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ABSTRACT

This paper discusses the development of and provides examples of exercises from a student workbook for a college-level course about natural hazards. The course is offered once a year to undergraduates at Western Illinois University. Students are introduced to 10 hazards (eight meteorological plus earthquakes and volcanoes) through slides, movies, and filmstrips. Handouts regarding each provide information about the physical characteristics of the hazard, its geographical distribution in the United States, and the safety measures appropriate to reduce the rise of injury or death. The textbook used in the course is "The Environment As Hazard" by Burton, Kates, and White. To supplement course materials the student workbook was developed. Each of the 10 exercises comprising the workbook begins with a brief introduction to the hazard. A brief discussion and/or supplemental reading are recommended before each exercise is begun by the students. Data prepared by federal agencies comprise the single most important source of information for the exercises. Many tables and maps are used. A discussion of certain hazards is augmented by case studies. To illustrate how different types of materials were utilized in developing the workbook, samples of exercises are included in the paper. For example, in one exercise students analyze a map depicting the average number of tornadoes by state for the period 1953-1978. In another exercise students plot the paths of six hurricanes that have affected the United States. (Author/RM)

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A Natural Hazards Workbook

A Paper Presented At

The 1980 National Council for Geographic Education

October 18, 1980

by

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Western Illinois University

SO 013 803

A Natural Hazards Workbook

Introduction

Two years ago a course entitled Natural Hazards was taught for the first time in the Department of Geography at Western Illinois University. The course is now offered once a year to undergraduates and requires no prerequisites. The use of numerous slides, frequent movies and occasional film strips provided the visual means by which many of the students first encountered a specific hazard. Handouts regarding each of the ten hazards - eight meteorological plus earthquakes and volcanoes - provided information about the physical characteristics of a hazard, its geographical distribution in the United States and the safety measures appropriate to reduce the risk of injury or death.

The third component which comprised the course materials was the paperback textbook. The Environment As Hazard by Burton, Kates and White summarized how individuals and groups have responded to extreme events in nature. The authors provided tentative conclusions about the nature of hazard behavior after examining the responses that people exhibited in ten different countries.

A major concern of the course was student involvement. In order to provide greater interest in the course an effort has been made to develop a workbook which would supplement present course materials and offer the student a greater opportunity to investigate more closely the characteristics of natural hazards.

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Sources of Information

One year was spent reviewing materials that might be appropriate for inclusion in a natural hazards workbook.* Part of this review involved a computer search for existing hazard exercises or workbooks. Neither of these types of materials was available. The lack of hazard exercises made the job of developing a format for the workbook somewhat more difficult. Many of the ideas for the workbook that seemed appropriate initially were not feasible because detailed information or specific data were not available. Ultimately, the data which were collected determined the general framework of the workbook.

The data for developing the exercises for the workbook came from a variety of sources. In general, data prepared by federal agencies comprised the single most important source of information for the exercises. This was particularly true of the National Oceanic and Atmospheric Administration (N.O.A.A.) when meteorological information was required. Publications of the United States Department of the Interior were especially helpful with earthquake and volcano exercises. The Weather Almanac was an unexpected valuable source of data on both meteorological phenomena and earthquakes. The Illinois State Water Survey was an important source of substantial data on tornadoes and hail. Finally, the periodical Weatherwise was a major source of information about hurricanes, tornadoes, floods, snowfall, lightning, and drought. A list of the most useful references is found at the end of this paper.

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*A research grant from the Association of American Geographers was used to purchase materials during the literature search.

relationships between regions and among states. In a few cases, maps of two different hazards were compared in order to ascertain why distributional characteristics were either similar or different.

Tables were used frequently in presenting data about hazards in the workbook. Columns of data were compared, in some cases, to better understand both spatial and temporal characteristics of natural hazards. In several instances, students would manipulate the data in the tables when answering questions about a variety of geographical concerns at both the state and regional level.

In a number of cases two variables were compared by plotting data from a table onto a graph. Trend lines would be drawn and questions considered about the characteristics of the two variables including possibilities for predicting one of the variables when the other was known. For some hazards the results on the graphs could be compared to quantitative measures of the relationship between the two variables. Both the correlation coefficient and Spearman rank correlation would be calculated with the results used to determine which method was most useful in depicting relationships. In one case, a completed wind chill graph would be used by students to determine wind chill values. The temperature humidity index could also be calculated using a formula and graph. The results would be used by the students to evaluate different applications of the index.

In two instances, indexes were used for evaluating certain hazards. A tornado threat index would be developed by utilizing three other maps to formulate a relative state index. Questions regarding the advantages and shortcomings of such an index will be discussed as part of the exercise. Students could even be asked how relationships between regions and among states. In a few cases, maps of two different hazards were compared in order to ascertain why distributional characteristics were either similar or different.

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In two instances, indexes were used for evaluating certain hazards. A tornado threat index would be developed by utilizing three other maps to formulate a relative state index. Questions regarding the advantages and shortcomings of such an index will be discussed as part of the exercise. Students could even be asked how they would improve such an index. A coefficient of variation would be derived for a drought exercise from yearly precipitation values for eight cities across the country. This index could then be compared to the standard deviation calculated by the students for the same eight cities. Students would have the opportunity to observe how certain cities changed rankings relative to one another depending on which method was used. Several questions would also be in order regarding drought tendencies of the eight cities as depicted by the index values.

A discussion of certain hazards was augmented by case studies. This was particularly true of flash floods. Four different examples were used in the United States which occurred recently and which were especially devastating. Students would now have the chance to compare and contrast how different geographic settings influenced this type of flooding. A case study of earthquakes involved examining maps of areas of present-day San Francisco which are considered most hazardous. Questions would be posed about why this is the case and what major problems might occur in the same area if the city was subjected to a powerful earthquake.

Safety precautions before, during and after were considered when discussing each of the ten hazards. Efforts were made to have students develop preliminary safety rules based entirely on the physical characteristics of the hazard. Their rules could then be compared to recommended procedures, and questions asked about why differences in strategies occurred. Other questions relating to safety were hypothetical and involved student opinions about the difficulties associated with evacuation along a heavily populated coastal area prior to a hurricane landfall.

Examples of Natural Hazards Exercises

The length of the exercises in the workbook varied according to the availability of raw data. Figure 1 contains three different categories into which each hazard has been classified. Information on tornadoes, hurricanes and floods was available in large amounts which was easily adopted in the development of the exercises. Data on hail, drought, volcanoes and earthquakes were abundant but not as easily converted into exercises which focused on geographical relationships. Exercises dealing with lightning, winter storms and snow avalanches were limited, and as a consequence were the shortest in length.

Exercises have been selected for discussion which provide examples of how different types of materials were utilized in developing the natural hazards workbook.

Tornadoes

Figure 2 depicts the average number of tornadoes by states for the period 1953-1978. Questions about the distribution on this map would be as follows:

1. Which region on Figure 2 experiences the greatest number of tornadoes?
2. Would it be correct to characterize the south central and southeast portions of the United States as a "Tornado Alley"?
3. Which five states have the greatest annual average number of tornadoes?
4. Can you offer some reason why Florida is not contiguous to the other four states with the highest tornado activity?
5. What problem arises when comparing the number of tornadoes in Texas with the number in Oklahoma?

FIGURE 1

APPLICABILITY OF NATURAL HAZARDS DATA

Hazard	Data Available and Readily Applicable to Exercises	Data Available but Not Readily Applicable to Exercises	Data Limited
Tornadoes	Yes		
Hail		Yes	
Lightning			Yes
Hurricanes	Yes		
Floods	Yes		
Drought		Yes	
Winter Storms and Blizzards			Yes
Snow Avalanches			Yes
Volcanoes		Yes	
Earthquakes		Yes	

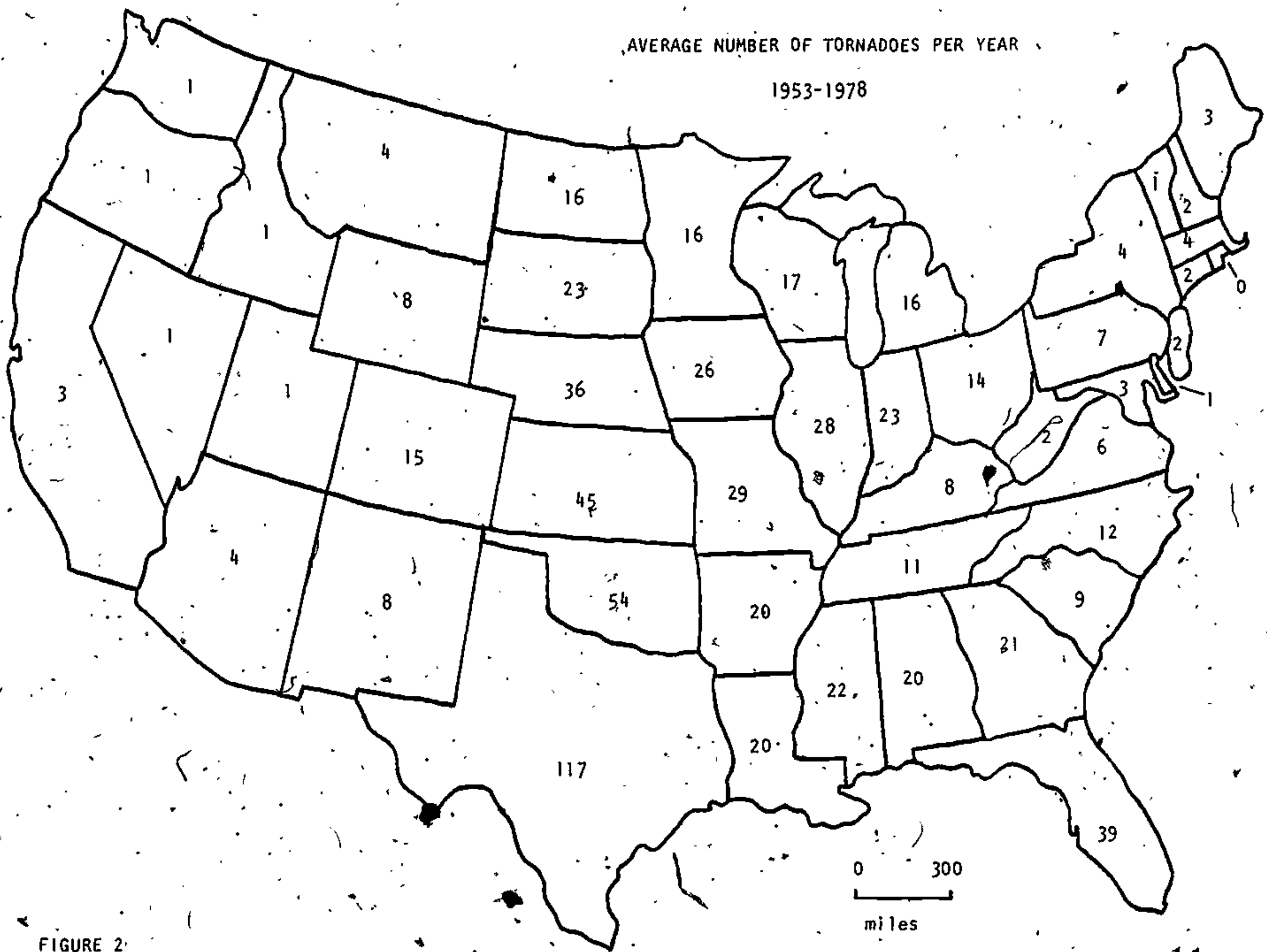
AVERAGE NUMBER OF TORNADOES PER YEAR
1953-1978
1
1
1
4
16
16
23
8
17
16
3
1
1
36
26
14
7
15
28
23
45
29
8
6
12
4
8
54
20
11
9
21
22
20
20
117
39
3
1
2
4
2
0
4
2
3
2
1
0
300
miles

FIGURE 2

Figure 3 offers an improvement over Figure 2 when comparing tornado activity. The number of tornadoes has been computed for a standard area of 10,000 square miles. Thus, the state of Texas no longer is number one in tornado activity. In fact, ten states now rank ahead of Texas when area is normalized.

1. Which five states experienced the largest number of tornadoes on both Figures 2 and 3?
2. Why are Massachusetts and Delaware so prominent on Figure 3 but not on Figure 2?
3. On both Figures 2 and 3 Kentucky, Tennessee and West Virginia have fewer tornadoes compared to surrounding states. How might the topography in these areas account for the low tornado figures? (See Figure 4)
4. According to Figure 3 which portion of the country is least likely to experience a tornado - the East Coast or West Coast?
5. Why do you suppose the East Coast has a greater frequency of tornadoes than the West Coast? (Consider climate, air masses, prevailing winds, and conditions most conducive to tornado development)

Hail

Figure 5 represents the average annual number of days with hail in the United States. Notice the highest occurrences (8 days or more) in southeastern Wyoming, western Nebraska and northeastern Colorado.

1. What geographical feature do these areas of high hail activity all seem to have in common? (Consult Figure 6)
2. An area of high hail activity (4-8 days) is located in the northwestern part of the country. How is the physical geography of this area similar or different than the enterior locations which also have high hail activity?

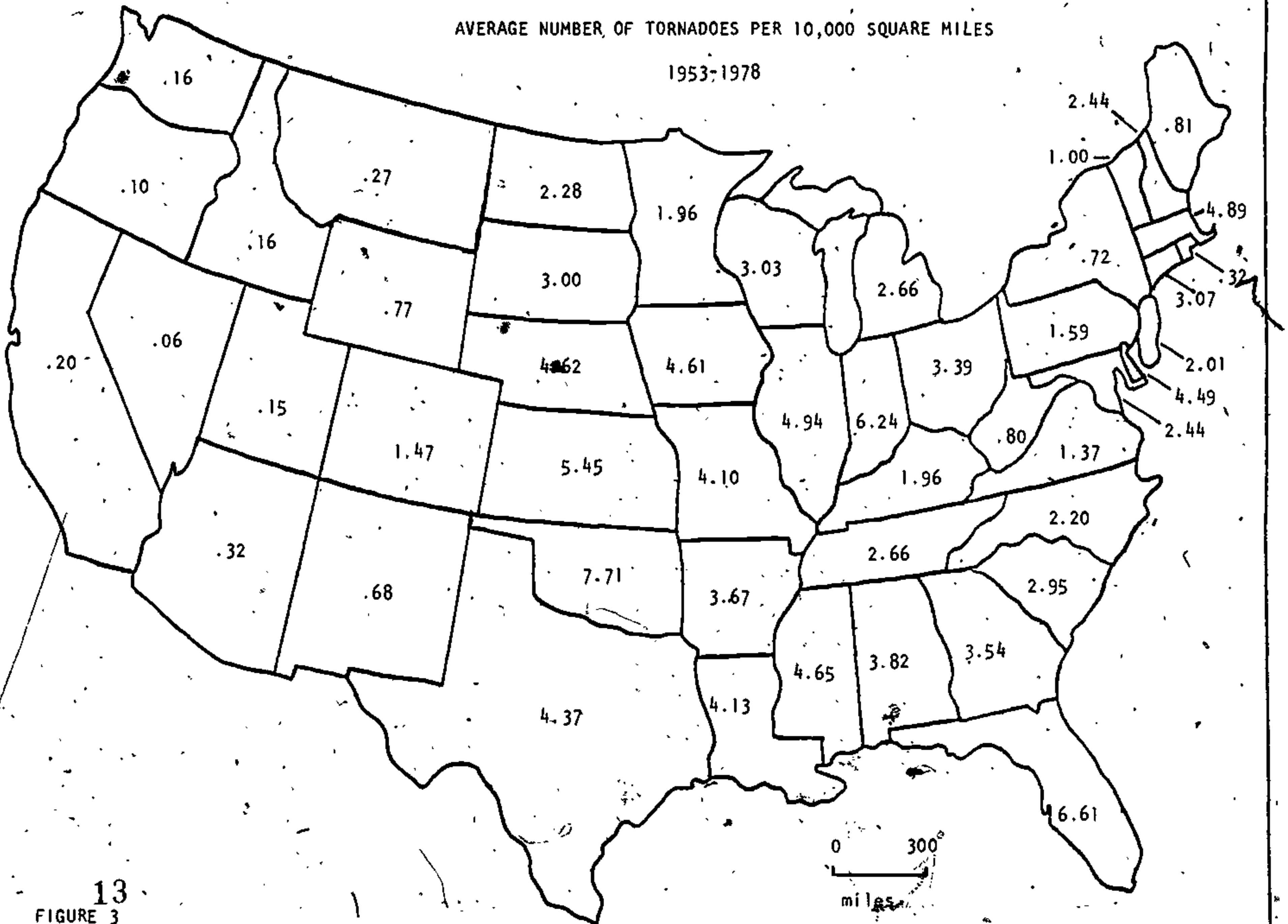
AVERAGE NUMBER OF TORNADOES PER 10,000 SQUARE MILES
1953-1978
.16
.10
.16
.27
2.28
1.96
3.00
3.03
2.66
.20
.06
.77
4.62
4.61
.15
1.47
5.45
4.10
4.94
6.24
3.39
.80
1.37
1.96
2.44
.81
1.00
4.89
.72
.32
3.07
1.59
2.01
4.49
2.44
2.20
.32
.68
7.71
3.67
2.66
2.95
4.65
3.82
3.54
4.37
4.13
6.61
0
300
miles

FIGURE 3

FIGURE 4

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RELIEF MAP OF THE EASTERN UNITED STATES

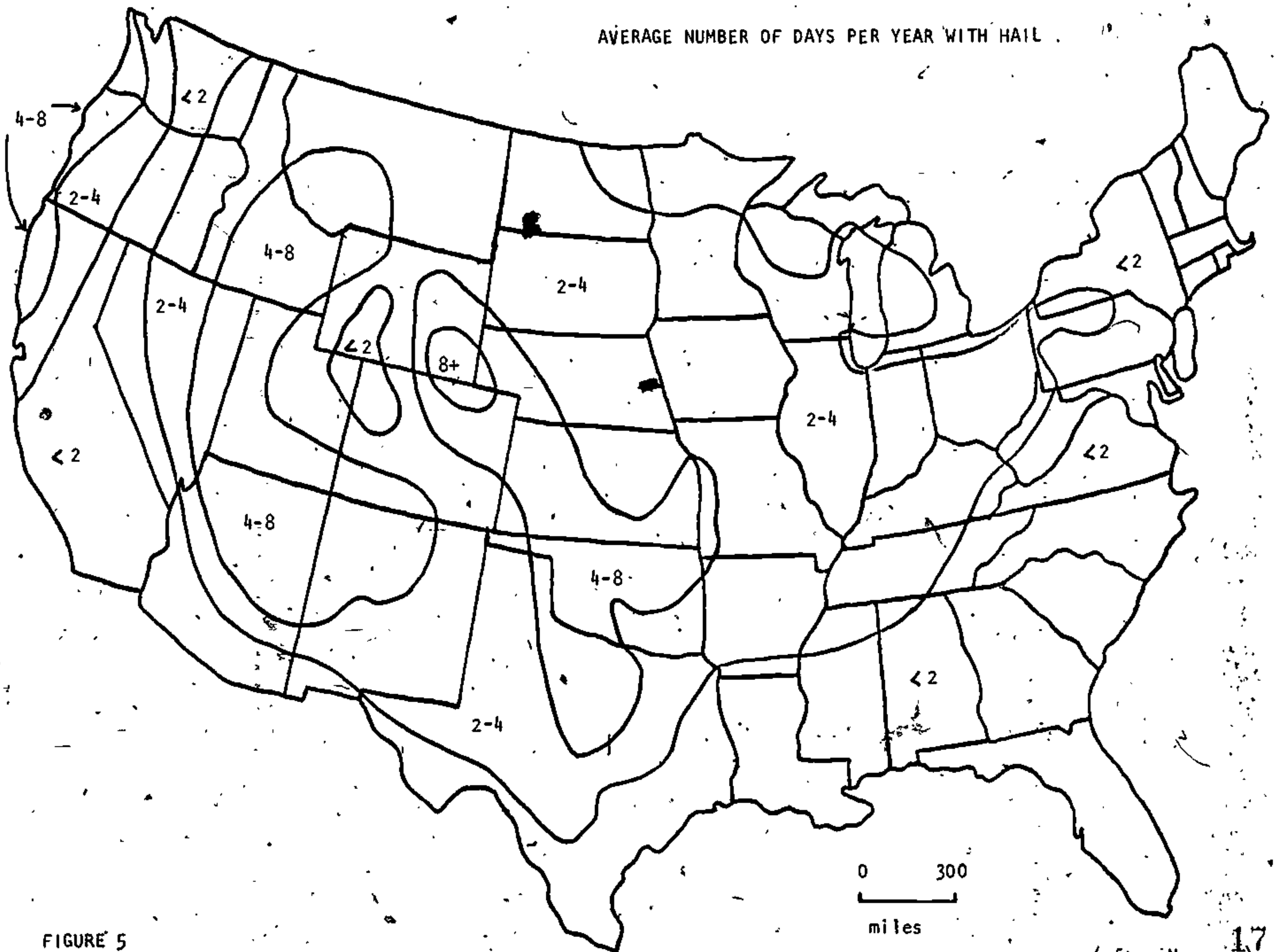

FIGURE 5

(after Navarra)

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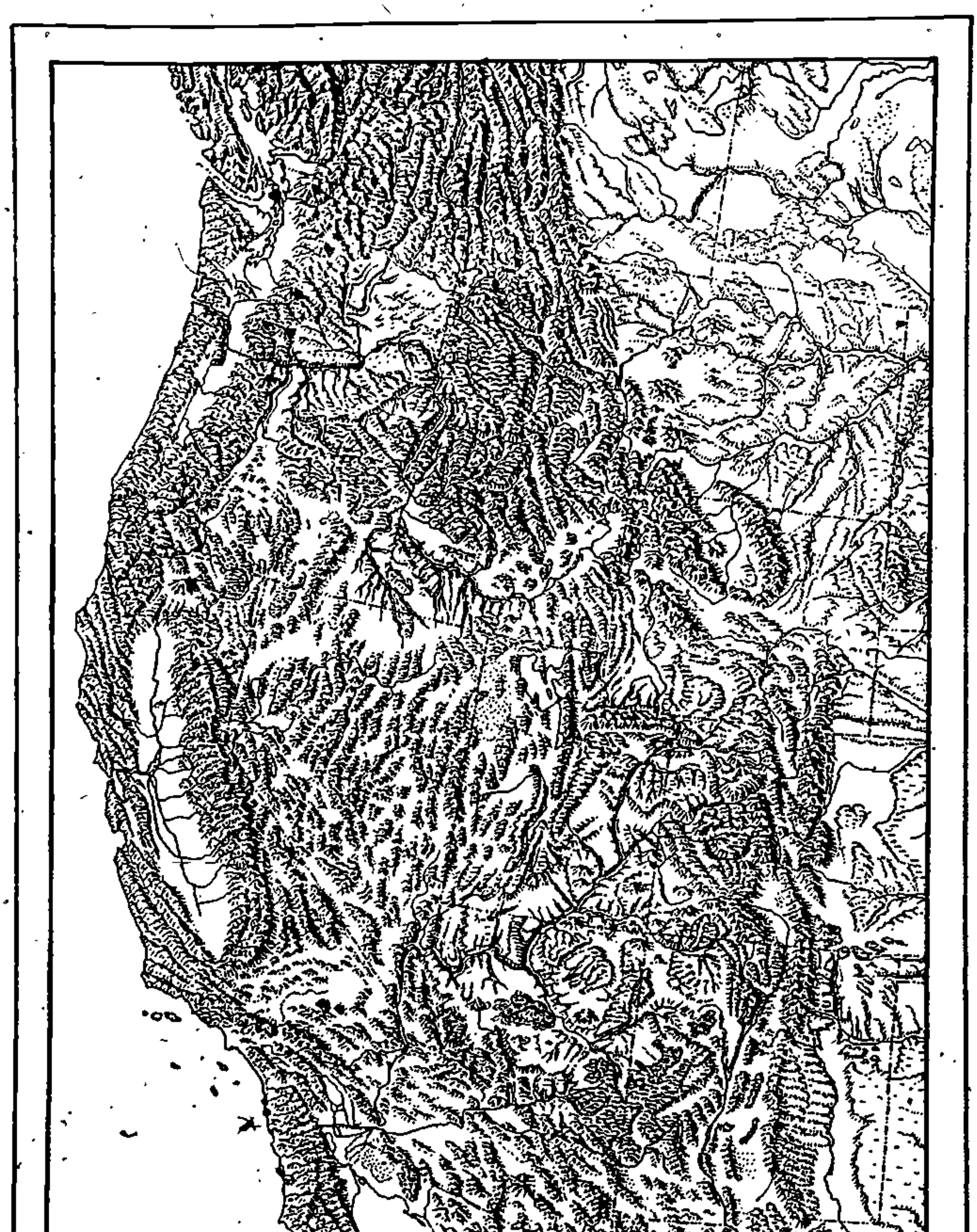
FIGURE 6

RELIEF MAP OF THE WESTERN UNITED STATES



3. In which of the two regions mentioned in question 2 would hail be most damaging to agriculture? (Consider air mass interaction)

Figure 7 reveals where thunderstorm activity is most frequent in the continental United States. Compare this map with Figure 5.

1. Which area of greatest thunderstorm activity coincides most closely with areas of high hail activity?

2. Notice that the northwest is low in thunderstorm activity but high in average annual number of days with hail. Speculate why this might be so?

3. The southeastern United States experiences a very high (60-90) average annual number of thunderstorms. Yet, this region experiences less than two hail days per year on the average. In what way would the summer temperatures in this region affect hail formation?

4. Consider the temperature conditions during the summer in the areas of high hail activity in the interior portions of the western United States. How are they different than in the Southeast?

5. Why would hail activity in the Northwest occur more frequently in winter and spring than in summer?

Volcanoes

Figure 8 is a relief map of the northwestern United States. Students were asked to locate on the map as many of the individual volcanic peaks as possible in the states of California, Oregon, and Washington. They would then consider the following questions.

1. What physical characteristics of the volcanoes made their detection relatively easy?

2. Which mountain range contains the majority of these volcanic peaks?

3. Which volcanoes have been active during this century?

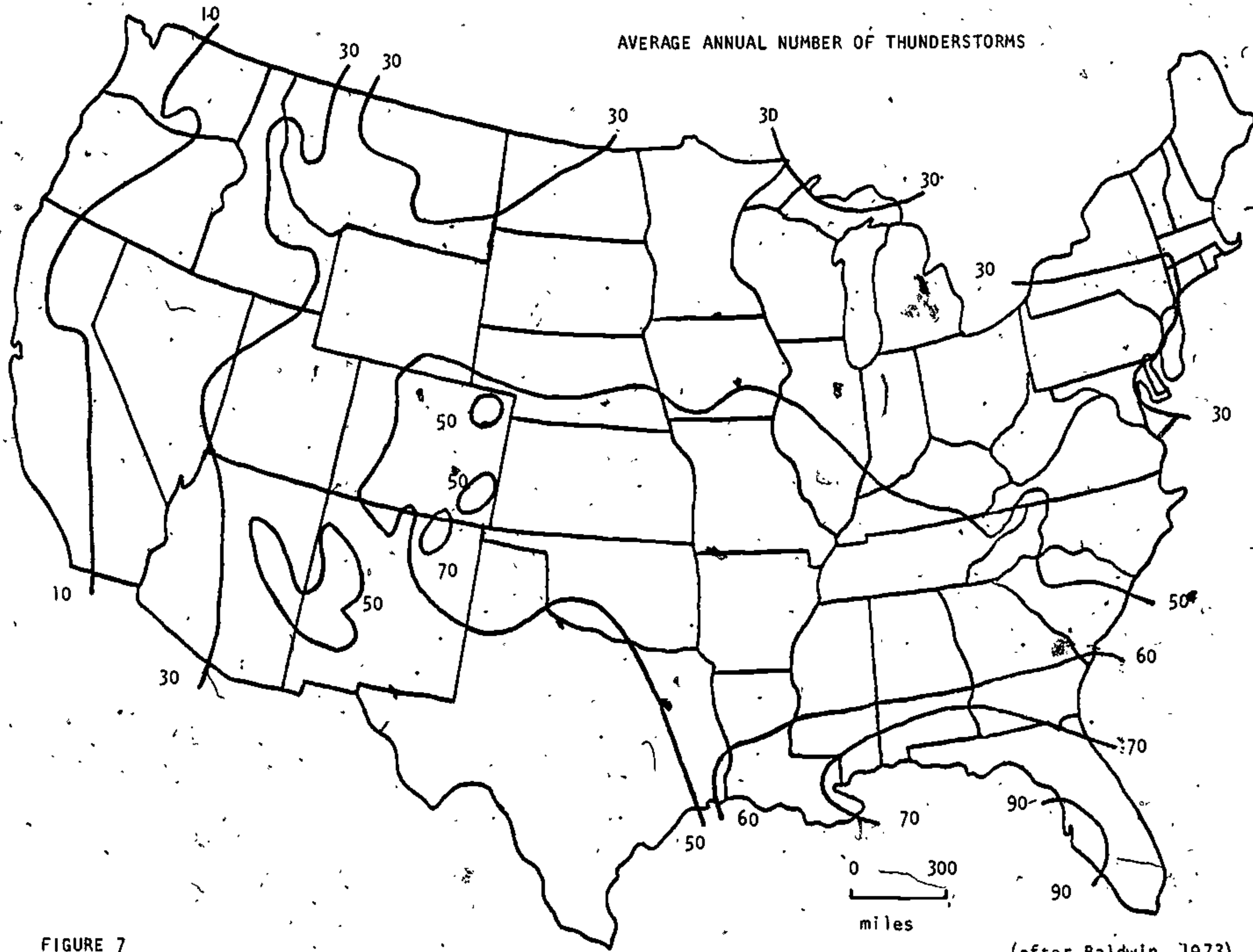
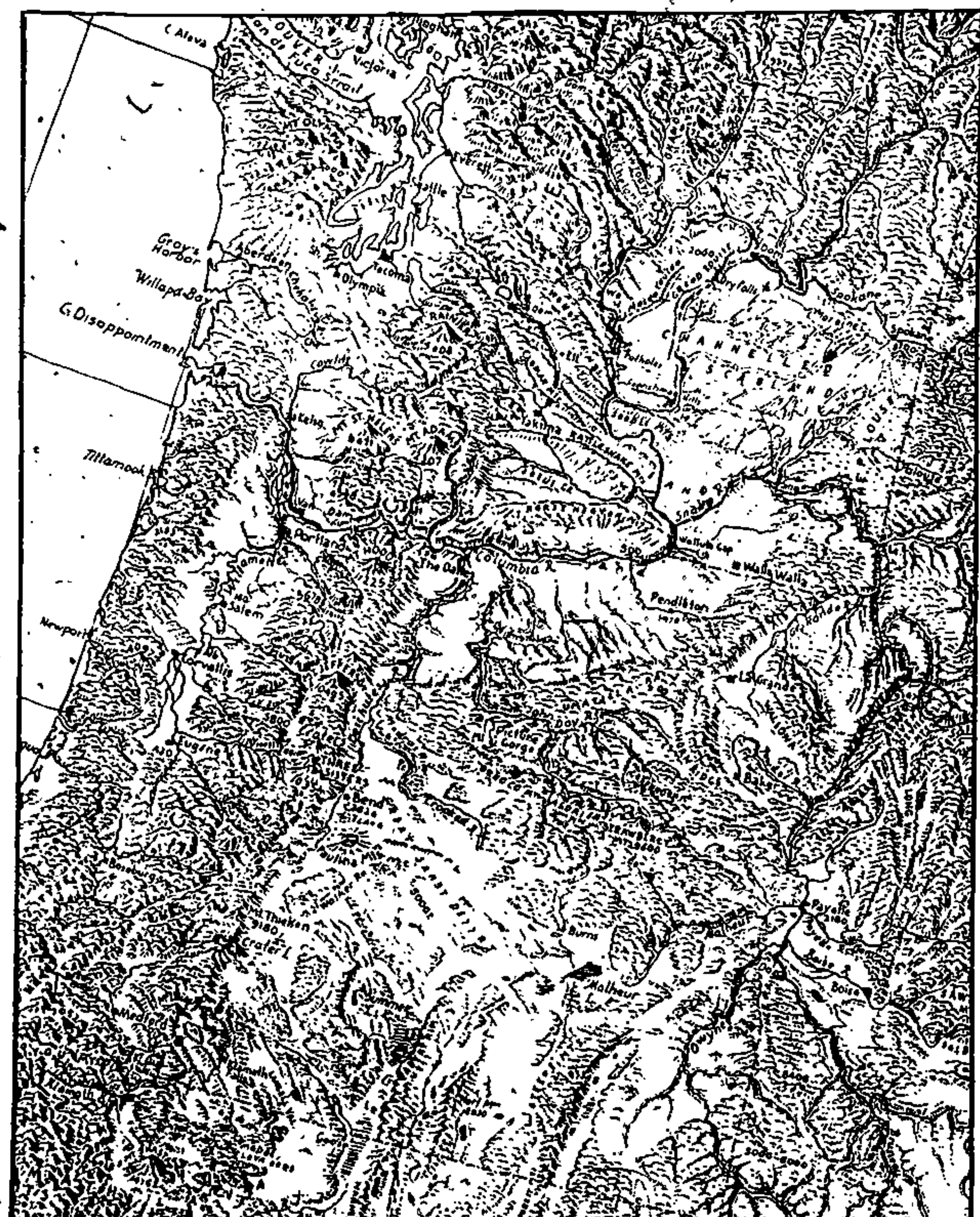


FIGURE 7

(after Baldwin, 1973)

FIGURE 8 **BEST COPY AVAILABLE**

RELIEF MAP OF THE NORTHWEST



4. Crater Lake was formed during the eruption of Mt. Mazama nearly 6000 years ago. If prevailing wind directions are the same today as during the eruption, where would you expect to find most of the ash and pumice deposits?

Figure 9 is part of an Oregon state highway map of the area surrounding Crater Lake. Study this map carefully. Then answer the following questions.

1. If the eruption of Mt. Mazama (which formed Crater Lake) occurred today what kind of volcanic hazards would affect nearby communities? (Consider the recent eruption of Mt. St. Helens for ideas. You may want to check newspaper accounts of this recent eruption.)
2. The cities of Grants Pass and Medford are located to the southwest of Crater Lake, well removed from the direct effects of lave or other volcanic deposits. What types of hazard might develop and threaten these cities if volcanic materials entered the streams which originate on the slopes of Crater Lake? (Check Figure 8 for assistance)
3. Would Klamath Falls, almost due south of Crater Lake, be affected in the same way as Grants Pass and Medford during a volcanic eruption? Why or why not? (Check Figure 8)
4. Which type of human activities depicted on Figure 9 would suffer most from another eruption of Mt. Mazama?

Hurricanes

This exercise provides the opportunity to plot the paths of six major hurricanes that have affected the United States. Selected values of latitude and longitude are available for each hurricane in Figure 10. The path of a hurricane can be plotted by placing a dot at the intersection of each grid coordinate on Figure 11. The dots can then be connected with a smooth curve to approximate the changes in direction

FIGURE 9

CRATER LAKE AREA

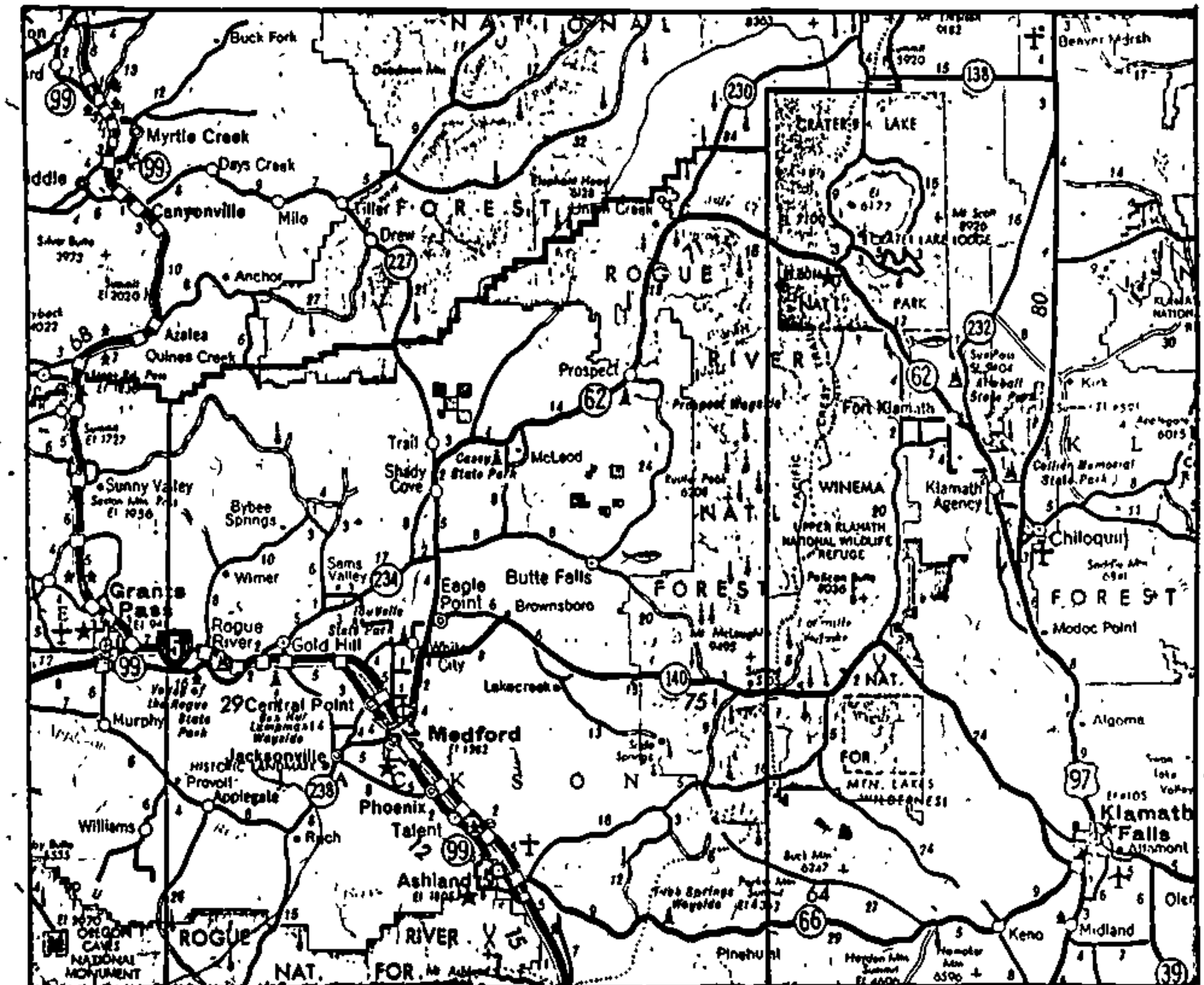


FIGURE 10

HURRICANE GRID COORDINATES

Name	Dates	Latitude	Longitude
Agnes	June 14-22, 1972	20°N (start)	88°W
		21 N	86 W
		30 N	86 W
		33 N	82 W
		37 N	78 W
		39 N	75 W
Camille	August 14-22, 1969	19°N (start)	82°W
		23 N	85 W
		25 N	87 W
		32 N	89 W
		34 N	90 W
		35 N	89 W
		38 N	86 W
Betsy	August 26-September 12, 1965	21°N (start)	65°W
		22 N	66 W
		22 N	70 W
		28 N	75 W
		26 N	77 W
		25 N	80 W
		26 N	85 W
		29 N	90 W
		32 N	92 W
		35 N	90 W
		38 N	87 W
Carol	August 25-31, 1954	24°N (start)	75°W
		30 N	77 W
		31 N	78 W
		35 N	76 W
		37 N	75 W

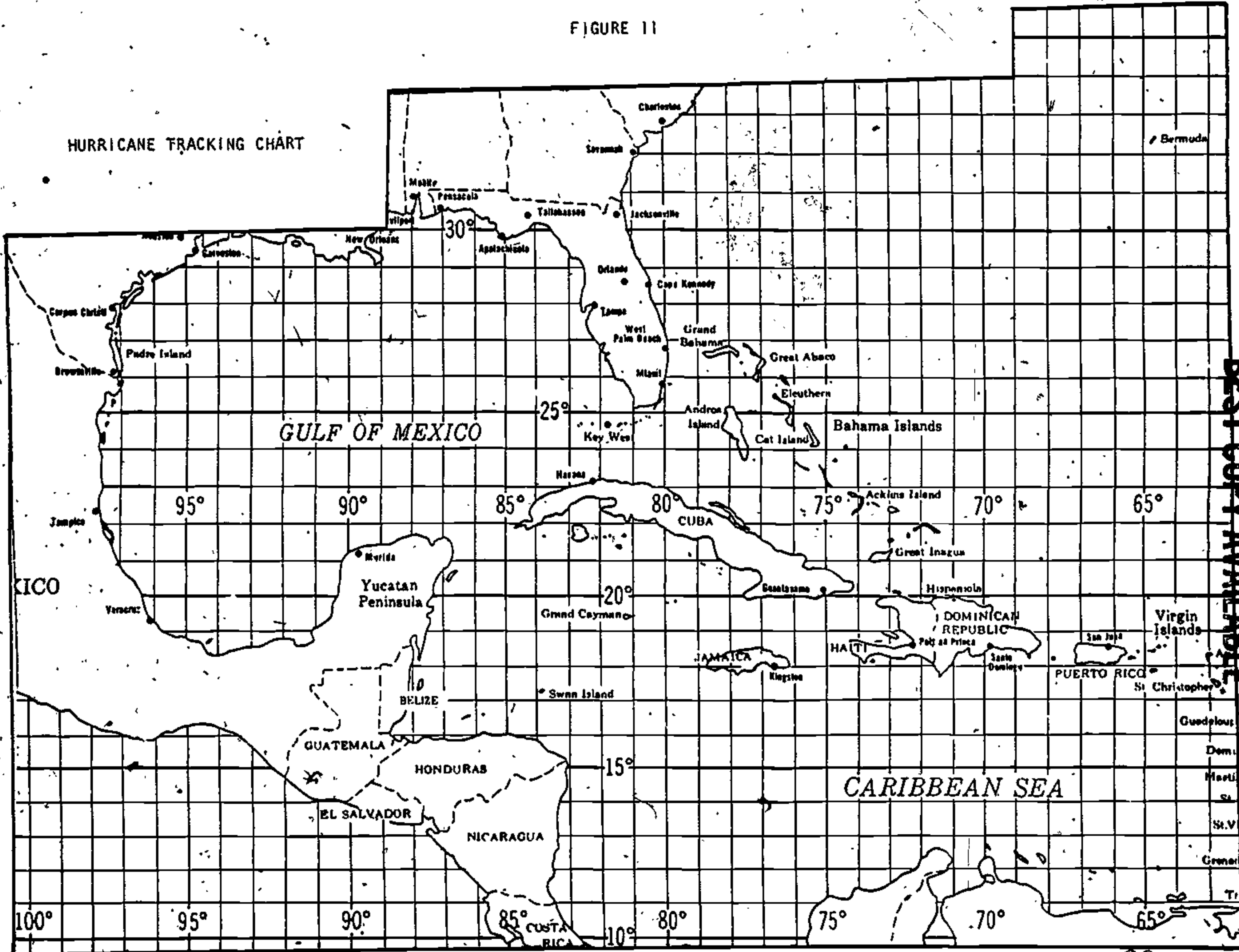
FIGURE 10

CONTINUED

Name	Dates	Latitude	Longitude
New England	September 10-22, 1938	23 N (start)	70 W
		28 N	75 W
		31 N	75 W
		35 N	73 W
		30 N	73 W
Galveston	August 27-September 15, 1900	23 N (start)	82 W
		26 N	85 W
		27 N	90 W
		29 N	95 W
		32 N	97 W
		35 N	96 W
		37 N	95 W
		40 N	93 W

FIGURE 11

HURRICANE TRACKING CHART



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of the hurricane. Outline each hurricane track with a different colored pencil. Write the name start where you begin plotting and place an arrow with the last set of coordinates to indicate general direction of each hurricane. Also label each hurricane by name and with the dates that it existed. Now answer the questions that follow.

1. Based on your completed tracking chart, hurricanes move in approximately which direction when they first develop? Why? (Consult an atlas for world wind systems)

2. At approximately what latitude do the six hurricanes abruptly turn toward the north-east? Why? (See the atlas again)

3. Why do you suppose that all six hurricanes originated at nearly the same latitude?

4. What prevents hurricanes from originating nearer the equator?

5. Which of the six hurricanes exhibited the most erratic path?

6. List at least three different ways that hurricanes can cause major destruction and numerous fatalities as they approach the coast and then move inland?

7. In what ways do tornadoes and hurricanes which affect the United States differ in their longevity, forward speed, rotational speed, direction and predictability of the path they will follow?

8. Why do tornadoes sometimes develop adjacent to hurricanes?

Lightning

Figure 12 provides statistics for the ten states which suffered the greatest number of lightning deaths from 1968-1976. Notice that eight of the ten states are located in the southern part of the country. Only Ohio and New York are outside this region.

FIGURE 12

LIGHTNING STATISTICS BY STATES

1968-1976

State	Total Deaths	Deaths/Million People	Average Number of Thunderstorms Per Year	Population Density/ Square Mile
Florida	110	1.80	80	126
North Carolina	53	1.16	45	104
Texas	48	.48	40	43
Ohio	46	.48	40	260
Oklahoma	40	1.97	55	37
New York	39	.24	30	381
Missouri	36	.86	55	68
Louisiana	36	1.10	60	81
Tennessee	35	.99	55	95
Arkansas	34	1.96	55	37

1. Use the data in Figure 12 to assist in formulating reasons why Ohio and New York rank so high in lightning fatalities even though thunderstorm activity (Figure 7) is low compared to the other eight states?

2. Compare lightning deaths by state with total average number of thunderstorms per year. Also compare lightning deaths by state with population density. Which of the two relationships appears to be strongest?

3. How would you use a graph to assist in making the comparison in the preceding question?

4. The States of Arkansas and Oklahoma have the lowest population densities and yet the highest number of deaths from lightning per million people. Why may this be the case? (Consider types of activities most often associated with lightning deaths).

5. Your instructor will explain the use of the Spearman rank correlation and its application in also answering question number four. Once you have calculated this value compare it to your graphs. What advantages and disadvantages are associated with both methods of analysis?

6. Based on the completed graphs and calculated value define what is meant by a direct and indirect relationship?

Concluding Remarks

The preceding discussion offers several different ways that natural hazards material could be incorporated into exercises that should prove useful in the geography classroom. Hopefully, additional work in this area would help to expand and refine existing exercises so that greater use would be made of such materials.

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