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INTENSE RAINFALL IN GREAT SMOKY MOUNTAINS NATIONAL PARK

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ABSTRACT

The Tennessee Valley Authority defines intense rain as having one or more inches of rain in one hour or three or more inches of rain in 24 hours. In Great Smoky Mountains National Park intense rainfall is more prevalent during the summer half of the year (April through September). Intense summer rains are almost equally divided between the one hour-short duration type and the 24 hour-long duration type. Intense winter rains, however, consist entirely of the long duration form. Although data are insufficient, intense rainfall of both types apparently occurs more frequently at higher elevations.

INTRODUCTION

One may argue that the existing network of weather observation stations is never sufficiently dense to record all major atmospheric occurrences for a given area. This is especially true in mountainous locations. Because of the additional factors of elevation and exposure, climatic diversity and rapid rate of change are integral features of high relief areas. This diversity necessitates a relatively close spacing of recording stations, but mountainous areas usually have fewer stations per unit area than their lowland counterparts. The task of interpretation is not only more difficult, but fewer data are generally available.

Great Smoky Mountains National Park lies within the Tennessee River drainage basin and precipitation is monitored by the Tennessee Valley Authority, United State Department of the Interior, United States Weather Bureau, Aluminum Company of America, and other interested groups. Rainfall data within the park boundary are available from 14 rain gauge locations, 12 of which are currently operational (Table I). Unfortunately, in such a high relief area, only four of these rain gauges are positioned above 4000 feet in elevation, and large areas of the park, particularly the western half, have limited coverage (Figure 1). Supplemental rainfall data are available from six rain gauge stations outside the park but located close to the boundary. Only one is above 4000 feet. Some additional data on intense rains are obtained from bucket surveys conducted after heavy storms.

TABLE I. RAIN GAUGE STATIONS IN AND ADJACENT TO GREAT SMOKY MOUNTAINS NATIONAL PARK

Station	Location	Owner	Date of First Observation	Elevation (feet)
176	Calderwood Powerhouse	ALCOA	November, 1930	950
177	Cades Cove	TVA	April, 1936[a]	1964
183	Noland Creek	TVA	February, 1935	2520
184A	Clingmans Dome	TVA	January, 1939	6250
186	Oconaluftee	USDI	December, 1932	2100
187	Spruce Mountain	TVA	January, 1935	4500
206	Elkmont	USWB	January, 1931[b]	2146
209	Gatlinburg	USWB	December, 1921	1460
209A	Gatlinburg	TVA	March, 1967	1460
210	Mt. Le Conte	TVA	May, 1935[c]	6350
245	Mt. Sterling	TVA	November, 1934	2830
399A	Pittman Center	TVA	October, 1938[d]	1350
407	Cataloochee Ranch	TVA	April, 1939	4800
536	Cades Cove No. 3	USDI	January, 1941[e]	1800
542	Cherokee	USDI	January, 1941	1950
599	Big Cove	TVA	January, 1942	2620
656	Cataloochee	USDI	June, 1945	2590
660	Twentymile	USDI	July, 1945	1310
668	Abrams Creek	USDI	January, 1946	920
819	Newfound Gap	TVA	March, 1967	5000

[a]No readings made from April, 1945 to April, 1965.
[b]Station operated only from January, 1931 to November, 1943.
[c]Record consists of seasonal observations only.
[d]No readings made from May, 1943 to February, 1957.
[e]Station operated only from January, 1941 to March, 1946.

The basic information on intense rainfall was provided by the Tennessee Valley Authority, but this organization recognizes that the average spacing of rain gauges fails to sample many intense rains, especially

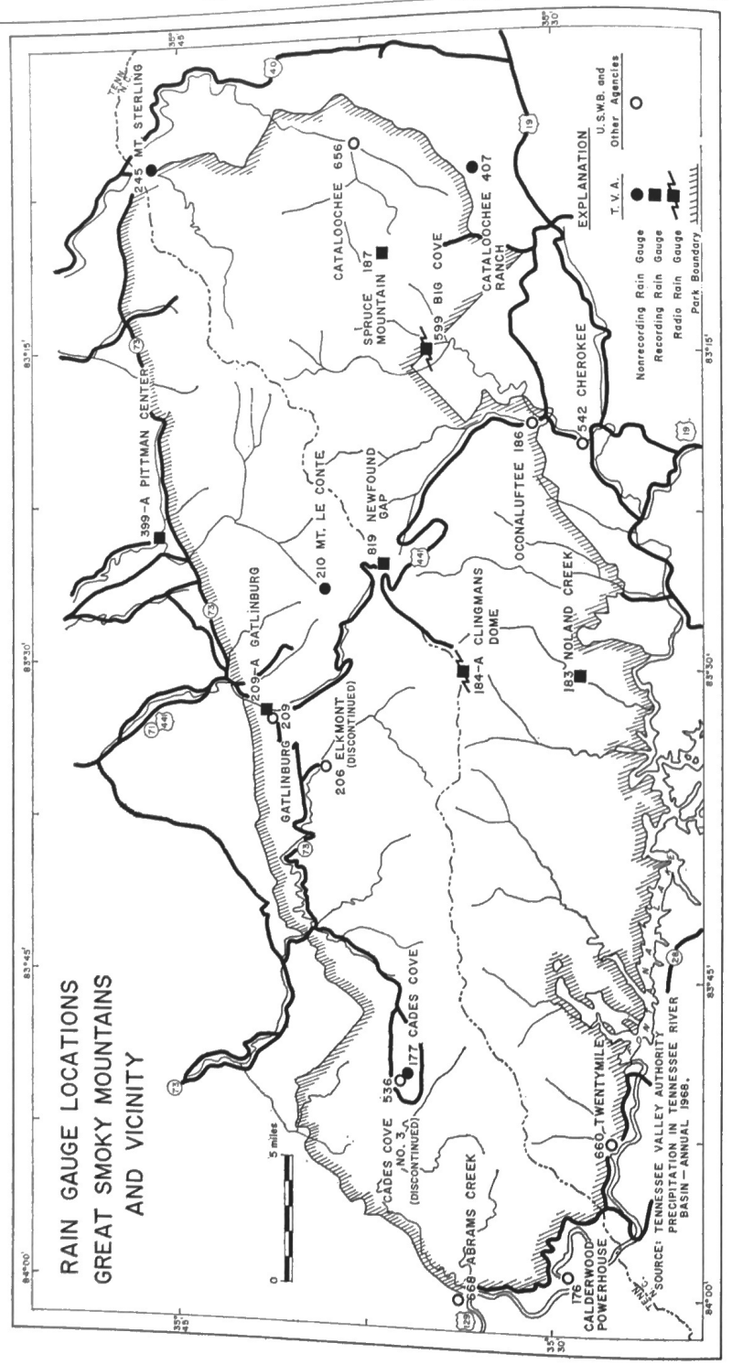

FIGURE 1. RAIN GAUGE LOCATIONS IN GREAT SMOKY MOUNTAINS NATIONAL PARK AND VICINITY

precipitation resulting from relatively isolated storms (Schwarz and Helfert 1969). Although the precipitation record is short and somewhat sporadic, the combined efforts of the various observers have resulted in a fair number of stations collecting pertinent data on rainfall duration and amount in the park area.

It should be emphasized that the number of recorded intense rains does not necessarily coincide with the number of storms that produced these rains. Data presented in this investigation are simply number of intense rainfalls recorded at the various stations, and intense rains resulting from a single storm may be recorded at several rain gauges. Without considerably more detailed information, it is nearly impossible to accurately differentiate individual storms.

Definition of Intense Rainfall

Cloudburst (also torrent, rain gush, rain gust, pour, and gulley washer) is a term used in a generally colloquial manner to describe heavy rainfall; but, by definition, a cloudburst is normally considered to have a rate of fall equal to or greater than 100 millimeters (3.94 inches) of rain per hour (United States Weather Bureau 1946; Meteorological Office, Air Ministry 1940; American Meteorological Society 1959). Rainfalls of this magnitude are relatively infrequent, however, and the Tennessee Valley Authority has adopted a classification which is more meaningful in understanding the nature and occurrence of heavy precipitation in the Tennessee River Basin. This scheme defines an intense rain as having one or more inches of rainfall in one hour on three or more inches of rainfall in 24 hours (Tennessee Valley Authority 1937). Intense rainfalls which occurred in 24 hours or less with exact duration unknown are included within the 24 hour type. The nature of intense rain under this classification may be quite variable. Rainfall of short duration but rapid rate of fall, as well as rainfall of long duration but perhaps only moderate rate of fall, conform to the above classification. The one hour rainfall will usually be associated with precipitation resulting from convectional activity whereas rainfall resulting from large-scale frontal or cyclonic conditions will generally be characteristic of the 24 hour rainfall.

Occurrence of Intense Rainfall

In compliance with the above classification, all precipitation data collected by the 20 rain gauges in Great Smoky Mountains National Park and vicinity, regardless of length of record, indicate that a total of 293 intense rains were recorded between 1937 and 1968.[1] According to the data, heavy rains appear to be more prevalent during the summer half of the year. Approximately 71 per cent of these rains occurred April through September while 29 per cent occurred October through March. June, July, and August are clearly months with the greatest number of intense rainfalls (Table II).

[1]Because data were not available, intense rainfalls that occurred in 1956 are not included.

TABLE 11. TOTAL THIRTY-ONE YEAR INTENSE RAINFALLS BY MONTH RECORDED BY RAIN GAUGES IN AND ADJACENT TO GREAT SMOKY MOUNTAINS NATIONAL PARK 1937 to 1968*

Month	Days
January	22
February	13
March	18
April	12
May	14
June	42
July	52
August	64
September	24
October	15
November	11
December	6
TOTAL	293

*No data for 1956.

The 1939 to 1968 rain gauge records (1956 storms are not included) for Noland Creek, Gatlinburg, Mt. Sterling, Clingmans Dome, Spruce Mountain, and Cataloochee Ranch were examined to determine if any relationships exist among elevation, month of occurrence, and nature of intense rain in the Great Smoky Mountains. The Noland Creek, Gatlinburg, and Mt. Sterling rain gauges are located below 4000 feet in elevation whereas the Clingmans Dome, Spruce Mountain, and Cataloochee Ranch gauges are situated above 4000 feet.

The occurrence of heavy precipitation is apparently related, at least in part, to elevation. A total of 194 intense rainfalls were recorded at the three gauges above 4000 feet. Stations below 4000 feet recorded 56 intense rains (Table III). Clingmans Dome, highest rain gauge location in the park, accounted for 122 of these higher elevation rains while Spruce Mountain had 55. Cataloochee Ranch, although 300 feet higher in elevation than Spruce Mountain, recorded only 17 heavy rains. Other factors such as location and exposure must therefore exert some influence on the occurrence of intense rainfall, but insufficient data preclude detailed investigation at this time.

Between 1946 and 1950 the United States Weather Bureau, National Park Service, and Tennessee Valley Authority conducted a study of the relationship between climatic variation and elevation (Smallshaw 1953). Although not directly concerned with intense precipitation, results of the investigation show a decided increase in rainfall with increasing elevation.

Rainfall information from the six rain gauges indicates that summer months have the greater number of intense rainfalls. This is true for the group of stations above the 4000 foot elevation mark as well as those below it. However, Noland Creek and Cataloochee Ranch, one station from each group, recorded more days of intense rain during the winter months than the summer months. The six gauges recorded 155 intense rains for the period April through September and 95 between October and March.

TABLE III. NUMBER AND MONTHLY DISTRIBUTION OF INTENSE RAINFALLS
1939-1968

Number	Station	Elevation (feet)	Intense Rainfalls																									
			Jan*		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec		Total	
			S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L
	Low elevation stations																											
200	Gatlnburg	1460	0	4	0	1	0	4	0	0	0	0	0	4	2	4	1	3	0	0	0	1	0	0	0	0	3	21
183	Noland Creek	2520	0	3	0	1	0	2	0	0	0	0	0	2	0	0	1	0	0	1	0	0	0	0	0	0	1	9
245	Mt. Sterling	2830	0	1	0	1	0	6	0	2	2	0	1	2	2	0	0	3	0	2	0	0	0	0	0	0	5	17
		Sub Total	0	8	0	3	0	12	0	2	2	0	1	8	4	4	2	6	0	3	0	1	0	0	0	0	9	47
	High elevation stations																											
187	Spruce Mountain	4500	0	6	0	5	0	4	1	3	1	0	5	2	5	2	7	4	2	5	0	1	0	2	0	0	21	34
407	Cataloochee Ranch	4800	0	5	0	1	0	0	0	0	0	0	1	0	0	0	3	0	1	2	0	1	0	1	0	2	5	12
184	Clingmans Dome	6250	0	9	0	6	0	9	2	4	3	0	9	5	11	8	17	6	4	10	0	9	0	4	0	6	46	76
		Sub Total	0	20	0	12	0	13	3	7	4	0	15	7	16	10	27	10	7	17	0	11	0	7	0	8	72	122
		TOTAL	0	28	0	15	0	25	3	9	6	0	16	15	20	14	29	16	7	20	0	12	0	7	0	8	81	169

*S represents intense rain of one inch or more in one hour.
L represents intense rain of three or more inches in 24 hours.

A distinctive pattern relating type or nature of intense rainfall to elevation and month of occurrence is evident from the data. The six stations have never experienced a one inch or more rain in one hour between October and March. During the summer months, nine of these intense rains have been documented at the lower elevation rain gauges while the gauges above 4000 feet have recorded 72. Intense precipitation of short duration is apparently the result of convectional activity during the warmer months, with the higher rain gauge group experiencing approximately eight times as many one hour-short duration intense rains as the lower stations. Clingmans Dome received the largest number of short intense rains with 46 recorded occurrences. The longer duration intense rainfalls are generally more evenly distributed throughout the year. Lower elevation rain gauges recorded 24 intense rainfalls of long duration during the winter months and 23 during the summer months. The upper elevation group experienced 71 long duration rainfalls during the winter period and 51 during the summer half of the year.

No direct relationship between average annual precipitation and number of recorded intense rainfalls could be determined. Clingmans Dome has the greatest annual precipitation and also had the highest number of intense rainfalls; but Cataloochee Ranch, second in total average annual precipitation, had only 17 intense rainfalls (Table IV).

TABLE IV. AVERAGE ANNUAL PRECIPITATION AND INTENSE RAINFALLS AT SIX SELECTED RAIN GAUGES

Station	Average Annual Precipitation (Inches)	Intense Rainfall
Clingmans Dome	75.73	122
Cataloochee Ranch	62.60	17
Spruce Mountain	60.47	55
Noland Creek	57.90	10
Gatlinburg	55.19	24
Mt. Sterling	53.35	23

Cloudbursts

Only two storms of cloudburst intensity were recorded between 1937 and 1968. Both occurred on September 1, 1951. The rain gauge at Mt. Le Conte recorded 4.00 inches of rain in 1.0 hour while Cataloochee Ranch received 4.80 inches in 1.2 hours. These gauges, however, were apparently not positioned directly beneath the most intense sections of the storms. Subsequent bucket surveys and slope-area studies on streams draining the two areas indicate that total rainfall may have been in excess of 6.0 inches (Tennessee Valley Authority 1951). The August 4-5, 1938 storm over Webb Mountain, located near Pittman Center, may also have been of cloudburst intensity. The Pittman Center rain gauge was not in operation at that time, but at least 11 inches of precipitation fell in four hours over a 27 square mile area. Rainfall of 12 to 15 inches was reported near the storm center (Moneymaker 1939).

The storm of September 1, 1951 is well remembered in Gatlinburg, Tennessee. Normally one or two feet deep, headwater streams that drain Mt. Le Conte rose eight to ten feet; and the overflow in Gatlinburg reached a maximum depth of about five feet and a width of nearly 600 feet (Tennessee Valley Authority 1966). In addition, the cloudburst resulted in the formation of more than 100 debris slides in the Mt. Le Conte-Sugarland Mountain area (Bogucki 1970).

Summary and Conclusions

As defined by the Tennessee Valley Authority, an intense rainfall has one or more inches of rain in one hour or three or more inches of rain in 24 hours. Rainfalls of this magnitude are not uncommon in Great Smoky Mountains National Park and vicinity. From 1937 to 1968 a total of 293 intense rainfalls were recorded by the 20 rain gauges selected for this investigation, and intense rains occurred somewhere within the study area in each of the 31 years for which records exist. Because the spacing of rain gauges is not systematic or exceedingly dense, a relatively large number of intense rainfalls, especially the isolated summer storms, were probably never recorded.

According to 1939 to 1968 data obtained from rain gauge records of six stations, higher elevation areas generally receive more intense rainfall than lower elevation areas. This is not necessarily true for all stations, however, and other factors such as location and exposure apparently affect the occurrence of heavy precipitation. The 24 hour-long rains occur with some regularity throughout the year, but rain gauge records indicate that a one hour-short duration rainfall has never been recorded between October and March. Intense rainfalls of both types occur with greater frequency at the higher elevation stations.

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THE OCCURRENCE OF CORN BORERS IN THE UPPER MISSISSIPPI VALLEY

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Abstract

A survey was conducted to determine the infestation resulting from two broods of corn borers. It was conducted twice each summer, in June and August, 1968 and 1969, and covered a 15 county area in Tennessee, Arkansas, and Mississippi. Five fields in each county were located and surveyed to represent the infestation of the entire county.

The comparison of the data obtained from the first survey of 1968, to the data from the first survey of 1969, indicated there was a general increase in the amount of infestation in 1969. However, data from the second survey of 1969, indicated a decrease in the amount of infestation as compared to the data of the second survey of 1968. The decrease was probably due to existing drought conditions in the summer of 1969. Overall, borer populations during 1969, were somewhat lower than in 1968.

Introduction

The European corn borer, *Ostrinia nubilalis* (Hubner), and the southwestern corn borer, *Zeadiatrea grandiosella* (Dar), are two of the great destructive insect pests in the United States. These pests cause millions of dollars in damage each year. Because corn is becoming an ever increasing crop, and because corn borers destroy millions of dollars worth of corn annually in the South, a study of the European corn borer and the southwestern corn borer, collectively known as the corn borer complex, was conducted. There is little known of the abundance of corn borers in the tri-state area of the Mississippi Delta. The abundance of corn borer infestations was determined by a quantitative infestation survey in 15 counties in the tri-state area of western Tennessee, eastern Arkansas, and northern Mississippi. Figure 1 is a map of the fifteen counties surveyed.