To the Graduate Council:

I am submitting herewith a thesis written by Mary Ellen Bruhn entitled "Vegetational Succession on Three Grassy Balds of the Great Smoky Mountains." I recommend that it be accepted for eighteen quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Botany.

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VEGETATIONAL SUCCESSION ON THREE GRASSY BALDS OF THE GREAT SMOKY MOUNTAINS

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Mary Ellen Bruhn

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I. INTRODUCTION

The Great Smoky Mountains Conservation Association recently requested that the National Park Service take steps to preserve three grassy balds (Andrews Bald, Spence Field, and Gregory Bald) of the Great Smoky Mountains by preventing the invasion of woody vegetation on these balds. The National Park Service requested that the University of Tennessee Department of Botany look into the problem and thus the problem was brought to the attention of the author by Dr. E. E. C. Clebsch.

This is a study of vegetation change on these three grassy balds. Special interest is given to the rate of encroachment of woody species. This is a preliminary step in understanding the fate of the balds over time if nothing is done to preserve them.

II. GENERAL DESCRIPTION OF THE AREA, CLIMATE, GEOLOGY, AND SOILS

The grassy balds are high mountain meadows which are dominated by herbaceous vegetation, predominately grasses and sedges of which the most important is Danthonia compressa.[1] They occur in the southern section of the Blue Ridge Province (Fenneman 1938) mainly in the western portion of North Carolina and along the North Carolina-Tennessee line. Whitetop Mountain Bald in southern Virginia is the only exception to this. The grassy balds are found between elevations of 4, 500 and 6, 300 feet and may occupy dome-shaped summits, gaps or slopes. The slope on the balds ranges from 0° to 28° (Mark 1958). At least some of the areas which are now called balds are thought to be of natural origin.

The grassy balds in the Smoky Mountains lie in an area which probably receives 80 or more inches of rainfall a year. This is based on rainfall data from Clingmans Dome and Newfound Gap (Shanks 1954). They are quite frequently engulfed in fog. September and October are the driest months and droughts are not uncommon in late summer and early fall.

[1]The nomenclature used for the vascular plants follows "Gray's Manual of Botany" 8th Ed. (Fernald 1950) where feasible. A small number of names are those of "Manual of Southern Flora." (Small 1933). The lichen nomenclature follows the "Lichen Handbook" (Hale 1961).

The Great Smoky Mountains lie in an area which was well south of the continental ice sheets of the pleistocene epoch. However, there is evidence which would indicate that a timberline once existed in the Smokies. Boulder deposits found on the lower slopes of the mountains were produced by processes which are no longer at work in the area. These deposits resemble those now forming in alpine and subarctic regions above timberline in other mountain ranges (King and Stupka 1950). The Great Smoky Mountains make up part of the Unaka Chain of the southern Blue Ridge Province. The Unaka Chain forms the northwestern edge of the Blue Ridge Province and merges with the Blue Ridge chain in southern Virginia. The Great Smoky Mountains contain some of the highest mountains in eastern North America. For 36 miles the main divide remains above 5,000 feet and there are 16 peaks which rise above 6,000 feet. The highest peak is Clingmans Dome which stands 6,643 feet high. All of the grassy balds in the Great Smoky Mountains occur on the Great Smoky group of later precambian rock of the Ocoee series. The Great Smoky group is made up of clastic rocks - fine conglomerates, coarse to fine sandstones and silty or argillaceous slates, phyllites and schist (King 1958). However, Mark (1958b) said, "It is apparent from the geological maps and also from field observations that there is no correlation between distribution of balds and of certain rock types." This was also the conclusion of Fenneman (1938).

According to Mark (1958b) the soils of the balds are, for the most part, sandy loams or loamy sands and are generally about the same as those of the adjacent forest. The differences among the balds are greater than the differences between bald and forest. There are only slight differences in the soil depth and the color of the A_1 horizon between the balds and the forests adjacent to them. These differences do not justify classifying the soils on the balds as grassland soils. The soils of the balds are generally somewhat less acid than those of the forest (Mark 1958b). Mark found that the organic matter content of the balds was not consistently different from that of the adjacent forest, though the forest soils in general tended to be higher in organic matter content. The cation exchange capacity of the forest soils tended to be higher than that of the balds but other chemical characteristics were in general similar.

In the literature there appears to be some confusion about which soil series the bald soils belong in. The soil of Andrews Bald, as mapped in the Swain County Soil Survey (1937), is Burton stony loam shallow phase. In 1962 McCracken, Shanks, and Clebsch recommended the soil of Andrews Bald be included in the group Sol Brun Acide. In personal communication Clebsch stated that it was his opinion that Andrews Bald had a Ramsey soil. Spence Field is reported by the Blount County Soil Survey (1959) as occurring on Ramsey stony loam,

hilly phase. Gilbert (1954) tentatively said that Spence Field occurred on Burton Soil. Gregory Bald was reported to have a Ramsey slately silt loam steep phase by the Blount County Soil Survey (1959). The Swain County Soil Survey (1937) located Gregory Bald on Burton stony loam, shallow phase. The confusion in the literature is evident. It is evident that more study is needed on the soils of the balds. From the literature about all that can be determined is that this soil is generally shallow, silt loam on a steep slope and that it may be somewhat rocky.

III. ORIGIN AND FUTURE

The origin of the balds has long been a matter of debate. No attempt will be made here to present a complete summary of this question as both V. C. Gilbert (1954) and A. F. Mark (1958) have presented excellent reviews of the problem. It is known that the period of origin for at least some of the balds was prior to the advent of white man since the presence of the balds is recorded in Cherokee Indian legend (Gilbert 1954). What caused the balds? Many theories have been advanced but none of them adquately explains the formation and maintenance of the balds. Mark's theory is probably the best one proposed to date. He proposes that they originated from forests through some agent of destruction which eliminated the protection of the forest tree canopy. In most areas, however, a relatively rapid succcession would soon replace the forest. In ecotonal regions and especially in areas of hardwood forest occupying a potential coniferous forest zone the rate of seedling establishment would be very slow. Areas of hardwood forest occupying a potential coniferous forest zone may have resulted from post-Wisconsin climatic fluctuations. During a hypsithermal (Deevy 1957) period spruce-fir forests were restricted to an altitude of from 300-1000 feet higher than its present lower limits. This fluctuation would have eliminated spruce-fir from some

of the lower peaks and would have resulted in a decrease in the available biotypes on the other peaks. A bald susceptible zone may have been produced (Billings and Mark 1957). It was during the period of cooling climate that has followed that the balds have become established. This theory does not, however, explain the origin and maintenance of those balds which lie in a coniferous forest zone and are surrounded by coniferous forest nor does it explain ecotonal balds such as Andrews Bald. Andrews Bald lies at the lower limit of the spruce-fir forest. The spruce-fir forest which partly surrounds the bald is continuous with that forest which reaches Clingmans Dome, and which extends for miles along the state line ridge. There, if anywhere in the park biotype depletion should not be important. Also, if Mark's theory is correct, it is strange that those areas which lost their forest canopy in the fire of 1925 and which were in an ecotonal region such as Andrews Bald are returning to forest and are not developing into balds. Thus, although Mark's theory may be part of the answer, it alone does not answer the question of how the balds arose. The answer may lie in some combination of factors as yet undetermined.

The question of how well the balds are maintaining themselves is difficult to answer. According to Malde (1953), "Historical records, soil and botany indicate that the plant communities in the bald area have

been changing, perhaps cyclically in the last few hundred years. Under the present climate hardwoods are encroaching upon the grassy balds and have been for about one hundred years." Soil studies suggest a former time when trees (presumably hardwoods) occupied the balds. The present encroachment of hardwoods is concurrent with world-wide warming that has been under way since about 1860 A. D. (Malde 1953). (See Table I). Webb (1964) stated that the grass balds which occur in south Queensland, Australia were also being invaded by woody vegetation due to the warmer climate of the present day. We know that the balds in the Smokies were grazed from some time in the 1800's until the 1930's. This, of course, helped maintain them during those years. In fact, heavy grazing may have destroyed the woody vegetation which was present prior to grazing. Gregory Bald is reported to have been a blueberry meadow by the long time residents of Cades Cove (Gilbert 1954), and therefore, it certainly had woody vegetation present on it at the time. Yet photographs taken in the 1920's and early 1930's show the bald practically bare of such woody vegetation. In 1931 Camp reported the woody vegetation which was present was so over grazed that it was not identifiable. Since grazing has been halted there has been an encroachment or reencroachment by woody vegetation. (Safford as early as 1869 wrote of the balds, "They abound in grasses, ferns, and small shrubs.")

Table I. Malde's summary of geologic history of balds.

Plant community	Date	Climate
Encroachment of hardwoods on grassy balds	Present to 1860 AD	Warming
Grassy balds	1860 AD to 1400 AD	Cooler than present
Hardwood forest (Spruce-fir forest restricted and extinguished)	1400 AD to 1000 AD	Warmer than present
Spruce-fir forest	1000 AD to 1000 BC	Cooler than present

Will the balds if left to themselves be completely grown over by woody vegetation? The generally prevailing answer to this question is affirmative. On the other hand, it may be that some environmental extreme has helped to maintain the balds. This extreme may occur only every 50 to 100 years but it might be sufficient to kill back the woody vegetation. No long term studies have been made on the balds and thus there is not sufficient evidence to support this theory but study of tree rings might throw light on the matter.

In predicting the future of the balds, the balsam woolly aphid (Chermes piceae Ratz.) must be considered. This insect attacks all true firs and was introduced into this country prior to 1908 (Speers 1958). It is thought that this insect may completely eliminate Abies fraseri from the southern Applachians. Insecticides have been fairly effective in controlling the aphid in some scenic and recreational areas, but rough terrain, dense stands, and the high cost of application limit the use of this treatment. Possible biological controls are at present being tested (Amman 1961). If these controls do not prove to be effective or if no other means of controlling the aphid are found soon, the future for fir in the Smokies does not look good. The aphid has already been found in the park and programs have been undertaken to try to prevent its spread throughout the range of the species. If the fir is eliminated from the spruce-fir zone, the vegetational changes which

may follow can only be guessed. The invasion of one of the most important forest trees on Andrews Bald will be halted. Balds may be produced on some of the higher peaks on which fir is now the sole dominant. Did the balds originate from this type of deforestation at some time in the past?

IV. INDIVIDUAL BALD DESCRIPTIONS

Andrews Bald

Andrews Bald is situated on a southwest facing slope at an elevation of 5,700 feet. It is located on Forney Ridge approximately two miles south of the Forney Ridge Parking Area. This bald is surrounded on two sides (east and south) by steep cliff-like slopes. The bald lies in an ecotonal zone between the spruce-fir forest, which borders on the north and west, and the hardwood forest which borders the south and east portions. The bald is believed to be a natural opening, as there is no known history of clearing. However, it may have been enlarged during the period in which grazing took place. Grazing was stopped on Andrews Bald in 1931. Six years later when the bald was surveyed it was found to be 12.5 acres in size. A small bog is present in the lower west corner of the bald.

The bald has been invaded by small islands of woody plants. These islands almost always occur around a rock. Individual trees do not seem to be able to become established without the presence of either a rock or another tree. Often the large boulders are completely surrounded by numerous small trees and shrubs.

Fir and spruce are the most prominent of the invading tree species. Fir is a more common invader, however, than is spruce.

Spruce is more common in the upper than the lower portion of the bald. Amelanchier is the third most prevalent tree taxa present on the bald. There is little invasion of the bald by species from the hardwood forest except along the lower edge of the bald, but this invasion is minor. It consists mainly of red oak, beech, and some birch. A few firs are present also on the bald's lower edge. Along the steeper edges of the bald the little invasion that is occurring is mainly by species of Rhododendron, Vaccinium, and Viburnum.

There is a single Table Mountain pine present on the bald, and although badly deformed, has a radial growth increment of about one inch per six years. The spruce and fir found on the bald show a diameter growth greater than the trees in the surrounding forest. However, many of the trees on the bald have had their leaders killed back. Some trees growing on more exposed sites are flagged to the southeast. This is, the branches are longer on the southeast side of the trees than on the other sides. This may be due to prevailing winds from the northeast.

Small erosional areas (usually less than three meters across) are evident around the edge of the bald (notably the northeast border). These areas are apparently caused by small rodents such as field mice. These rodents kill the grasses which make up the ground cover, thus leaving areas exposed to erosional forces. Rodent feces and/or burrows are frequently found in areas which are in early stages of erosion. Soon

after an area is exposed the surface is invaded by small mosses. These mosses and the bare ground between them are in turn invaded by Cladonia and crustose lichens. Polytrichium and Danthonia finally invade and dominate the area.

Over the bald there are many scattered Polytrichium mats and forb patches made up mainly of species of Aster and Solidago. Numerous small spruce and fir seedlings are present in the Polytrichium mats but they are rarely more than six inches tall. Rubus sp. patches are found along the north and west borders of the bald. These edges are in general more weedy and subject to invasion than is the rest of the bald. During the late summer and early fall Angelica triquinata takes on an aspect dominance on the bald.

Spence Field

Spence Field lies along the top of an east-west lying ridge which runs along the state line between Tennessee and North Carolina. It is approximately a mile to the west of Thunderhead Mountain and its elevation is between 4, 950 and 5, 000 feet. Spence Field included 37. 7 acres when it was surveyed in 1944. It is entirely surrounded by hardwood forest and for years it has been thought to have been cleared from a beech forest. Andrew Maxey, when he was 83 years old told Carlos Campbell that he could remember the clearing of both Spence Field and

Russell Field in 1880 (Gilbert, 1954). Further evidence that Spence Field was cleared is that Guyot in 1863 made no mention of Spence Field (Gilbert 1954). That Spence Field was entirely cut out of the forest seems highly unlikely to the present author. After looking only briefly at Russell Field some 500 feet lower and comparing their "original" area as well as could be determined from aerial photos taken in 1953, the rate of invasion and the species composition seem to be vastly different. Russell Field has been rapidly invaded and the area which resembles a bald in its openness and characteristic species is probably now only about two acres in size. The original field, however, must have been somewhat larger than Spence Field. Spence Field has had some invasion by woody species but the majority of the "original" area is still open. Its species composition is like that of the other two balds studied. Thus its vegetation would not indicate that it had been entirely cleared. Its location indicates that it may have been a continuation of Thunderhead Bald which lies along the ridge just to the east of Spence Field. Thunderhead Bald is a long narrow bald which here and there widens out. It extends for about a mile along the state line ridge on Thunderhead Mountain. This may have been the original condition of Spence Field; and if so, the clearing remembered by the elderly residents could have been the widening out of some of the narrow places. If this were the case, Guyot might

have considered it part of the Thunderhead Bald system since many people up to twenty years or so ago spoke of going to Thunderhead when they were, in fact, going to Spence Field. According to Malde (1953) the surface soil indicates that Spence Field has been under grass cover for some time, perhaps a few hundred years. In any case, Spence Field was certainly in a much more bald succeptable zone than was Russell Field.

On Spence Field there are large erosional areas. The original removal of turf is thought to have been due to heavy grazing by cattle and/or sheep. Many of these areas are eroded to bare rock, others are deeply gullied. A lichen, Stereocaulon daclytophyllum, invades the smaller rocks in these areas, forming almost pure stands. Rhododendron spp. and Kalmia invade the areas between the rocks where there is enough soil for them to become established.

The bald is at present made up of three segments. Two of these segments appear to have been cut off from the main portion of the bald by peninsular intrusions of woody vegetation from the north and south edges of the bald. There is a considerable amount of beech at both the east and west ends of the bald. The north slope falls off fairly sharply and is bordered by hardwoods mixed with some Rhododendron. The south slope is also bordered by hardwoods. Throughout the bald there are scattered patches of asters and goldenrods. Blackberry

patches are scattered throughout the west end of the bald.

Gregory Bald

Gregory Bald occurs on the state line ridge about half a mile to the west of the intersection of Gregory Ridge with the state line ridge in a summit position at an elevation of 4, 948 feet. It is thought to be a natural opening. Recorded in Cherokee Indian legend as the "Rabbit Place," Gregory Bald was thought to be the place where the Great Rabbit lived and where the rabbits had their town house (Gilbert 1954). According to Mrs. Oliver, a long-time resident of Cades Cove, "Gregory Bald has always been a blueberry meadow." "She had it from folks long dead (Gilbert 1954)." In 1944, some seven years after grazing was stopped, the bald was surveyed and found to be 15. 7 acres in size. The bald is surrounded by hardwood forest made up mainly of red oak (Quercus rubra). A large part of the bald has been and is being damaged by the European Wild Boar (Sus scrofa). The boars overturn large areas of the sod and leave substantial areas bare of vegetation. The National Park Service has tried to replace the sod as much as is feasible and thus prevent ensuing erosion. Where erosion is not too severe, weedy grassy patches soon develop. Where erosion is more severe and much of the soil is removed, a surface of broken rock fragments is left. This surface is invaded by Rhododendron spp., Kalmia, a few forbs, and some lichens; such as, Parmelia lustania (which is almost limited to

the balds) and Cladonia spp.

Near the summit of the bald extensive areas are covered by Rubus patches. Although the rate of total invasion by woody plants seems high on this bald, it is due to the great amount of low bush blueberry which has invaded (Table II). (This table will be discussed more fully later.) When standing on Gregory Bald it appears to be more open than either of the previously discussed balds, because Gregory Bald has fewer trees and shrubs over two or three feet in height. Ther are fewer boulders and rock outcroppings on this bald than on the other balds studied.

Table II. Percent cover woody vegetation by growth form for the three balds.

	Andrews	Gregory	Spence
Potential overstory trees	9.76	5.33	12.32
Potential understory trees			0.93
Shrubs (excluding Rubus)	16.92	33.51	11.01
Woody herbs (Diervilla)	0.66		
Total without Rubus	27.34	38.84	24.41
Rubus	6.82	10.06	4.40
Total	34.16	48.90	28.81
Vaccinium	9.22	19.93	0.21
Total without Rubus or Vaccinium	18.12	18.91	24.20
Total ericads	13.06	30.93	10.29
Total without Rubus or ericads	14.28	7.91	13.91

V. METHODS AND PROCEDURES

The method used for sampling the vegetation of the balds was basically one of line transects. A line was run the length of each bald. Crosslines were run at 90° angles to the original line. These crosslines were placed at 50-meter intervals on Andrews Bald and Gregory Bald and at 100-meter intervals on Spence Field. The reason 100-meter intervals between crosslines were used on Spence Field was because of its large size. Any woody vegetation which was crossed by the transect lines was recorded by the length of line intercepted. The herbaceous vegetation was sampled at 10-meter intervals along each of the transect lines by dropping a 10-tine sampling device. The top-most plant touching each tine was recorded. Rubus was sampled with the woody vegetation because its growth form is such that it was easier to include it with the woody species than with the herbaceous species.

The coverage for woody species was estimated as the percentage of the total line covered by each species. Coverage of herbaceous species was estimated by calculating the percentage of the total number of points that each species touched. No attempt was made to distinguish between the species of grasses on Andrews Bald since few of the grasses had spikelets at the time of sampling and the investigator

was not familiar enough with the grasses to otherwise distinguish them. Whenever it was not possible to definitely determine the genus of a grass it was simply recorded as grass. The same is true at the species level for Carex, Aster, and Solidago.

The frequency of occurrence of herbaceous vegetation was figured using ten points as one sampling unit. Thus the frequency is the number of samples in which each species occurs. The percent frequency is the percent of the total number of sampling units in which a species occurs. Frequency was not recorded for the woody plants as it was not always possible to decide what made up an individual plant.

Collections were made of the vascular plants and lichens which were found on the balds (Appendix A). These collections have been deposited in The University of Tennessee herbarium.

The balds were surveyed in the late 1930's and early 1940's. The first maps which are known to exist were made at this time by A. E. Bye, a National Park Service employee, who made the maps of Gregory Bald and Spence Field. The surveyor of Andrews Bald is not known. These maps were used as base maps upon which the changes in the margin of the balds were drawn. Slides were made from aerial photos taken in 1952 and 1961. The image of the bald was projected upon the base map and the new borders drawn. Care was taken to make sure that the projected image was at the same scale as the base map.

This was done by selecting fixed points on both the base map and the projected image and moving the projector until these points coincided. The aerial photos were examined under a stereoscope and an attempt was made to map the woody vegetation according to four groupings: conifers, deciduous trees, deciduous shrubs, and evergreen shrubs.

The area of the balds was determined with the use of a polar planimeter. The area of the balds is known for the year in which they were surveyed. Their outline for that year was traced with the planimeter and this planimeter reading was divided into the acreage. Thus, a factor was obtained which could be used to convert the planimeter readings into acreage figures. The outlines of the border for 1952 and 1961 were traced and the figures converted into acreage. Where large islands of tree invaders were present their area was determined and substracted from the border figure.

VI. RESULTS

The sampling data obtained in this study are found under the columns marked B in Tables III, IV, V, and VI. In the floristic list (Appendix A) the taxa found in the present study are marked with X. These data were compared with those obtained by V. C. Gilbert (1954) and A. F. Mark (1958). It was hoped that some successional trends might be recognized. However, all three investigators used different sampling methods, so this may explain some of the differences apparent in the data (Tables III, IV, V, and VI). Gilbert considered cover for only four taxa of herbaceous plants. He assigned each sample to a coverage class. To make his coverage data comparable with the other investigators, his coverage classes were coverted into percent coverage by multiplying the mid-values for each coverage class by the number of samples with that coverage value. The values for each species were summed and divided by the total number of samples. This gave a very rough estimate of the percent cover which can be compared with the percent cover figures of the other investigators. Frequency figures (in percent) for the herbaceous vegetation were available from each investigator. I did not, however, obtain frequency data on the woody vegetation. The percent frequency data

Table III. Percent frequency-herbaceous vegetation for the balds by the investigator.

Taxa	Andrews			Gregory			Spence		
	G	M	B	G	M	B	G	M	B*
Grass	93.0	100.0	91.0	100.0	89.7	78.8	97.0	96.7	98.2
Sedge	17.0	30.0	62.0	2.0	3.3	7.5	2.9	1.7	0.8
Potentilla	87.0	100.0	17.0	92.0	86.7	30.0	97.0	98.3	22.1
Achillea					1.0	1.3		5.0	
Agrostis					6.7				
Angelica	33.0	100.0	27.0				2.9		
Anemone					3.3				
Asclepias				2.0					
Aster	10.0	40.0	9.0	86.0	63.3	20.0	12.9	18.7	8.0
Botrychium				2.0					
Cerastium					3.3				
Cirsium					3.0	7.5			0.9
Coreopsis						2.5			

Table III. (Continued).

Taxa	Andrews			Gregory			Spence		
	G	M	B	G	M	B	G	M	B
Dennstaedtia			5.0				1.4	5.0	4.4
Epigea						7.5			0.9
Eupatorium					3.0				
Fragaria	10.0			6.0	16.7		2.9		
Houstonia	3.3	10.0	1.0	4.0	3.3	2.5	2.9		
Hypericum	17.0		7.0	6.0					
Juncus			1.0	2.0		2.5	2.9		
Lactuca			2.0			1.3		6.7	
Lechea				2.0					
Lilium			1.0						
Luzula					0.3				
Lysimachia						1.3			

Table III. (Continued).

Taxa	Andrews			Gregory			Spence		
	G	M	B	G	M	B	G	M	B
Mitchella									0.9
Monarda								3.3	
Oxalis					13.3	1.2			
Parthenocissus									0.9
Polytrichum			4.0		11.7	2.5			7.1
Prenanthes		6.0	4.0		8.3				
Prunella					3.3	1.3	2.9	5.0	1.8
Rubus	27.0			14.0			16.0		
Rumex	87.0	90.0	1.0	78.0	86.0	10.0	91.0	83.3	6.2
Senecio	3.3				3.3		2.9		
Solanum								1.7	
Solidago	17.0		11.0	8.0		16.3	24.0	1.7	7.1

Table III. (Continued).

Taxa	Andrews			Gregory			Spence		
	G	M	B	G	M	B	G	M	B
Stenanthium	10.0		4.0						
Trautvetteria				3.3					
Trifolium				1.7					
Viola	62.0	60.0	1.0	10.0	16.7	3.8	18.6	21.7	0.9
Unknowns						1.3			0.9
Cladonia									1.8
Crustose lichen			1.0						
Lasallia			1.0						
Parmelia			1.0						
Soil			6.1		10.0	32.5			9.7
Rock			2.0						0.9

* G = Gilbert's data, M = Mark's data, B = Bruhn's data.

Table IV. Percent frequency woody vegetation for the balds by investigator.

Species	Andrews		Gregory		Spence	
	G	M	G	M	G	M
Abies fraseri		20.0				
Acer rubrum				6.6	2.9	13.3
Aesculus octandra					1.4	3.3
Amelanchier laevis			4.0	23.3	2.9	63.3
Betula lutea						13.3
Crataegus macrosperma	3.3			36.6		1.7
Fraxinum americana				1.6		18.3
Kalmia latifolia			4.0		4.3	15.0
Lyonia ligustrina			8.0	18.3		
Oxydendrum arboreum				3.3		
Pinus strobus				1.6		3.3
Prunus pensylvanica						13.3
Prunus serotina				3.3		23.3
Pyrus americana						6.6
Pyrus malus				1.7		3.3
Quercus rubra				10.0		

Table IV. (Continued).

Species	Andrews		Gregory		Spence	
	G	M	G	M	G	M
Rhododendron calendulaceum			6.0	21.7		
Rhododendron catawbiense					1.4	
Ribes rotundifolium						0.3
Rubus canadensis		80.0				20.0
Vaccinium corymbosum		20.0				20.0
Vaccinium hirsutum				26.7		3.3
Vaccinium vacillans				52.3		

*G - Gilbert's date, M - Mark's data

Table V. Percent cover-herbaceous vegetation for the balds by investigator.

	Andrews			Gregory			Spence		
	G	M	B	G	M	B	G	M	B *
Grass	42.00	42.60	54.50	36.40	29.84	58.25	47.80	40.37	83.28
Carex		2.50	21.80		1.00	3.13		0.1	0.18
Potentilla canadensis	15.75	6.10	2.60	15.30	9.83	5.63	23.29	19.37	4.25
Achillea millefolium					2.53	0.13		0.07	
Angelica triquinata		15.00	7.80						
Agrostis spp.					0.27	3.26			0.09
Anemone virginiana					0.16				
Aster acuminatus			0.20			2.13			0.09
Aster divaricatus		1.30	0.80						
Aster lateriflorus					3.60			1.87	
Aster lowrieanus						3.86			1.24
Aster surculosus					10.37			1.03	

Table V. (Continued).

	Andrews			Gregory			Spence		
	G	M	B	G	M	B	G	M	B
Aster undulatus			0.50		0.23				
Aster sp.					1.06			0.03	
Carex debilis		2.50	5.70						
Carex festucacae		3.80							
Carex misera			12.60						0.18
Carex normalis		0.40	0.40			3.00			
Carex pensylvanica				1.00				0.10	
Carex swannii						0.13			
Carex spp.			3.00						
Cirsium muticum					0.30	0.25			
Coreopsis major						0.88			
Danthonia compressa	42.00	42.50		36.40	23.23	28.90	47.80	40.10	77.26

Table V. (Continued).

	Andrews			Gregory			Spence		
	G	M	B	G	M	B	G	M	B
Epigaea repens						1.88			0.09
Eupatorium rugosum					0.10				
Fragaria virginiana					0.97				
Houstonia spp.		0.20	0.10		0.10	0.63			
Hypericum mitchellianum		0.40	0.10						
Juncus acumninatus			0.20						
Juncus marginatus			0.10						
Juncus tenius						0.38			
Lactuca canadensis		0.40	0.20			0.13		0.43	
Lilium superbum			0.10						
Luzula echinata					0.13				
Lysimachia quadrifolia						0.13			

Table V. (Continued).

	Andrews			Gregory			Spence		
	G	M	B	G	M	B	G	M	B
Mitchella repens									0.27
Oxalis stricta					0.56	0.25			
Panicum lanuginosum						0.13			
Parthenocissus quinquefolia									0.09
Phleum pratense		0.20			0.50	1.30		0.27	0.09
Poa spp.		0.10			0.17				0.09
Prenanthes spp.		2.90	0.40		0.63				
Prunella spp.					0.17	0.13			0.17
Rumex acetosella	6.67	2.70	0.10	10.54	4.67	1.25	9.69	8.26	1.42
Rumex obtusifolius					0.57				
Solidago glomerata		3.20	0.80					0.10	

Table V. (Continued).

	Andrews			Gregory			Spence		
	G	M	B	G	M	B	G	M	B
Senecio aureus					0.10				
Solidago juncae									0.18
Solidago bicolor					0.57				
Solidago patula			1.50						
Solidago caesia		0.80							
Solidago spp.						2.75			1.32
Stenanthium gramineum			0.50		0.40	0.38			1.50
Trautuettaria caroliniensis					0.10				
Trifolium repens					1.50				
Trifolium pratense					0.10				
Viola spp.		1.50	0.10		0.47	0.50		0.57	0.09

Table V. (Continued).

	Andrews			Gregory			Spence		
	G	M	B	G	M	B	G	M	B
Dennstaedtia punctilobula			1.50						0.18
Polytrichum spp.			1.50		0.40	0.38		6.86	2.48
Mosses					0.10				0.27
Cladonia spp.									0.18
Crustose lichens			0.60						
Lasallia papulosa			0.30						
Parmelia spp.			0.10						
Rock			1.10						0.27
Soil			1.40		1.36	16.63			2.30
Unknowns						0.63			0.18

* G = Gilbert's data, M = Mark's data, B = Bruhn's data

Table VI. Percent cover-woody vegetation for the balds by investigator.

	Andrews		Gregory		Spence	
	M	B	M	B	M	B
Abies fraseri	0.9	3.31				
Acer rubrum		0.30	0.3	0.12	0.13	1.35
Amelanchier laevis		4.76	0.7	1.91	5.07	8.57
Betula lutea		0.06		0.04	1.86	0.15
Castanea dentata						0.15
Cornus florida						0.11
Crataegus macrosperma		1.06	1.40	3.86	0.03	1.15
Diervilla sessilifolia		0.66				
Fagus grandifolia						0.04
Fraxinus americana			0.03		0.43	0.63
Ilex montana						0.30
Lyonia ligustrina			0.47	3.19		
Kalmia latifolia					1.16	6.90
Oxydendrun arboreum			0.07	0.11		0.30
Picea rubens		1.33				
Pinus pungens						0.22
Pinus strobus			0.03	0.23	0.26	

Table VI. (Continued).

	Andrews		Gregory		Spence	
	M	B	M	B	M	B
Prunus pensylvanica					0.77	
Prunus serotina			0.10		0.47	0.70
Pyrus americana					0.17	0.50
Pyrus malus			0.03		0.06	
Quercus rubra		0.19	0.03	2.92		0.36
Rhododendron calendulaceum		1.37	1.20	4.78		
Rhododendron catawbiense		2.47				
Rhododendron maximum					0.03	2.75
Ribes rotundifolia	0.2	0.26				
Rubus canadensis	30.2	6.82		10.06	4.83	4.40
Salix humilis				1.75		
Vaccinium corymbosum	2.3	8.97			1.03	0.21
Vaccinium erythrocarpum		0.25				
Vaccinium hirsutum				0.67	0.61	0.10

Table VI. (Continued).

	Andrews		Gregory		Spence	
	M	B	M	B	M	B
Vaccinium vacillans			3.50	19.32		
Viburnum cassinoides		2.54				

* M= Mark's data, B= Bruhn's data

obtained by Mark for Gregory Bald and Spence Field were taken in three separate units representing three slopes. For purposes of comparison these three values have been averaged (Tables III and IV). Since the sample size used by each investigator was different and since frequency is largely dependent on sample size, this may explain some of the differences in the data presented here.

VII. DISCUSSION

One of the most obvious trends shown by the data is the increase of woody vegetation. It has been well established that although there was some woody vegetation present during grazing, the amount of woody vegetation on the balds has increased since grazing halted. It is known, for example, that spruce and fir trees were present on Andrews Bald only six years after grazing ceased (1937). These trees, as shown in photographs taken at the time (Figure 10) and as shown in the original survey (Figure 1), were large enough that they must have been present long before grazing stopped. Wells (1937) reported the presence of Viburnum cassinoides and Ribes rotundifolium. However, when Gilbert (1954) sampled Andrews Bald the only woody species he recorded was Crateagus macrosperma. Mark sampled the bald in 1956 and recorded only four species of woody plants. In contrast to this, I found the bald had woody coverage of 27. 34 percent (Table II). On Gregory Bald and Spence Field the previous investigators found some woody vegetation in sampling, but once again I recorded much more woody vegetation than they did. There is undoubtedly some woody invasion taking place on the balds. Grazing was stopped on the three balds within five years of each other; Andrews was grazed until 1931, Gregory until 1936, and

Spence Field until 1933 (Malde 1953). From the data presented in Table II it is evident that Gregory Bald has had the greatest amount of invasion by woody species. This is due mainly to the invasion by low bush blueberry. The rate of invasion by woody taxa other than Vaccinium on Gregory Bald approximates very closely that of Andrews Bald. Most of the invasion of Gregory Bald had been by ericaceous species. Potential overstory trees make up only a little over five percent of the cover on Gregory Bald. The invasion by woody plants on Andrews Bald has been pretty well divided between ericaceous shrubs and potential overstory trees. Other shrubs make up only a minor part of the woody invaders. The invasion by woody plants on Spence Field has been rather similar to that on Andrews Bald except that a somewhat higher proportion is made up of potential overstory trees.

From Table VI it may be concluded that Amelanchier laevis contributes more to the total cover than any other potential overstory tree which is invading on each of the balds. Other tree invaders with relatively high cover values are Abies fraseri and Picea rubens on Andrews Bald, Quercus rubra on Gregory Bald and Acer rubrum on Spence Field. The present invasion by potential overstory trees indicates that if these balds do grow over and become forested Amelanchier will become less frequent. This follows since it does not normally make up an important part of the tree canopy in the region. Andrews Bald

would probably become a spruce-fir forest, Spence Field a northern hardwood forest, and Gregory Bald (if it does not remain a blueberry meadow) may become either a red oak forest or a northern hardwood forest.

One change which has taken place in the woody vegetation in the past 35 years has been the invasion by pine. S. A. Cain made a vegetative collection of pine from Parsons Bald in 1929. He noted on the herbarium sheet that this was the only pine observed on any of the balds and that this specimen was only about a meter high. There are now three species of pine on the balds and pine was encountered on all of the balds studied. There is but a single table mountain pine on Andrews Bald; but on both Spence Field and Gregory Bald the three species of pine are common enough so that they were encountered in the sampling.

The dominant vegetation of the balds consists, of course, of herbaceous species. As can be seen from Tables III and V, the dominant species is Danthonia compressa. Potentilla canadense is the second most prominent and characteristic species. In the past Rumex acetocella and Viola spp. have been found to be important enough to help characterize the balds. In the present study these two were not found to be of great importance. This is probably due in part to an actual decrease in cover and frequency of these species and, in part,

to the sampling method used. The method used discriminates against short plants but is justified in that the taller species, for the most part, dominate the habitat.

The herbaceous vegetation of the balds is rather variable. It apparently changes in response to yearly climatic variations. In very dry years certain of the grass species are reduced, especially Danthonia compressa, and certain weed species such as Aster surculosus increase. This was reported by both Mark (1958) and Gilbert (1954). In years of higher rainfall the Danthonia increases and the asters become less important. These flucuations which occur from year to year may help to explain some of the sampling data in which frequency of certain species fluctuates but does not show consistent change from 1954 to 1963. Just which of the changes shown here (Table V) indicate true successional trends as opposed to annual fluctuations is difficult to determine. The sampling data suggest that the grasses and sedges have increased in both cover and frequency and the Potentilla, Rumex, Aster, and Viola have decreased. On Andrews Bald Angelica triquinata is now very abundant and in late summer assumes aspect dominance. This species was not mentioned by Wells in 1937.

The area of the balds has been decreasing since grazing ceased (Table VII). The rates of invasion for Andrews Bald and Spence Field are quite similar (Table VIII). Table VIII shows the rate of invasion

Table VII. Area of the balds in acres.

Bald	Area at time of initial survey	1952	1961
Andrews	12.50 (1937)	9.67	9.17
Spence	35.03 (1944)	35.24	29.84
Gregory	15.70 (1944)	13.34	11.71

Table VII. Rate of invasion of balds in acres per year.

Bald	Year of initial survey	Invasion rate since initial survey	Rate from initial survey to 1952	Rate from 1952 to 1961	Acres/year/acre of bald since inital survey
Andrews	1937	0.14	0.19	0.06	0.011
Spence	1944	0.31	-0.03*	0.60	0.009
Gregory	1944	0.23	0.03	0.18	0.015

*The negative value is due to differences in mapping technique and incomplete mapping in the initial survey, combined with the observation, in 1952, that some border forest areas were being invaded by grass.

of the balds. The rate of invasion was determined as the number of acres of the bald which have been invaded by woody species, divided by the number of years since the original survey of the bald was made. The last column of this table shows the rate of invasion (acres/year) per acre of bald at the time of the initial survey. This figure was computed so that a comparison of the rates of invasion could be made. This was necessary because the balds are of different sizes. The rate of invasion of Gregory Bald is 50 percent greater than that of the other two balds. The rapid invasion of low bush blueberry accounts for a major portion of this increase. The rate of invasion of Andrews and Gregory Balds appears to be decreasing. The data for Spence Field show an apparent artifact for when the map of Spence Field made in 1944 (Figure 4) is compared with the revised map made from an aerial phot. from 1952 the area of the bald appears to have increased. This is due in part to the fact that the 1944 surveyor only included half of a small clearing to the west of the main part of the bald. He also prematurely cut off an extension of the bald which now leads to the new shelter cabin. There are also some small areas along the margin of the bald in which the species on the bald appear to be invading the surrounding forest. The original surveyor mapped islands of woody vegetation by summer crown cover while I mapped them from winter aerial photos in which these areas appeared smaller. Thus, although

the acreage of Spence Field did decrease between 1944 and 1952 the data show a slight increase due to these factors. It should be noted that the figures presented in Tables VII and VIII may be somewhat high due to the methods used.

The floristic list (Appendix A) includes those species found by Gilbert (1954) and I by the bald on which they occur. Only those species that Mark (1957) found which were also found by Gilbert (1954) and I were listed. This was done because Mark's floristic list was not broken down by individual balds, but was made up of all species he found on all of the balds that he studied. I found 14 species of herbs and three woody plants not found by Mark or Gilbert. From Table IX one may see that I found five more herbaceous species and four more woody species than did Gilbert (1954). This study also includes a preliminary list of 47 lichens which occur on the balds.

Table IX. Evaluation of floristic list data-numbers of taxa per bald by investigator.

Herbaceous Vegetation	Andrews	Gregory	Spence	Total
Gilbert	65	42	44	92
Mark*				94
Bruhn	55	57	50	97
Woody Vegetation				
Gilbert	20	29	24	42
Mark*				45
Bruhn	24	22	35	46

*Only species found by the other two investigators are listed for Mark as his floristic list was not broken down by bald but listed all of the species he found on all of the balds that he studied.

VIII. SUMMARY

Three grassy balds; Andrews Bald, Spence Field, and Gregory Bald, in the Great Smoky Mountains were studied in the summer of 1963. The vegetation was sampled in two layers. The herbaceous vegetation made up one layer and the woody vegetation the other. The sampling data were compared with those of Gilbert (1954) and Mark (1958). Two maps of each bald were drawn from aerial photos made in 1952 and 1961. These maps were drawn from aerial photos made in 1952 and 1961. These maps were drawn over base maps made in 1937 (Andrews Bald) and 1944 (Gregory Bald and Spence Field). Rates of invasion by woody vegetation were calculated and found to be between 0.009 and 0.015 acres per year per acre of bald at the time of the initial survey. Gregory Bald was found to have been invaded most quickly as a result of the rapid invasion by low bush blueberry. Spence Field has the lowest rate of invasion by woody species but the greatest amount of invasion by potential overstory trees. The invasion by woody species may in part be due to a return of the woody vegetation which was destroyed by grazing. It may also be due to a warming of the climate. The balsam woolly aphid may set back the invasion of Andrews Bald by killing Fraser fir, the most important woody invader. A floristic list of all vascular

plants and lichens occurring on the balds was made. The list of vascular plants was compared with those of Gilbert and Mark. It contained 17 taxa not listed by them as occurring on the balds.

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APPENDIX A

Table X. Floristic list.*

Species	Andrews			Gregory		Spence	
Herbs							
Achillea millefolium	M			G	X	G	X
Agropyron repens	M		X			G	X
Agrostis alba	M	G	X	G	X	G	X
Agrostis scabra	R		X	G			
Agrostis tenuis	R	G					
Ambrosia artemisiifolia	M			G			
Andropogon scoparius	M			G	X		
Angelica triquinata	M	G	X			G	X
Antennaria plantaginifolia	M	G					
Arctium minus				G			
Asclepias tuberosa	R			G			
Aster acuminatus	M	G	X				
Aster curtisii					X		
Aster divaricatus	M	G	X	G		G	X
Aster lateriflorus	M			G			X
Aster lowrieanus			X		X		
Aster pilosus	M				X		

Table X. (Continued).

Species	Andrews			Gregory		Spence	
Aster puniceus							X
Aster surculosus	M	G			X		
Aster undulatus	M		X	G	X		X
Campanula americana	M		X				
Carex brunnescens	R					G	
Carex crinita	M	G	X				
Carex debilis	M	G	X	G	X	G	X
Carex intumescens	M	G	X			G	O
Carex misera			X				
Carex normalis	M	G	X	G	X	G	X
Carex ruthii	M	G	X				
Carex swanii	M				X		
Cerastium arvense	M	G				G	X
Chrysanthemum leucanthemum	M	G		G	X	G	X
Chrysopsis mariana	M			G			
Cirsium muticum			X	G	X		
Claytonia caroliniana		G					
Coreopsis major	M						
Cuscuta sp.	R						X

Table X. (Continued).

Species	Andrews			Gregory		Spence	
Dactylis glomerata	M		X		X	G	X
Danthonia compressa	M	G	X	G	X	G	X
Danthonia spicata	M			G		G	
Daucus carota				G			
Deschampsia flexuosa		G					
Drosera rotundifolia	R	G	X				
Epigea repens	M	G	X	G	X	G	X
Erythronium americanum	M		O				
Eupatorium rugosum	M				X	G	X
Fragaria virginiana	M	G		G	X	G	
Gaultheria procumbens			X				
Gentiana clausa	R	G					
Gentiana decora	M		X	G			X
Gentiana saponaria	M	G					
Gentiana villosa	R	G					
Glyceria nubigena	R	G					
Habenaria clavellata			X				
Habenaria ciliaris	M			G		G	X

Table X. (Continued).

Species	Andrews			Gregory		Spence	
Habenaria psycodes			X				
Helianthemum canadense	R	G					
Helianthus divaricatus	M	G	X				
Heuchera americana	R					G	
Hieracium paniculatum	M	G	X		X	G	X
Hieracium scabrum	M		X		X		X
Holcus lanatus	M				X	G	X
Houstonia purpurea	M	G	X	G	X	G	X
Houstonia serpyllifolia	M	G	X	G	X	G	X
Hypericum mitchellianum	M	G	X				
Hypericum punctatum	M				X		X
Juncus acuminatus	M	G	X				
Juncus effusus	M	G	X		X		
Juncus marginatus	R	G	X		X		
Juncus tenvis	M	G	X	G	X	G	X
Krigia biflora	M			G	X		
Lactuca canadensis							X
Lechea racemulosa	M				X		

Table X. (Continued).

Species	Andrews			Gregory		Spence	
Lilium superbum	M	G	X		X		X
Lysimachia quadrifolia	M	G	X	G	X	G	O
Maianthemum canadense	M		X			G	
Malaxis unifolia	M						X
Mitchella repens	M						X
Oenothera tetragona					X		
Oxalis stricta	M				X		
Panicum lanuginosum	M				X		
Parthenocissus quinquefolia							X
Pedicularis canadensis	M				X		
Phleum pratense	M		X	G	X	G	X
Plantago major	M			G			
Poa compressa	M			G	X		
Poa pratensis	M	G	X		X	G	
Polygonum scandens	R					G	
Potentilla canadensis	M	G	X	G	X	G	X
Prenanthes altissima	M						X
Prenanthes trifolia	M	G	X	G	X		

Table X. (Continued).

Species	Andrews			Gregory		Spence	
Prunella vulgaris	M	G	X	G	X	G	X
Rubus canadensis	M	G	X	G	X	G	X
Rubus idaeus	M	G					
Rudbeckia hirta	M				X	G	
Rudbeckia laciniata	M	G				G	
Rumex acetosella	M	G	X	G	X	G	X
Rumex obtusifolium	M				X	G	X
Senecio smallii	M			G	X	G	
Silene stellata	M	G					
Silene virginica	M				X	G	
Sisyrinchium angustifolium	M	G	X				
Smilax herbacea	M		X				
Smilax rotundifolia	M				X	G	X
Solanum carolinense	M			G		G	
Solidago bicolor	M	G			X		X
Solidago curtisii	M					G	X
Solidago glomerata	M	G	X				
Solidago juncea	M	G	X		X		X

Table X. (Continued).

Species	Andrews			Gregory		Spence	
Solidago odora							X
Solidago patula	M	G	X				
Solidago puniceus							X
Spiranthes sp.	M	G					
Stachys clingmanii	M	G	X		X		X
Stenanthium gramineum	M	G	X		X		
Taraxacum officinale					X		
Thalictrum revolutum	M		X				
Tradescantia subaspera	M						X
Trautvetteria caroliniensis	M					G	
Trifolium pratense	M			G	X		
Trifolium repens	M			G	X		
Trillium grandiflorum			X				
Verbascum thapsus	M			G			
Veronica officinalis	M						X
Viola sagittata	M	G		G		G	
Viola spp.	M	G	X	G	X	G	X

Table X. (Continued).

Species	Andrews			Gregory		Spence	
Woody Plants							
Abies fraseri	M	G	X				
Acer pensylvanicum	M			G	X		
Acer rubrum	M	G	X	G	X	G	X
Acer saccharum	M			G		G	
Aesculus octandra	M					G	X
Amelanchier laevis	M	G	X	G	X	G	X
Aralia spinosa	M						X
Betula lenta	R			G			
Betula lutea	M	G	X	G	X	G	X
Castanea dentata	M			G	X	G	X
Cornus florida	M						X
Cratageus macrosperma	M	G	X	G	X	G	X
Diervilla sessilifolia	M	G	X				
Fagus grandifolia	M	G	X	G		G	O
Fraxinus americana	M		X	G		G	X
Gaylussacia ursina							X
Hammamelis virginiana	M						X

Table X. (Continued).

Species	Andrews			Gregory		Spence	
Ilex montana	M	G	O			G	X
Ilex opaca	M				X		X
Kalmia latifolia	M	G	X	G	X	G	X
Liriodendron tulipifera	M			G			
Lyonia ligustrina	M	G	X	G	X		O
Magnolia acuminata							X
Oxydendron arboreum	M			G	X	G	X
Picea rubens	M	G	X				
Pinus pungens	M		X	G	X		X
Pinus rigida	M			G	X		
Pinus strobus	M			G	X	G	X
Prunus pensylvanica	M	G	X	G		G	X
Pyrus americana	M	G	X			G	X
Pyrus melanocarpa	M					G	
Quercus rubra	M	G	X	G	X	G	X
Rhododendron arborescens	R			G	X		
Rhododendron calendulaceum	M	G	X	G	X		X
Rhododendron catawbiense	M	G	X	G		G	

Table X. (Continued).

Species	Andrews			Gregory		Spence	
Rhododendron maximum	M		X			G	X
Rhododendron viscosum	R			G	X		
Rhus copallina	R						X
Ribes rotundifolium	M	G	X				X
Salix humilis	M		X	G	X		X
Sambucus canadensis	M					G	X
Tsuga canadensis	M			G	X		
Vaccinium altomontanum	M			G			
Vaccinium constablaei	M	G		G		G	X
Vaccinium corymbosum	M						X
Vaccinium erythrocarpum	M	G	X				
Vaccinium hirsutus	M			G	X	G	X
Vaccinium simulatus	M						X
Vaccinium stamineum	M					G	
Vaccinium vacillans	M		X	G	X		X
Virburnum cassinoides	M	G	X			G	X
Viburnum dentatum					X		

Table X. (Continued).

Species	Andrews			Gregory		Spence	
Ferns							
Athyrium felix-femina	M			G		G	
Botrychium dissectum	M			G			X
Dennstaedtia punctilobula	M	G	X	G	X	G	X
Osmunda cinnamomea	M		X				
Polystichum acrostichoides	M		X				X
Lichens							
Actinogyra muhlengergii			X				
Anzia colpodes			X				
Anaptychia sorediifera			Y				
Baeomyces roseus					X		X
Cetraria ciliaris			X		O		
Cetraria collata					X		
Cetraria oakesiana			X		O		
Cetraria tuckermannii			X		X		X
Cladonia cenotea			X				
Cladonia coccifera							X
Cladonia coniocraea			X				X

Table X. (Continued).

Species	Andrews	Gregory	Spence
Cladonia cristatella	X	X	X
Cladonia furcata	X		
Cladonia ochrochlora			X
Cladonia pleurota	X		X
Cladonia squamosa	X		
Cladonia subcariosa			X
Cladonia subtenuis		X	
Cladonia verticillata	X		X
Epheba solida	X		
Lasallia papulosa	X		X
Leptogium cyanescens			X
Loberia scrobiculata			X
Parmelia bolliana			X
Parmelia caperata	X	X	X
Parmelia cladonia	X		
Parmelia entermorpha	X		
Parmelia galbina	Y		
Parmelia lusitana	X	X	O

Table X. (Continued).

Species	Andrews	Gregory	Spence
Parmelia olivacea	Y		X
Parmelia perforata	X		
Parmelia physodes	Y		
Parmelia rudecta	X		X
Parmelia saxatilis	X		
Parmelia sulcata			Y
Physcia orbicularis			X
Physcia stellaris	X		
Pseudocyphellaria crocata	X		X
Ramalina fastigiata	X	O	X
Stereocaulon daclytophyllum	X		X
Sticta weigelii			X
Umbilicaria mammulata	X		
Usnea comosa	X		
Usnea florida	X	X	X
Usnea strigosa			X

Table X. (Continued).

Species	Andrews	Gregory	Spence
Usnea trichodea			X
Xanthoria polycarpa	Y		

*Symbols: M = collected by Mark, R = reported in the literature but not found by Mark, G = collected by Gilbert, X = collected by Bruhn, O = observed by Bruhn but not collected, Y = collected by Barbara Moore.

APPENDIX B

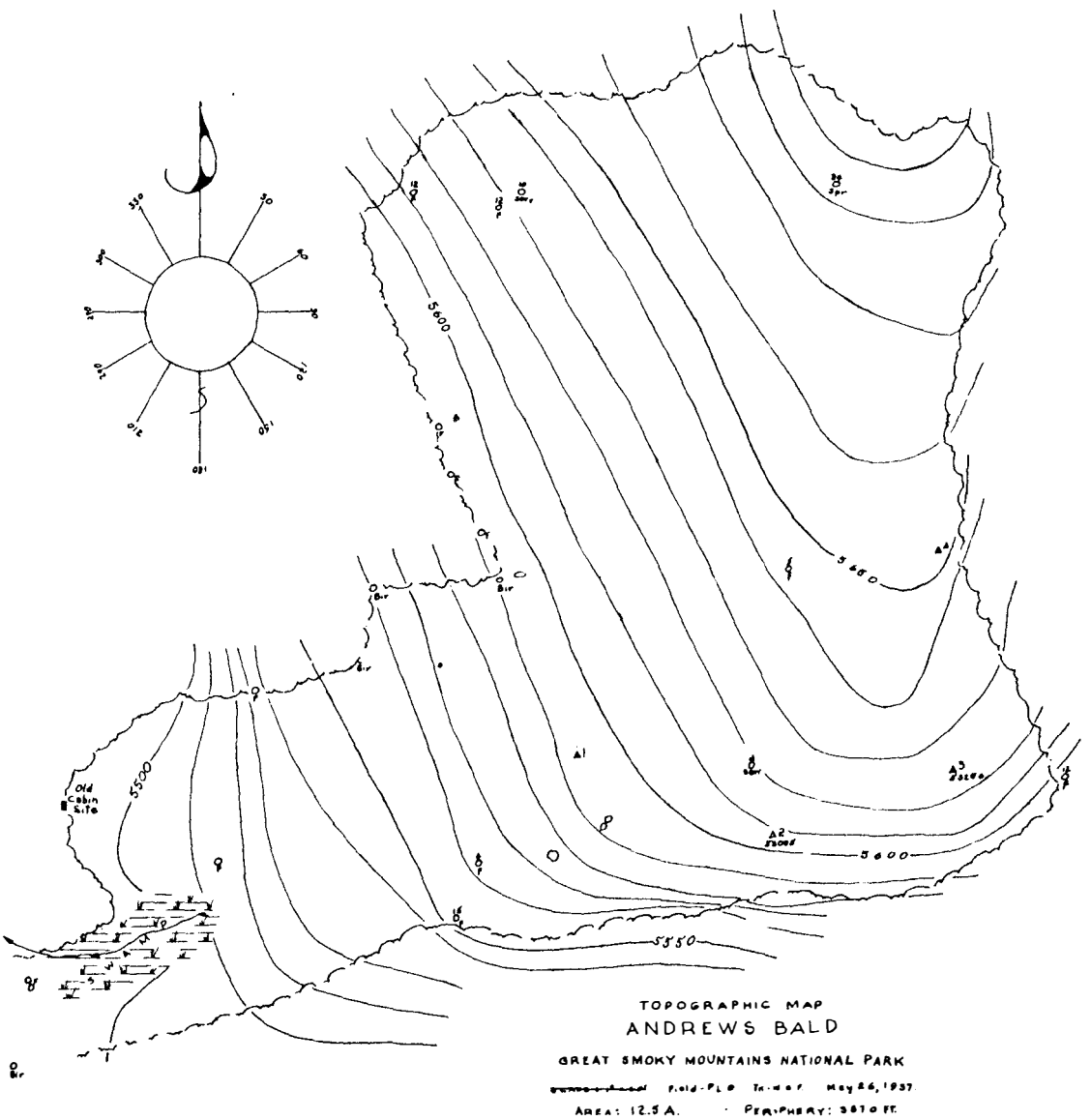

Figure 1. Andrews Bald 1937.

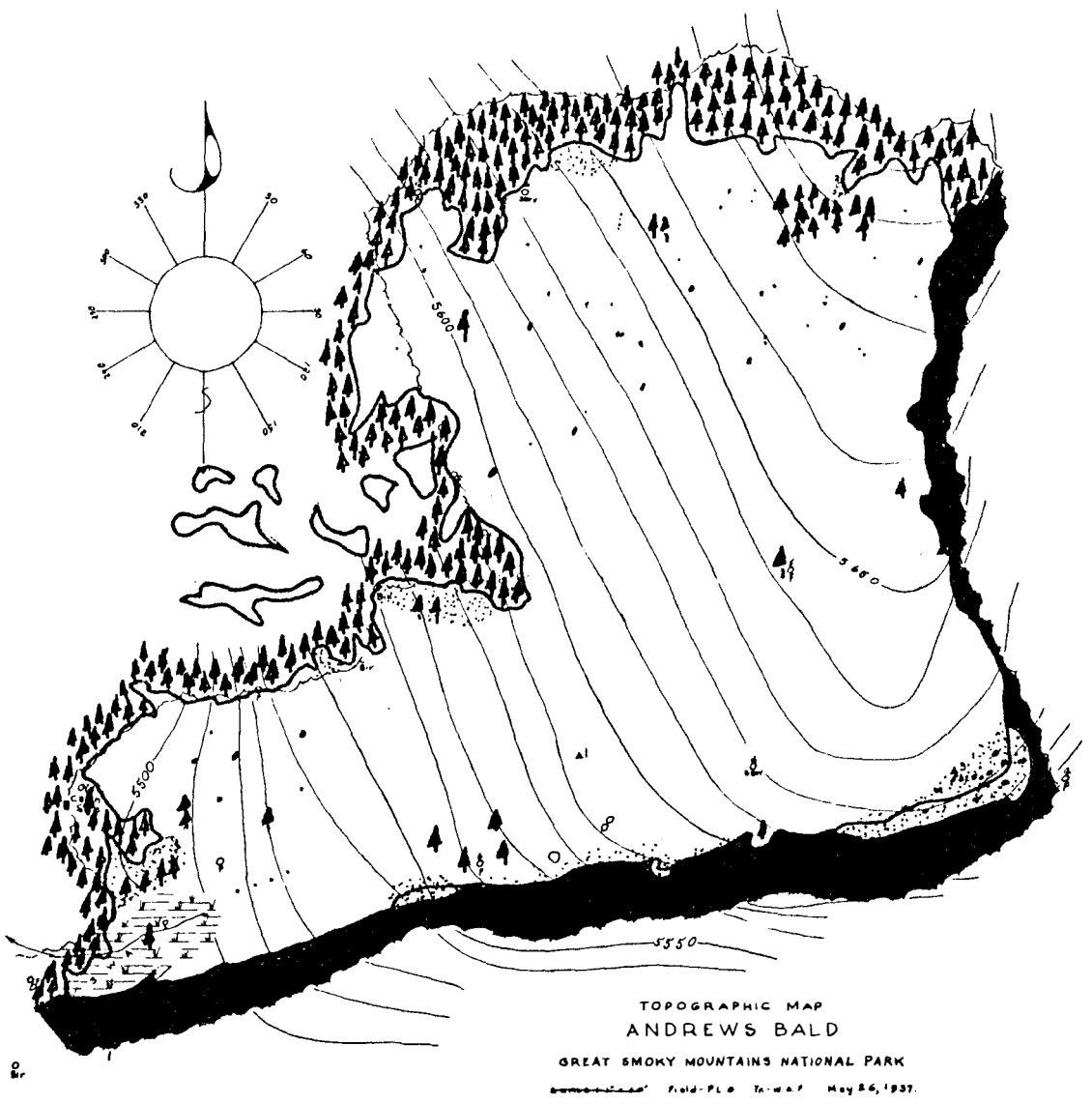

Figure 2. Andrews Bald 1952.

Conifer trees = Deciduous shrubs =

Deciduous trees= Evergreen shrubs =

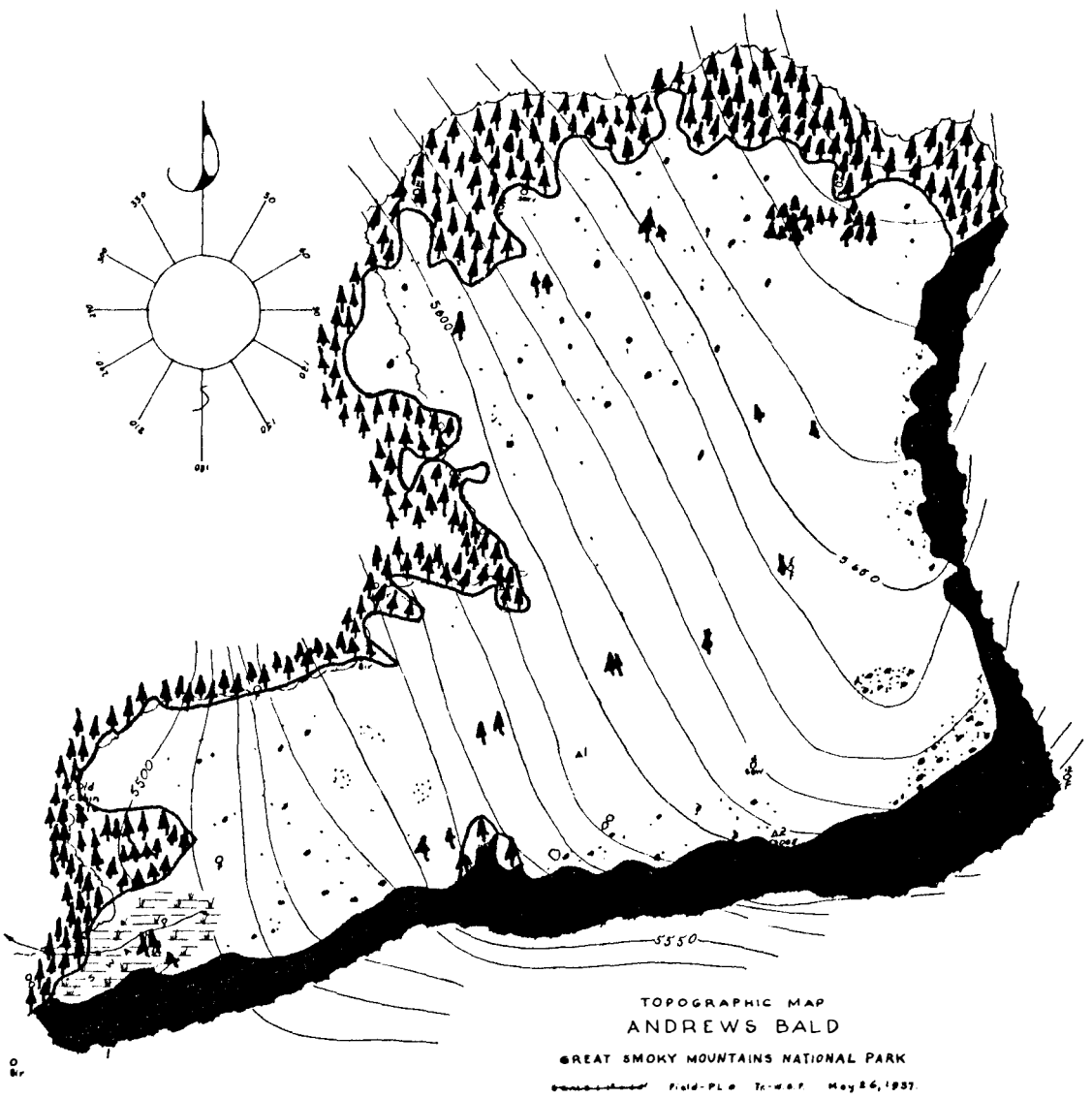

Figure 3. Andrews Bald 1961.

Conifer trees = Deciduous shrubs =

Deciduous trees = Evergreen shrubs =

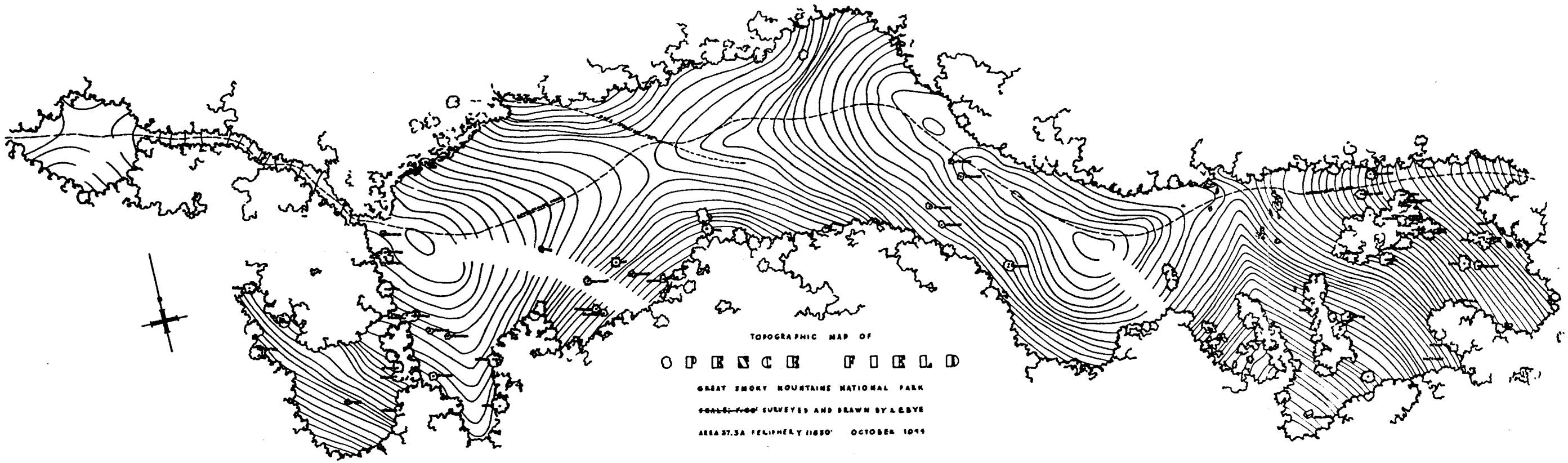

Figure 4. Spence Field 1944.

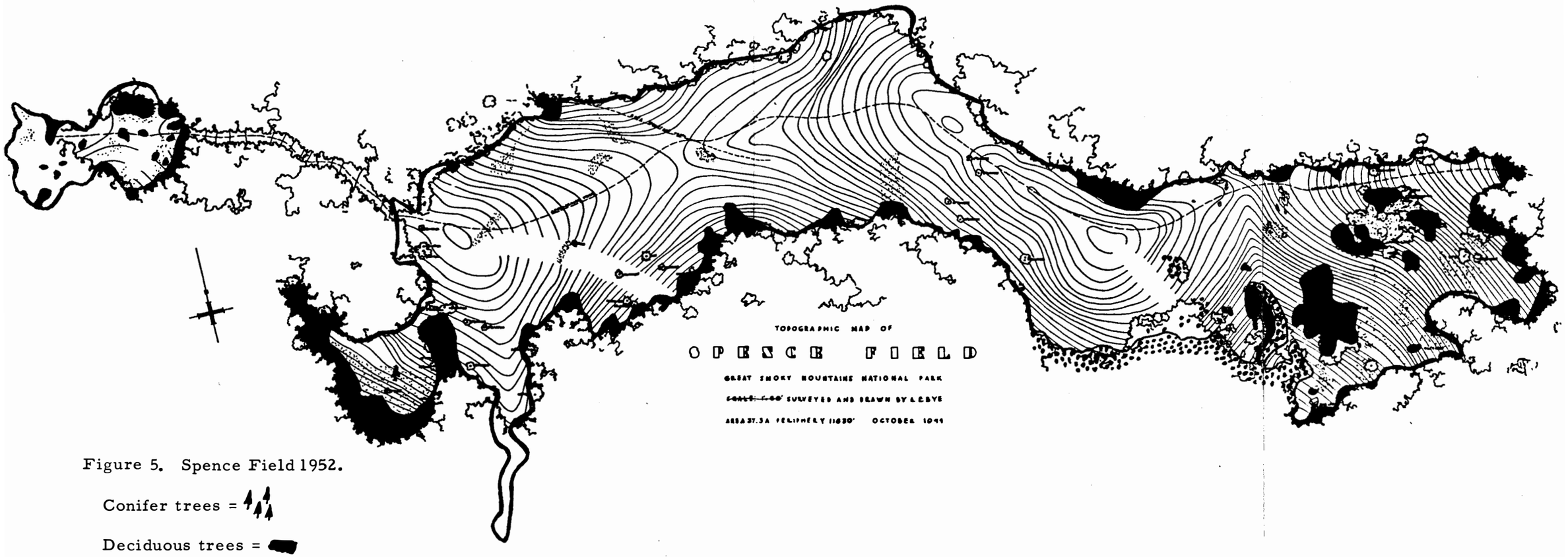

Figure 5. Spence Field 1952.

Conifer trees =

Deciduous trees =

Deciduous shrubs =

Evergreen shrubs =

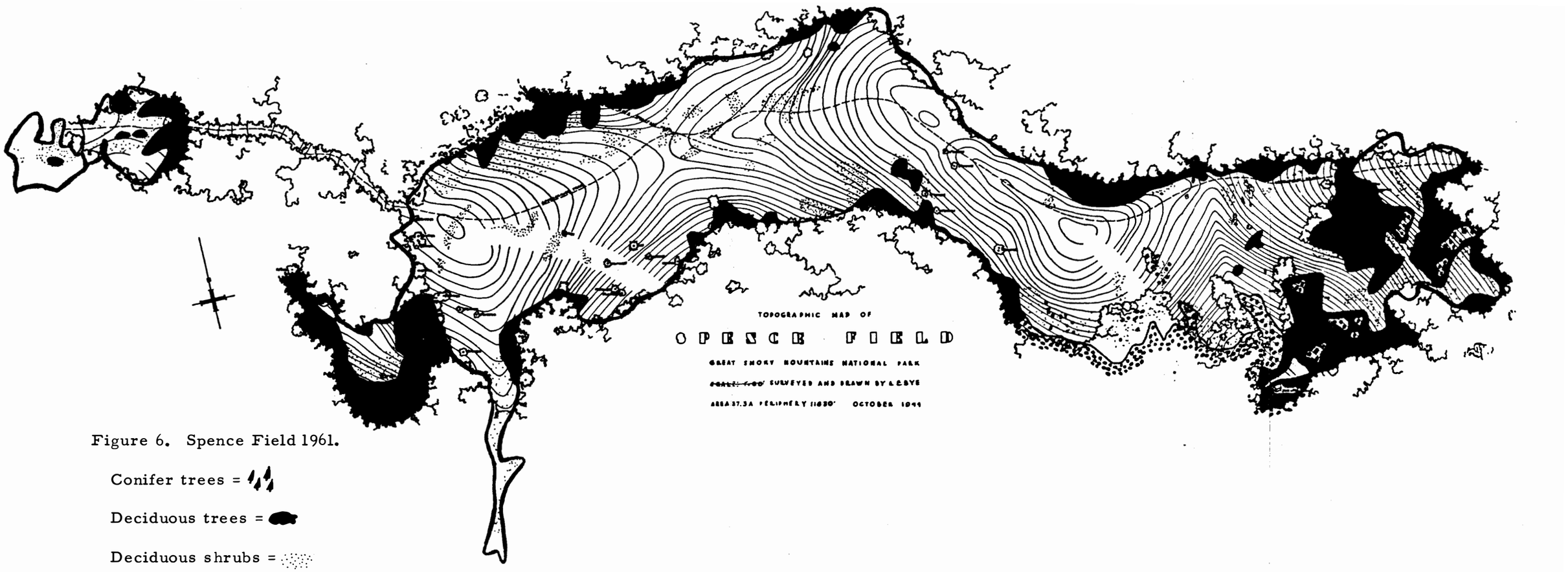

Figure 6. Spence Field 1961.

Conifer trees =

Deciduous trees =

Deciduous shrubs =

Evergreen shrubs =

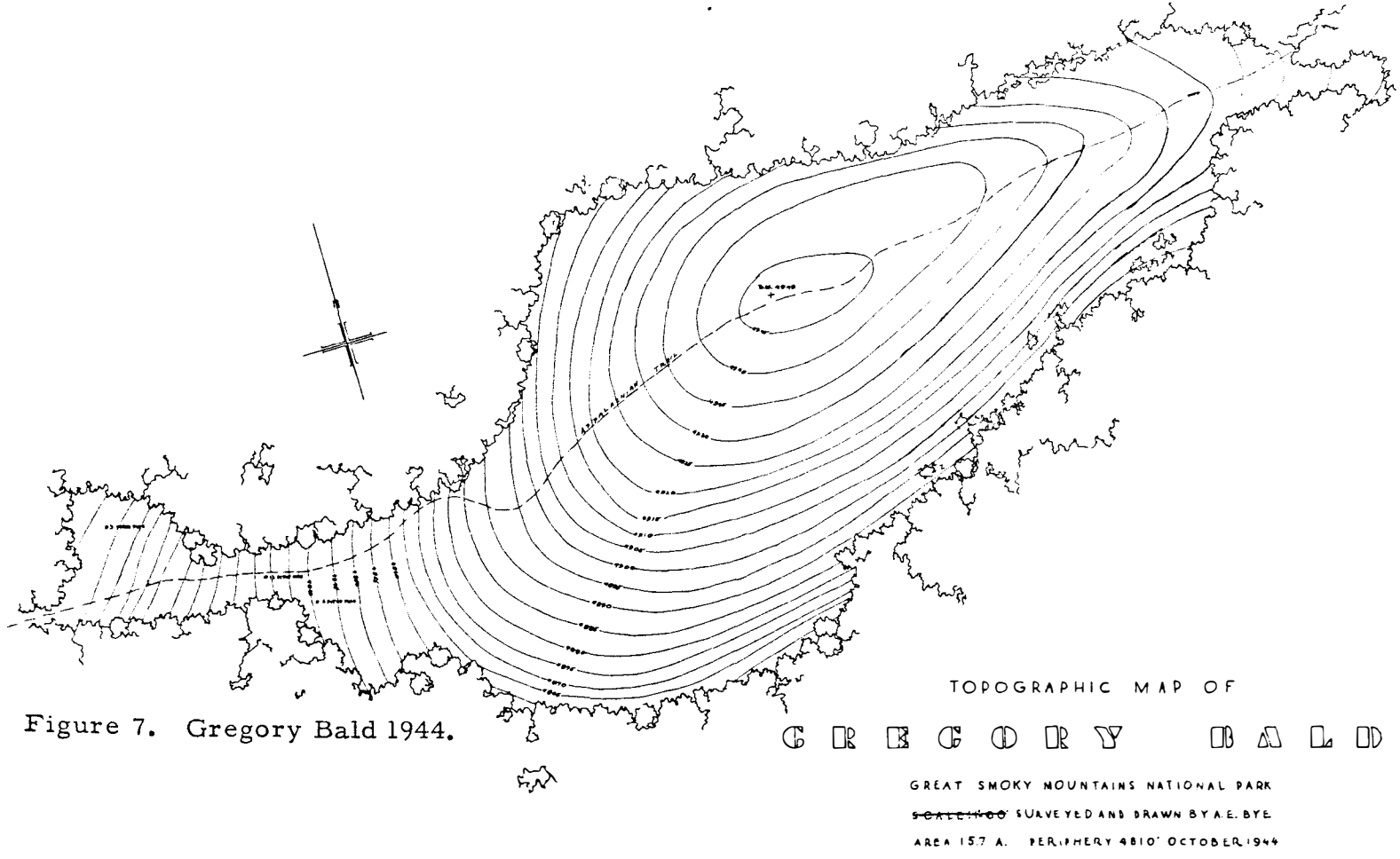

Figure 7. Gregory Bald 1944.

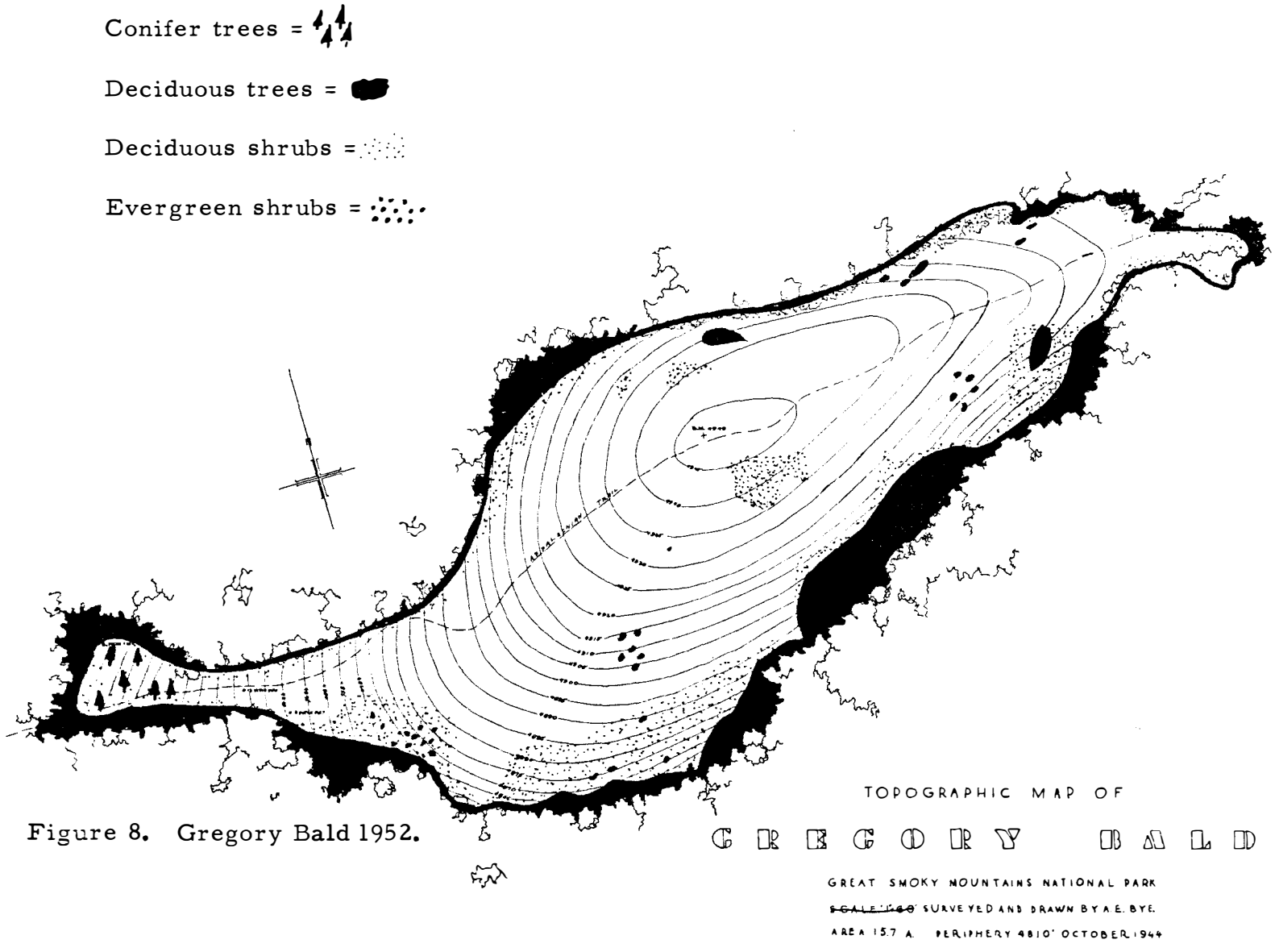

Figure 8. Gregory Bald 1952.

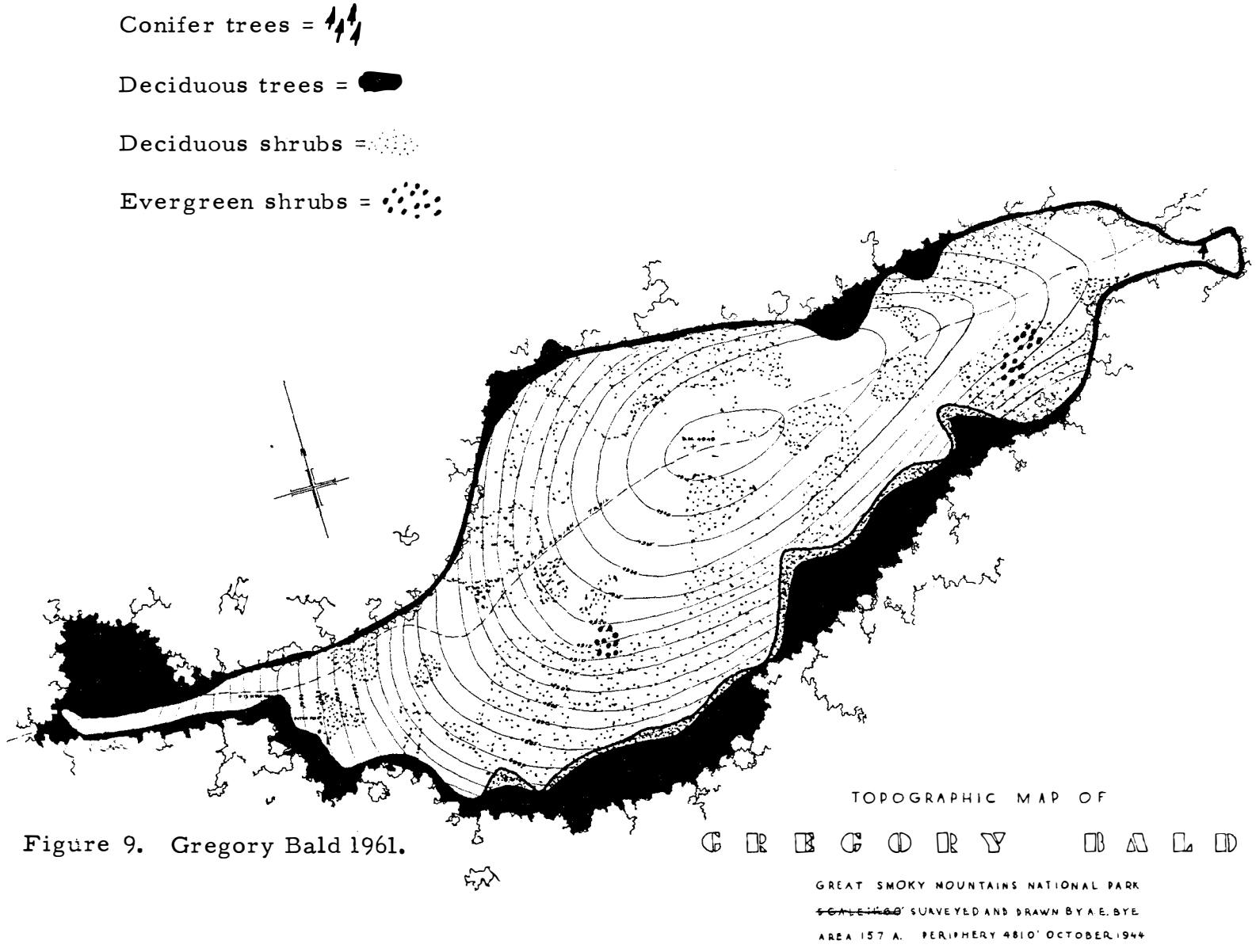

Figure 9. Gregory Bald 1961.



Figure 10. Andrews Bald 1937 (top) and 1963 (bottom).



Figure 11. Spence Field 1935.

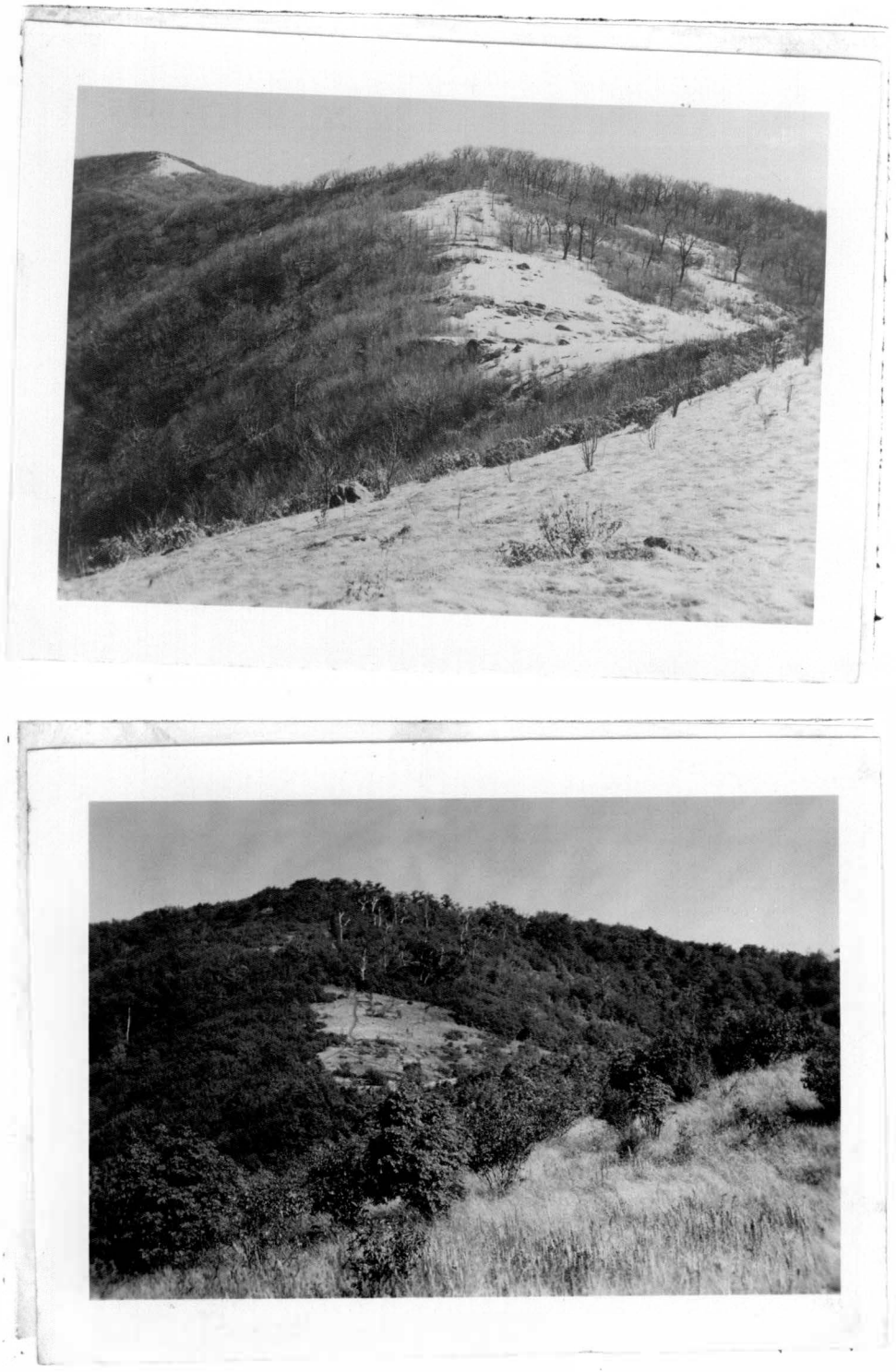

Figure 12. Spence Field 1953 (top) and 1963 (bottom).

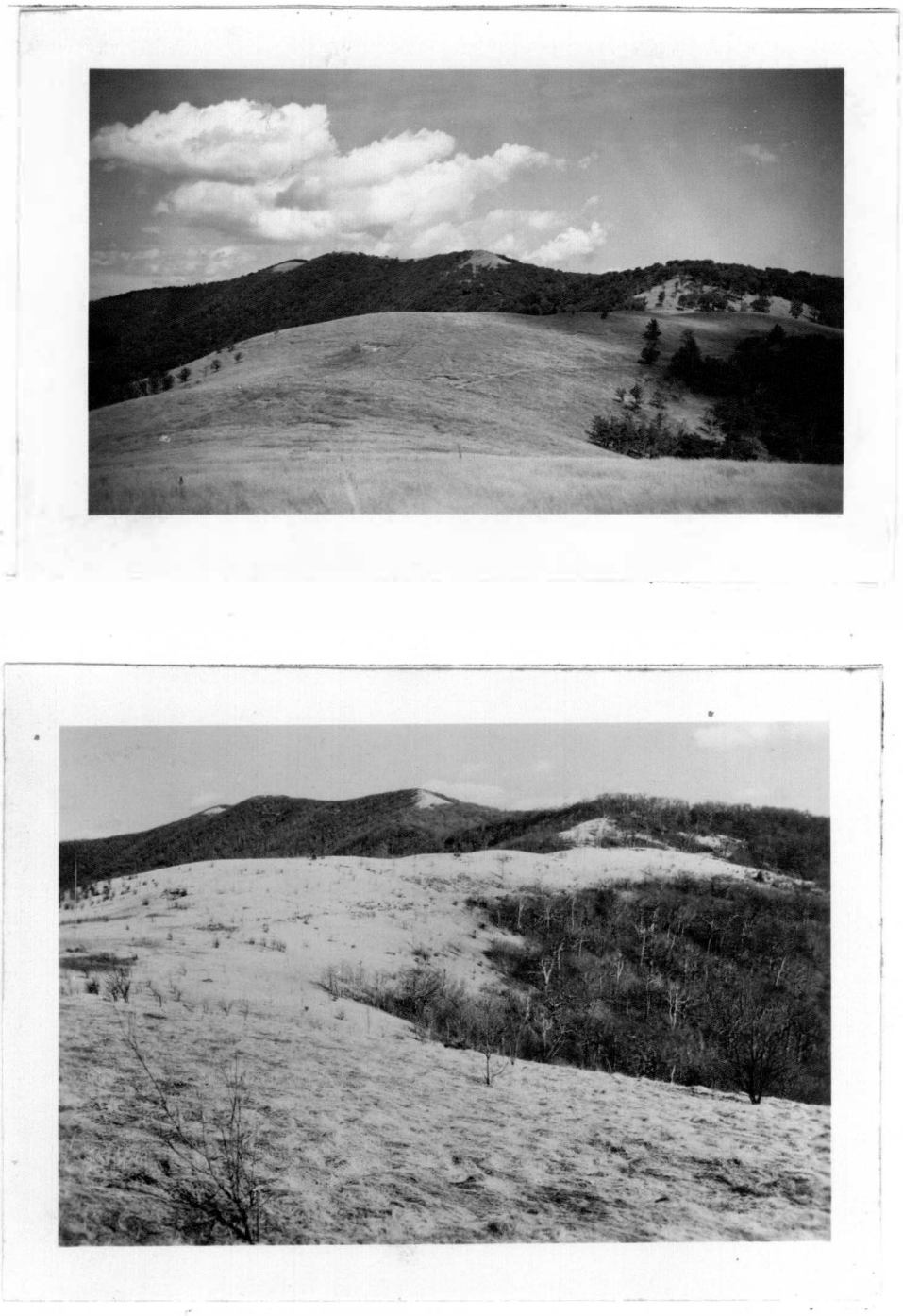

Figure 13. Spence Field 1935 (top) and 1953 (bottom).

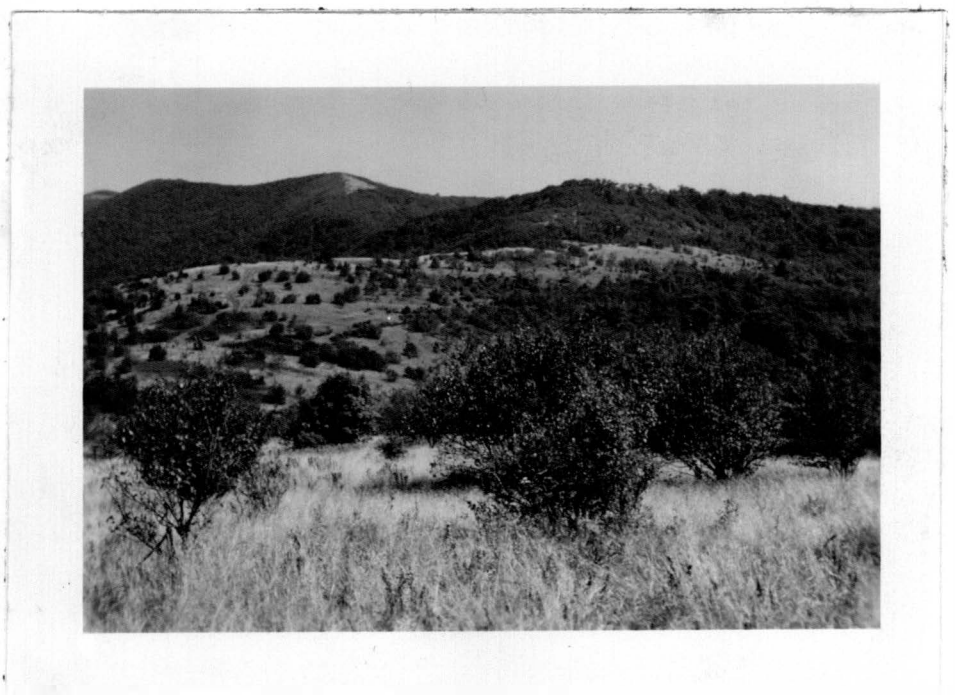

Figure 14. Spence Field 1963.



Figure 15. Gregory Bald 1934 (top) and 1963 (bottom).