EDUCATION IN THE HUMAN USE OF FLOOD PLAINS

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Aims and Scope

The purposes of this paper are to call attention to some recent developments in the study of the human use of flood plains in the United States and to some new materials which are becoming available. The flood problem of the Kansas River at Topeka and a new flood hazard map for the area are both described. Possible implications for geographic education are suggested.

Relevance to Geographic Concepts

The two main ideas which are generally accepted as dominating themes of geographic study are (1) man's relationship to his physical environment, including his use of natural resources and (2) man's organization of his activities in space. An example is here provided of some of the ways in which one resource (flood plain land) is being used, together with some comments about the arrangement of human activities in relation to it.

Educational Aspects

The use of flood plains as a case study in this connection has several advantages from an educational point of view. The widespread distribution of flood plains means that an example of this resource lies within easy reach of most schools. Some cities with flood problems are shown in Figure 1 and there are undoubtedly others. This enables on-the-spot field observations to be made in an area with which the student is familiar. Aspects of his environment previously unknown to him, or not realized, can be pointed out with advantage and his eyes may be opened to his surroundings in a new and stimulating way.

In the complex problem of man's relationship to his environment, students may gain greater insight by focusing on one element (flood plain land) so that the total number of factors to be considered is greatly reduced. Also the problem of the wise use and management of resources may be illuminated more clearly by emphasis on one resource. In the case of flood plains the interests of various parties (taxpayers, realtors, legislators, home owners, government agencies, and

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1 This paper stems in part from studies supported by Resources for the Future, Inc. The author wishes to thank Gilbert F. White for helpful comments on the draft of the paper.
industrialists) are seen to be sometimes compatible, sometimes at variance.

The Costs of Resource Use

The utilization of most resources is achieved only at some cost. At an elementary level this may be the cost of transporting the resource from the place where it is found to the place where it is used. At another level it may be the cost of developing the resource into a usable state, and of processing into a final product. In the case of flood plains the former cannot be said to apply, while the second may not always be relevant. Certain flood plains may be capable of use without special preparation, although most will require careful handling of such problems as drainage and perhaps bank erosion. There is a special cost resulting from flood plain use which may be quite high at times. This is the cost of damage caused by floods (Fig. 2). Floods are highly irregular both in time of occurrence and in magnitude, and many flood plains are flooded at rare intervals only.

To an individual or group contemplating the use of a flood plain for some purpose, the threat of a flood may seem very remote and unimportant compared with the advantage of using this resource at other times. The advantages may include access to waterborne transportation or the availability of level land for factories, houses, or farms. The low gradient of valley floors is also a well-known factor, inducing their use by highways and railroads which may in turn increase their attractiveness for other purposes.

Evaluating a Resource

Both individuals and groups within a society need to make some evaluation of the advantages and disadvantages of using a given resource. There is evidence to suggest that in the case of flood plains insufficient attention has been paid to this evaluation by the resource users themselves. The flood hazard has often been appraised inaccurately, if at all, and this has led to the development of a vicious cycle in some places.
Although the early pioneers usually seem to have learned to avoid flood plains, and to build their settlements above the danger area, later expansion has moved into the path of floods. When the inevitable flood has exacted its toll, the response of more modern generations has been to attempt to control the floods rather than to withdraw from the flood plain. Protection against the flood hazard, often undertaken on an increasingly lavish scale, has itself acted as a stimulus to the further development of some flood plains. This may be explained in part in terms of the common belief that protection works prevent flood losses. This is not the case. It has proved to be financially impracticable to build protective works such as dams and levees large enough to contain floods of a low order of probability. There will always be a flood which exceeds the magnitude of that discharge for which the flood control works were designed.

**Some Results of Resource Use**

Flood plains have been increasingly used at the cost of expensive protection works and occasional catastrophic flood losses. This pattern of resource use does not appear to have been wise. Indeed in places it amounts to folly. Recent studies have drawn attention to an apparent rise in flood losses in spite of a considerable...
expenditure for flood control. The magnitude of this rise is illustrated in Figure 2. This increase in flood damage has been attributed in part to an actual increase in the number of floods. The larger part of the increase, however, has been caused by "continuing human encroachment upon flood plains." 

Combatting the Rising Trend of Losses

Several ways of arresting the upward trend of flood losses have been suggested. White and others have called for a broader range of choice in making adjustments to flood hazards. In addition to the traditional measures of such engineering works as dams, levees, floodways, and channel improvements, there are other possibilities. The land itself may be elevated and buildings may be flood proofed. In the event of a flood, various emergency measures such as removal of property, flood fighting, and the rescheduling of activities may be undertaken. Public relief is sometimes provided for flood victims; and flood insurance remains for the most part a possibility for the future but awaits further action by the Federal Government. Lastly, and of major importance, the literature on flood plain regulation to control further encroachment is expanding rapidly.

The Chief of Engineers has recently stated that at the present rate of expenditure flood protection will "just about keep up with the increase in flood damage that may be anticipated by 1980 as a result of the flood plain development over the next two decades." In other words, the present program of flood control will only hold flood damages constant while spending about two or three hundred million dollars a year. In the view of the Corps of Engineers there exists "the need for action over the next two decades to regulate flood plain use so as to avoid, to the extent possible, the creation of new flood problems and damages, and to reduce the necessity for Federal expenditure."

Applying the Solution: Some Opportunities for Teachers

The recognition of a problem in resource use and the careful elaboration of its possible solutions is only a first step. There remains the second step which is the task of successfully applying the solution. One aspect of this, upon which it may depend in part, is public education. In this latter connection two developments have recently occurred. First, the United States Geological Survey has started to issue a series of maps depicting flood hazard areas. Second, the United States Congress in its 1960 legislation has charged the Corps of Engineers, for the

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5 White, et al., op. cit., p. 232.
6 The full range of possible adjustments is examined in Gilbert F. White, Human Adjustment to Floods, Department of Geography Research Paper No. 29, University of Chicago, Chicago, 1942.
8 See for example, Francis C. Murphy, Regulating Flood-Plain Development, Department of Geography Research Paper No. 56, University of Chicago, Chicago, 1958.
9 "Floods and Flood Control," Select Committee on National Water Resources, United States Senate, Eighty-Sixth Congress, Second Session, Committee Print No. 15, 1960, p. 29.
10 Ibid., p. 30.
first time, with the responsibility for the collecting and disseminating of flood information.

Taking this second development first, the Flood Control Act of 1960 authorizes the U. S. Army Corps of Engineers to provide information on floods to local interests in view of "the increasing use and development of the flood plains . . . and of the need for information on flood hazards to serve as a guide to such development, and as a basis for avoiding future flood hazards by regulation of use. . . ."12 Here is an opportunity for teachers to take constructive steps towards the creation of an informed public opinion by introducing the topic into the classroom.

The second development, the production of flood hazard maps by the Geological Survey, is directed towards the same general objectives as the new legislation in 1960. In this case a more tangible opportunity is presented to teachers. Here is a tool which can be used in the classroom as well as in the field. The maps are being designed to inform citizens of the nature and degree of the flood hazard. Although they were not drawn with school use specifically in mind, they can be so used with profit. At the time of writing, one such map has been published for Topeka, Kansas,13 and maps for the following areas are in preparation:

<table>
<thead>
<tr>
<th>Flood Hazard Maps</th>
<th>Status of Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Niles, California</td>
<td>Field work underway</td>
</tr>
<tr>
<td>Boulder, Colorado</td>
<td>Open-file report completed;</td>
</tr>
<tr>
<td></td>
<td>Hydrologic Investigations</td>
</tr>
<tr>
<td>Chicago Heights, Illinois</td>
<td>Atlas being prepared</td>
</tr>
<tr>
<td>Des Moines, Iowa</td>
<td>In Publications Division (HA-39)</td>
</tr>
<tr>
<td>Wichita, Kansas</td>
<td>Being processed for publication</td>
</tr>
<tr>
<td></td>
<td>Field work underway</td>
</tr>
</tbody>
</table>


Raritan, New Jersey       Second of a series of four open-file reports completed
Barberton, Ohio           Being processed for publication
Canton, Ohio              Being processed for publication
Chillicothe, Ohio         Being processed for publication
Circleville, Ohio         Being processed for publication
Columbus, Ohio            Being processed for publication
Fremont, Ohio             Being processed for publication
Mount Vernon, Ohio        In Publications Division (HA-40)
Newark, Ohio              In Publications Division (HA-44)
Springfield, Ohio         In Publications Division (HA-43)
Warren, Ohio              Being processed for publication
Youngstown, Ohio          Being processed for publication
Zanesville, Ohio          Being processed for publication
Harrisburg, Pennsylvania  Field work underway
Fairfax County, Virginia  Field work underway
Chattanooga, Tennessee    Field work underway

The remainder of this paper is devoted to a description of the Topeka map, for which some background information is provided, and to its application in two teaching situations.

The Kansas River at Topeka14

Before proceeding to a consideration of the map itself a short summary of the flood history of Topeka is presented. This provides an example of the spatial arrangement of man's activities in relation to the flood plain resource, which can be duplicated by the examination of other cities.

Topeka was founded on the bluffs on the south side of the Kansas River in 1854. If earlier settlements had been es-

established on the flood plain, they were soon abandoned in favour of the elevated site on the bluffs. For the first twelve years Topeka remained a town on the bluffs, but in 1866 railroad connections were established by the construction of the Union Pacific Railroad on the north side of the Kansas River and on the flood plain. From this time on the expansion of Topeka down into the flood plain began, and the town of North Topeka grew up on the north side of the river opposite Topeka, or almost entirely on the flood plain. The beginnings of flood plain development were stimulated further by the completion of the Atchison, Topeka, and Santa Fe line on the south side of the river in 1868. Topeka and North Topeka coalesced into one continuous urban agglomeration, and Topeka extended further onto the flood plain in a downstream direction, into the area now known as Oakland. Since that time the cities of Topeka and North Topeka have both grown and expanded over large areas of flood plain.

These twin cities are subject to floods from the Kansas River and also from its tributaries, Shunganunga Creek on the Topeka side and Soldier Creek on the North Topeka side. There was a major flood in 1908 during which 29 people were drowned and 8,000 persons were forced to leave their homes. Resulting from this flood, levees were constructed which mitigated the high stages of 1908 and 1935. In 1951, however, these levees were overtopped by several feet of water, and in North Topeka many buildings were flooded to the ceiling of the first story. The main current of the stream moved from its normal course and flowed through the city causing severe damage. Parts of the tributary flood plains of Shunganunga and Soldier Creeks were also flooded.

A plan for flood control on the Kansas River was drawn up by the Corps of Engineers in 1950 and is now in the process of installation. The plan encompasses a number of reservoirs upstream in the tributaries of the Kansas River, including Tuttle Creek Reservoir on the Big Blue River. When this plan is fully in operation it is estimated that full protection against floods of the magnitude of the 1951 flood will have been secured. Until that time Topeka is open to a repetition of the 1951 flood. Even when the project is finished, however, complete immunity from flood will not have been won. An unrecorded flood of 1844 is estimated from Indian references to have exceeded the 1951 flood by six feet.

In addition to the protection afforded by the Corps of Engineers project, the South Topeka Drainage District has constructed two small flood control reservoirs on the branches of Shunganunga Creek, south of the city.

Since the 1951 flood, development in the flood plain of the Kansas River seems to have been slowed considerably, but a new development is proceeding rapidly in the Shunganunga flood plain.

The Topeka Map

Into this situation of floods, flood control, and flood plain development, the United States Geological Survey has injected a map of flood hazard. Such a map may be a real contribution to the amelioration of the flood problem. In addition to the engineering works under construction, it may help in the development of other approaches to flood loss reduction.

The publication of this map rests on the need to make more accurate knowledge available to those responsible for de-

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16 House Document No. 642, 81st Congress, Second Session. Information on flood control projects and copies of documents can usually be obtained from the local District Office of the U. S. Army Corps of Engineers. Alternatively, write to the U. S. Army Corps of Engineers, Washington 25, D.C.

17 See Roder, op. cit.
Fig. 3. Organization and layout of the Topeka Flood Hazard Map.

Decisions on how to use the Kansas River flood plain. If there is public awareness of the problem and the possible approaches to it, full use is more likely to be made of the knowledge now readily available. An incidental benefit from the use of the Topeka flood hazard map in the classroom may be an increased public awareness. It is for this reason, as well as for the more direct educational benefits, that the map is now described in some detail and suggestions made for its use.

The familiar style of topographic quadrangle on the scale of 1:24,000 has been issued with a flood hazard over-print. The Kansas River is shown in dark blue, flowing from west to east across the center of the quadrangle, and the cities of Topeka and North Topeka are located on either side. A large belt of land about two and a half miles wide is colored in light blue and extends across the map on both the north and south sides of the river, dramatically portraying the extent of the 1951 flood. Within this area the smaller extent of the 1935 flood is also shown.

An explanatory text, together with three diagrams and an oblique aerial photograph, appears alongside of the map on the same sheet. The layout and organization of this sheet is illustrated in diagrammatic form in Figure 3. Each of these items is described below.

The Features of the Map

In addition to the river and its flood plain a variety of other physical features are shown. The river meanders between
clearly marked levees which are seen to have been effective in 1935 but not in 1951. The tributary Soldier Creek is a good example of a yazoo stream on a rather small scale, which has been straightened and placed between levees in the course of the human development of the flood plain. Old meander loops and cut-offs mark the former course of the creek. The strong contrast in drainage patterns between the flood plain and the upland areas to the north and south is paralleled by the contrast in relief. The relatively level flood plain offers a markedly different environment for man’s activities from the flanking upland dissected by tributary streams.

Many features of the cultural landscape are shown and can be related to the physical features in some cases. The early site of Topeka, marked by the State Capitol, the City Hall, and other public buildings, is located on the upland bluffs overlooking the flood plain. The utilization of the flood plain by industrial development is seen in several large buildings, and the lines of the Union Pacific and Santa Fe railroads, which served as a stimulus to flood plain development in earlier days, can be seen following the gentle gradient of the valley floor. More recent use of the flood plain by transportation facilities is indicated by the location of the Topeka Municipal Airport at the eastern border of the map.

Students can learn to recognize these features as portrayed on the map and to relate them one to another. The other items on the same sheet give this map an added advantage.

**Supplementary Material**

The printing of an oblique aerial photograph alongside of the map enables a ready comparison to be made between these two methods of portraying an area. Many of the features observed on the map can be recognized on the photograph. A simple test of the student’s understanding of the map and ability to relate it to the photograph is to ask from approximately what point the photograph was taken. Buildings marked on the map but not identified can be described by relating information from photograph to map. An example of this is the grain elevators in North Topeka.

The three diagrams printed above the photograph also have educational value. One graph shows the flood history of Topeka from 1900. Once understood, this illustrates with great clarity the unpredictable nature of floods both in time of occurrence and in magnitude. Accurate information about past floods does not enable us to say when the next flood will come or how large it will be. The gaging station at which most of these records were obtained is marked on the map at the Topeka Avenue bridge. The relative heights of the 1903, 1935, and 1951 floods can be compared with each other and with the smaller and more numerous floods.

The second graph presents a stage frequency curve which can be used to estimate the frequency of occurrence of past and future floods. The 1951 type of flood is likely to occur once in every 120 years, while the 1935 type of flood has an average frequency of once in about every 15 years. This information needs to be used with caution in order to avoid misinterpretation. The fact that a large flood took place as recently as 1951 does not necessarily mean that a long interval must elapse before the next major flood. If a coin is tossed and caught in the hand there is a fifty per cent chance that it will

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8 Information on local gaging stations can be found in the Water Supply Papers of the U.S. Geological Survey or from the District Office, which is usually located in the state capital. A visit to a gaging station can be included in a flood plain field trip, and the Geological Survey may be able to put teachers in touch with a person who will open the gage house and explain how it operates. Further information can be obtained from the U.S. Geological Survey, Washington 25, D.C.
"come down heads." When it is tossed a second, third, or any number of subsequent times, the chance of "coming down heads" is still fifty per cent. The result is in no way influenced by the outcome of the previous toss. The history of flood events may be used as an excellent illustration of this principle.

The third item on the sheet is a diagram illustrating the flood profiles for various stages or heights of water in the river. By relating the elevations on the profiles to the heights above mean sea level shown on the map, it is possible to estimate the approximate height of the water at various points on the map. For example the height of the water at the junction of Central Avenue and Kansas Avenue in North Topeka, slightly down stream from the gage, was about 893 feet in 1951. The elevation of this point shown on the map is 878 feet above sea level. By subtraction we obtain a height of about 15 feet above street level at this place. The calculation of water heights for various points during successive floods is a useful exercise for students with more than average ability. However an elevation of water higher than the land at some point does not necessarily mean that the point was flooded because in most cases it is clear that the levees have been effective in holding the flood waters.

Use of the Topeka Map

The map has been used twice in teaching situations, at both high school and college levels. In the high school, success can be described as moderate at best.\(^9\) The reasons for this can only be guessed. The class was composed entirely of high school girls, mostly seniors. Perhaps girls tend to be less interested in this type of problem than boys. Other reasons may have been: (1) the method of presenting the material was too technical, (2) the students may not have been sufficiently familiar with the usual type of topographic map, or, (3) perhaps Topeka is just too far away from Chicago for the map to be sufficiently interesting.

It seems possible, therefore, that the use of this map at the high school level would be more successful if the presentation would be made more dramatic and, at least at the outset, less technical. One good device may be to introduce students to the ordinary topographic quadrangle before showing them the flood hazard map. More interest may also be stimulated by relating the Topeka map to a local flood problem. Moreover the use of the map with only one class does not invalidate or validate its use.

At the undergraduate level a relatively technical presentation was highly successful and led to an investigation of the flood problem in the local area.\(^9\) The map was invaluable as an introduction to flood problems. Its relatively simple and straightforward presentation of information about the nature of the flood hazard was stimulating to the class. The map itself would have been of much less use without the supporting text, a photograph, diagrams, and the historical information about the growth of the city, and its expansion down into the flood plain. Students were provided with information about the development of protective works of the Kansas River flood plain, and came to an understanding of some of the complexities involved in the human use of flood plains.

The Little Calumet Study

Having become familiar with the national flood problem as described in the early part of this paper, and knowing something about the example of Topeka, students were then exposed to a flood problem in the local area. A field excurs-

\(^9\) At the Faulkner School for Girls, Chicago, 1959.
sion was made to parts of the flood plain of the Little Calumet River, in the vicinity of Gary, Indiana. Levees were examined, and residents of the area were interviewed. A stream gaging station was visited and an explanation given of its mode of operation.

The flood hazard on the Little Calumet flood plain contrasts sharply in some respects with that portrayed on the Topeka map, but the same general principles apply and students soon learned to transfer them to the new situation.

In addition to field observation and interview, documentary sources of information were consulted, and students were required to write a report on the study. The contents of these reports and the spirit in which they were written were most encouraging. Students showed an awareness of the problem; they were genuinely concerned about it, and several of them stated without any solicitation that the concern and awareness were entirely new to them. One older student described how he had intended to purchase a new house on the flood plain, but was now determined to look elsewhere. His wife stated that she was definitely "not prepared to add flood damages to the budget"!

Conclusions

A new series of flood hazard maps is being issued by the Geological Survey. These maps present opportunities to teachers on the high school and college level to introduce an interesting topic to their students in a dramatic and stimulating fashion. If used with care they can provide students with new insights into their own local environment and be an object lesson in man's use of his resources, as well as in the organization of his activities in relation to those resources.

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23 Information was supplied by the U. S. Army Corps of Engineers, Chicago District; by the Purdue-Calumet Development Foundation; and by the Indiana Flood Control and Water Resources Commission.