | 5 | |
| 10-29-71 | 2 | |

TABLE 11 (continued)

| Index Route | Scats Collected | Means |
|---|---|---|
| 11- 3-71 | 0 | |
| 12-15-71 | 2 | |
| 5-27-72 | 3 | |
| 10-12-74 | 1 | |
| | 28 | |
| Elkmont-Bent Arm | | |
| 4- 4-70 | 0 | Post-summer season 0.05 scats/km |
| 4-18-70 | 1 | Pre-summer season 0.07 scats/km |
| 5- 2-70 | 1 | |
| 5- 3-70 | 1 | |
| 5-16-70 | 1 | |
| 5-30-70 | 12 | |
| 10-17-70 | 3 | |
| 4-17-71 | 0 | |
| 4-29-71 | 0 | |
| 5- 1-71 | 2 | |
| 5-16-71 | 1 | |
| 6- 4-71 | 5 | |
| 10-30-71 | 2 | |
| 5-27-72 | 3 | |
| 10-28-72 | 0 | |
| | 32 | |
| Spence-Russell | | |
| 4- 4-70 | 0 | Post-summer season 0.04 scats/km |
| 4-18-70 | 1 | Pre-summer season 0.06 scats/km |
| 5- 3-70 | 6 | |
| 5-31-70 | 1 | |
| 10-22-70 | 0 | |
| 11-31-70 | 0 | |
| 12- 5-70 | 1 | |
| 4- 3-71 | 0 | |
| 4-18-71 | 0 | |
| 5- 2-71 | 0 | |
| 5-16-71 | 0 | |
| 5-27-71 | 3 | |

TABLE 11 (continued)

| Index Route | Scats Collected | Means |
|---|---|---|
| 5-29-71 | 0 | |
| 10-16-71 | 4 | |
| 3-10-72 | 0 | |
| 5-27-72 | 3 | |
| 12-17-72 | 0 | |
| 10-19-73 | 1 | |
| 10-12-74 | 0 | |
| | 20 | |
| Gregory-Hannah Mountain | | |
| 4- 4-71 | 0 | Post-summer season 0.05 scats/km |
| 4-19-71 | 0 | Pre-summer season 0.005 scats/km |
| 5- 1-71 | 0 | |
| 5-16-71 | 1 | |
| 6- 3-71 | 0 | |
| 10-16-71 | 1 | |
| 10-28-71 | 1 | |
| 5-27-72 | 0 | |
| 10- 2-72 | 3 | |
| 11-24-72 | 0 | |
| 10-10-73 | 5 | |
| 10-12-74 | 0 | |
| | 11 | |

APPENDIX G

ANOVA TABLE FOR SCATS/KM BY

HIKING PERIOD

TABLE 12

ANOVA TABLE FOR SCATS/KM BY HIKING PERIOD IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK, 1970-1975

| Source | df | SS | MS | F |
|---|---|---|---|---|
| Among groups | 8 | 0.0570 | 0.0071 | 1.34* |
| Within groups | 44 | 0.2317 | 0.0053 | |
| Total | 52 | 0.2887 | | |

* = significant difference at the 75 percent confidence level.

## APPENDIX H

## NUMBER OF SCATS COLLECTED WITHIN ALTITUDINAL CLASSES

TABLE 13

NUMBER OF SCATS COLLECTED WITHIN ALTITUDINAL CLASSES ALONG INDEX ROUTES IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK, 1970-1975

| Altitude (m) | Index Routes | | | | |
|---|---|---|---|---|---|
| | Sugarlands | Elkmont-Bent Arm | Tremont-Derrick Knob | Spence-Russell | Gregory-Hannah Mountain |
| 457- 609 | --* | -- | -- | -- | 2 |
| 610- 762 | 3 | 0 | -- | 2 | 23 |
| 763- 913 | 5 | 15 | 1 | 1 | 44 |
| 914-1066 | 10 | 38 | 3 | 3 | 3 |
| 1067-1218 | 17 | 32 | 6 | 3 | 3 |
| 1219-1371 | 55 | 65 | 26 | 8 | 4 |
| 1372-1524 | 18 | 83 | 48 | 12 | 5 |
| 1525-1676 | 25 | 66 | 5 | 3 | -- |
| 1677+ | 11 | 29 | -- | -- | -- |

* = this altitude did not appear in the corresponding Index Route.

## APPENDIX I

## NUMBER OF SCATS COLLECTED WITHIN VEGETATION TYPES

### TABLE 14

NUMBER OF SCATS COLLECTED ALONG INDEX ROUTES WITHIN VEGETATION TYPES IN RESPECT TO ALTITUDE CLASSES IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK, 1970-1975

| Altitude Class (m) | Vegetation Types | KM | # Scats | Scats/KM |
|---|---|---|---|---|
| 457- 609 | Closed oak | 1.4 | 1 | 0.7 |
| | Cove hardwood | 0.7 | 0 | -- |
| | Open oak-pine and balds | 4.1 | 1 | 0.2 |
| 610- 762 | Cove hardwood | 4.5 | 0 | -- |
| | Closed oak | 5.6 | 18 | 3.2 |
| | Open oak-pine and balds | 5.4 | 8 | 1.5 |
| | Hemlock | 3.4 | 2 | 0.6 |
| 763- 913 | Cove hardwood | 1.4 | 0 | -- |
| | Closed oak | 9.4 | 21 | 2.2 |
| | Open oak-pine and balds | 7.2 | 44 | 6.1 |
| | Hemlock | 1.3 | 1 | 0.8 |
| 914-1066 | Closed oak | 10.3 | 46 | 4.5 |
| | Open oak-pine and balds | 2.9 | 10 | 3.4 |
| | Hemlock | 0.7 | 1 | 1.4 |
| 1067-1218 | Closed oak | 8.1 | 40 | 4.9 |
| | Open oak-pine and balds | 5.4 | 21 | 3.9 |
| 1219-1371 | Closed oak | 10.1 | 81 | 8.0 |
| | Open oak-pine and balds | 5.1 | 48 | 9.4 |
| | Northern hdwd. | 4.0 | 14 | 3.5 |
| | Spruce-fir | 0.6 | 8 | 13.3 |

TABLE 14 (continued)

| Altitude Class (m) | Vegetation Types | KM | # Scats | Scats/KM |
|---|---|---|---|---|
| 1372-1524 | Closed oak | 6.4 | 82 | 12.8 |
| | Open oak-pine and balds | 1.3 | 1 | 0.8 |
| | Northern hdwd. | 15.7 | 72 | 4.6 |
| | Spruce-fir | 1.3 | 20 | 15.4 |
| 1525-1676 | Northern hdwd. | 11.0 | 74 | 6.7 |
| | Spruce-fir | 3.2 | 23 | 7.2 |
| 1677+ | Northern hdwd. | 2.6 | 29 | 11.2 |
| | Spruce-fir | 3.1 | 11 | 3.5 |

# VITA

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