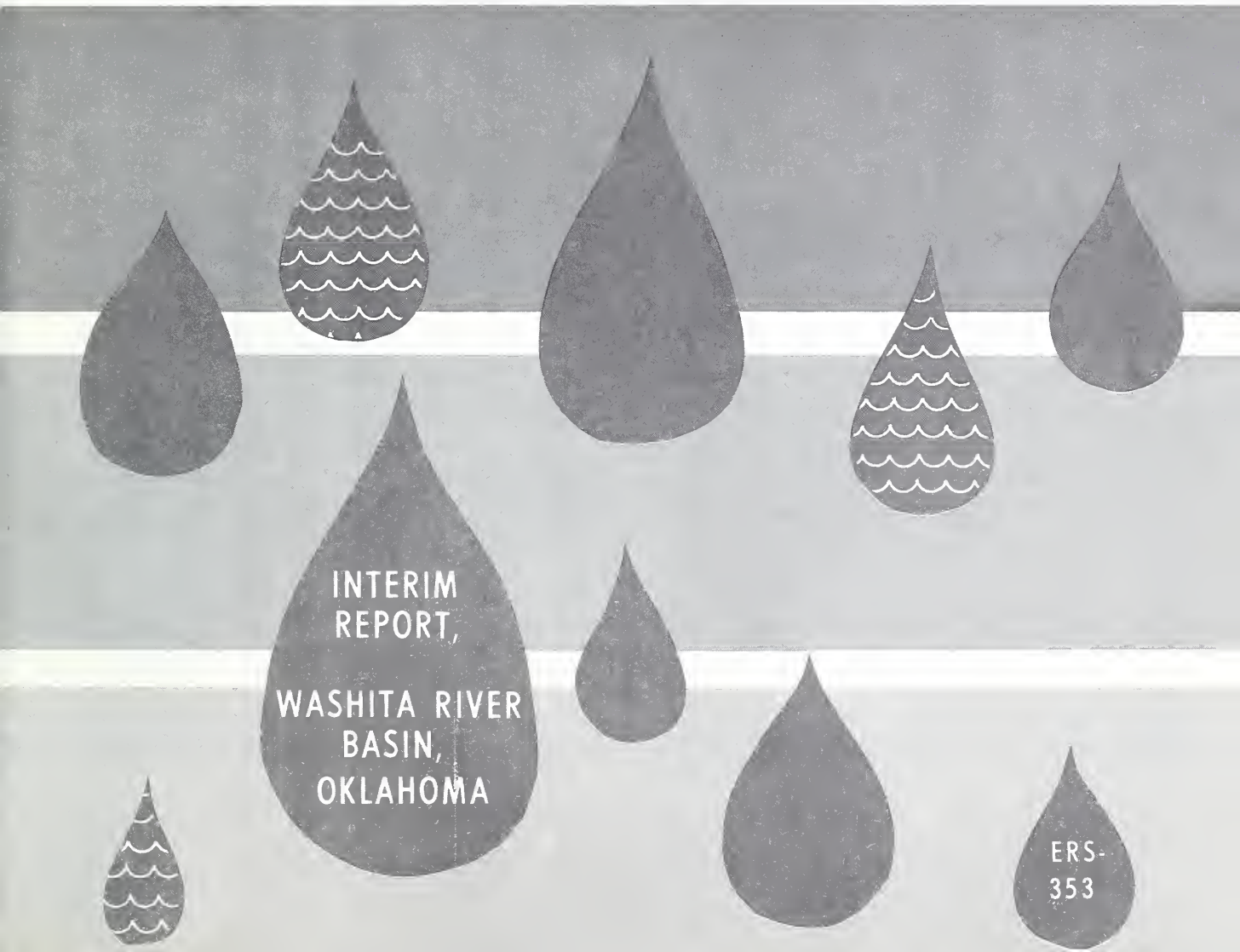
U.S. DEPARTMENT OF AGRICULTURE

ECONOMIC RESEARCH SERVICE

Evaluating FLOOD PREVENTION in Upstream Watersheds With an AREAL POINT SAMPLE--



PREFACE

A laboratory-type study of the economic effects of the installed upstream watershed program is being conducted by the Economic Research Service at the Department of Agricultural Economics, Oklahoma State University, at Stillwater. This continuing appraisal is part of a larger program of investigations of watershed protection and flood prevention being carried out through an agreement between the Economic Research Service and the Soil Conservation Service.

This interim report describes progress achieved to January 1, 1967, toward evaluating the major economic benefits of flood prevention in small watersheds. The report is limited to data collected in 1964-65. No definitive conclusions are drawn because (1) data for only 2 years have been collected and analyzed, and (2) the results reported herein are limited in geographic scope to 11 watersheds in the central portion of the Washita Basin. The major purpose of this report is to acquaint interested persons with the methodology and procedures in use and the kind of analysis to be performed. Similar techniques could be used for estimating flood damages and the major economic effects of resource development projects in other areas.

This study was planned for the period 1964-68. However, in 1965, the study area was enlarged to include a sample of planned watersheds in the Arkansas-White-Red Water Resource Regions, and a 1966-70 evaluation period was selected for the enlarged study.

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July 1967

SUMMARY

This interim report discusses the use of an areal point sampling technique in estimating the major economic effects of flood prevention in small, upstream watersheds. Data obtained from the areal point sample are also used to develop crop damage factors for use in future watershed planning.

USDA's Economic Research Service began this study in 1964, with an areal sample of 446 points. Twenty-seven of the points fell on stream channels, lakes, or farm ponds. The remaining 419 are used to represent 67,040 acres of floodplain land in 11 watersheds in the central Washita River Basin, Oklahoma. Some preliminary results of the study are given in this report.

The major crops on the floodplain are alfalfa, wheat, improved pasture, and cotton. Alfalfa production seems to be increasing on the protected floodplain. In 1964, fertilizers were applied to only 30 percent of the crops and pastures in the floodplain. The researchers plan to collect data on changes in fertilizer use again at the end of the study, in 1970.

Point sample estimates of flooding were only 320 acres in 1964, although flooding estimated by using the hydrologic procedures developed at the time the projects were planned would have been 14,300 acres. In 1965, the point sample data indicated more than 14,680 acres were flooded in the study area. This could not be compared with flooding estimated by using hydrologic planning procedures, as a major storm in 1965 exceeded the range of the data considered in developing the watershed work plans. However, point sample estimates of acreage flooded in 1965 closely approximated estimates made for a part of the area by the Agricultural Research Service from aerial photographs taken during the floods.

The data obtained from the areal point sample indicated no crop and pasture damages from flooding in 1964, but in 1965 these damages totaled $146,427 or $9.97 per acre inundated. The cotton crop sustained 27 percent of all crop and pasture damage in 1965, although it occupied only 6 percent of all the land inundated. Average annual crop and pasture damages estimated at the time the watershed projects were planned, adjusted for the present level of protection, are $9.11 per acre. However, in 1964-65, the crop and pasture damages determined from the point sample average only $1.09 per floodplain acre.

The 259 observations of flood damage to crops and pastures in September 1965 showed in most cases the general trend of increased damages with increases in depths of flooding. As more information for individual crops and for other months is assembled during the remainder of this study, it will be possible to combine it with damage factors presently in use, thereby improving estimates for use in planning future watershed projects.

The study area was enlarged in 1966, to include 2,225 additional sample points representing an additional 356,000 acres of floodplain. These points are located within a stratified sample of planned watersheds in the Arkansas-White-Red Water Resource Regions. The results from this enlarged study will have more general applicability and greater statistical accuracy. The study is scheduled to be completed in 1970.

EVALUATING FLOOD PREVENTION IN UPSTREAM WATERSHEDS WITH AN AREAL POINT SAMPLE--INTERIM REPORT, WASHITA RIVER BASIN, OKLAHOMA

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INTRODUCTION

Local, regional, and national planners of resource development can make more efficient allocations of public funds among competing uses if the actual effects of flood protection are known. Existing and future projects can be revised for greater efficiency as more knowledge is gained about hydrologic and economic relationships that are and have been occurring.

The Economic Research Service is conducting a study of the major land-based effects of the upstream watershed program in the Washita River Basin, Oklahoma. The land-based effects being investigated include (1) reduction in crop and pasture damage, (2) changes in land use and intensity, (3) reduction in sediment accumulation, (4) irrigation from floodwater detention structures, and (5) increased productivity from drainage. The study began in 1964. Some preliminary findings are reported here.

The general objectives of the study are to measure the major land-based economic effects of upstream watershed projects and to estimate the relationships between (1) flood characteristics and (2) yields and net income from crops and pastures. Specifically, the objectives are to estimate:

(1) Reduction in crop and pasture damages as a result of upstream flood protection structures;
(2) Benefits from irrigation and drainage on floodplain land stemming from upstream flood protection projects;
(3) Changes in land use and intensity of use as a result of flood protection;
(4) Other important land-based economic benefits of upstream flood protection projects; and
(5) Relationships between flood characteristics and amount or rate of damage to crops and pastures.

Purposes of this Report

This report presents the progress to date on the study. The methodology and procedures are described, and the results of 2 years' study in 11 watersheds of the Washita Basin of Oklahoma are given. Crop and pasture damages, changes in land use and intensity, and relationships between flood

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characteristics and crop and pasture damages are included in this report. Revisions in the study, undertaken after 2 years' work, are presented in the latter part of the report.

The primary data for this study are being obtained by interviewing the farm operators of sample locations within the floodplain of 11 watersheds in the central Washita River Basin. The sample locations for the study were selected by a systematic, stratified, unaligned sample of points. The point sampling procedure is described in detail in Agriculture Handbook No. 237. 2/ As this procedure is comparatively new, a secondary purpose of this report is to describe its use in an actual field investigation.

The Study Area

In 1964, 11 watersheds in the Washita Basin of Oklahoma were defined as the study area. Figure 1 shows the location of the 11 watersheds in the Washita Basin and figure 2 shows the boundaries of the watersheds. The study area is defined as the floodplain (usually the area expected to be inundated by a flood once in 20-25 years) of the 11 watersheds and main stem of the Washita River that is contiguous to these watersheds. In total, there are an estimated 67,040 acres of floodplain.

USDA's Agricultural Research Service is studying the physical effects of flood protection in the same 11 watersheds included in this study. The instrumentation installed for the ARS study facilitates linking hydrologic events with economic effects.

METHODOLOGY

Sampling Units

Whole farms as sample units were rejected in favor of an areal point sample of floodplain land. A more objective measurement of the benefits of flood protection can be made if the focus is on the original point of impact--the floodplain land. If whole farms are used as sample units, other factors affecting size, tenure, and management of the sample units unduly complicate the analysis. Advantages of the areal point sample are:

(1) Errors in measurement of flood magnitude, crop yields, flood damages, and other related variables can be reduced;
(2) Statistical confidence limits can be placed on estimates of floodplain attributes; and
(3) The point sample data are easily stored, manipulated, and analyzed by data processing machines.

2/ Berry, Brian J. L. Sampling, Coding, and Storing Floodplain Data. U. S. Dept. Agr. Handb. 237, 27 pp. 1962.

WASHITA RIVER BASIN AND STUDY AREA, OKLAHOMA

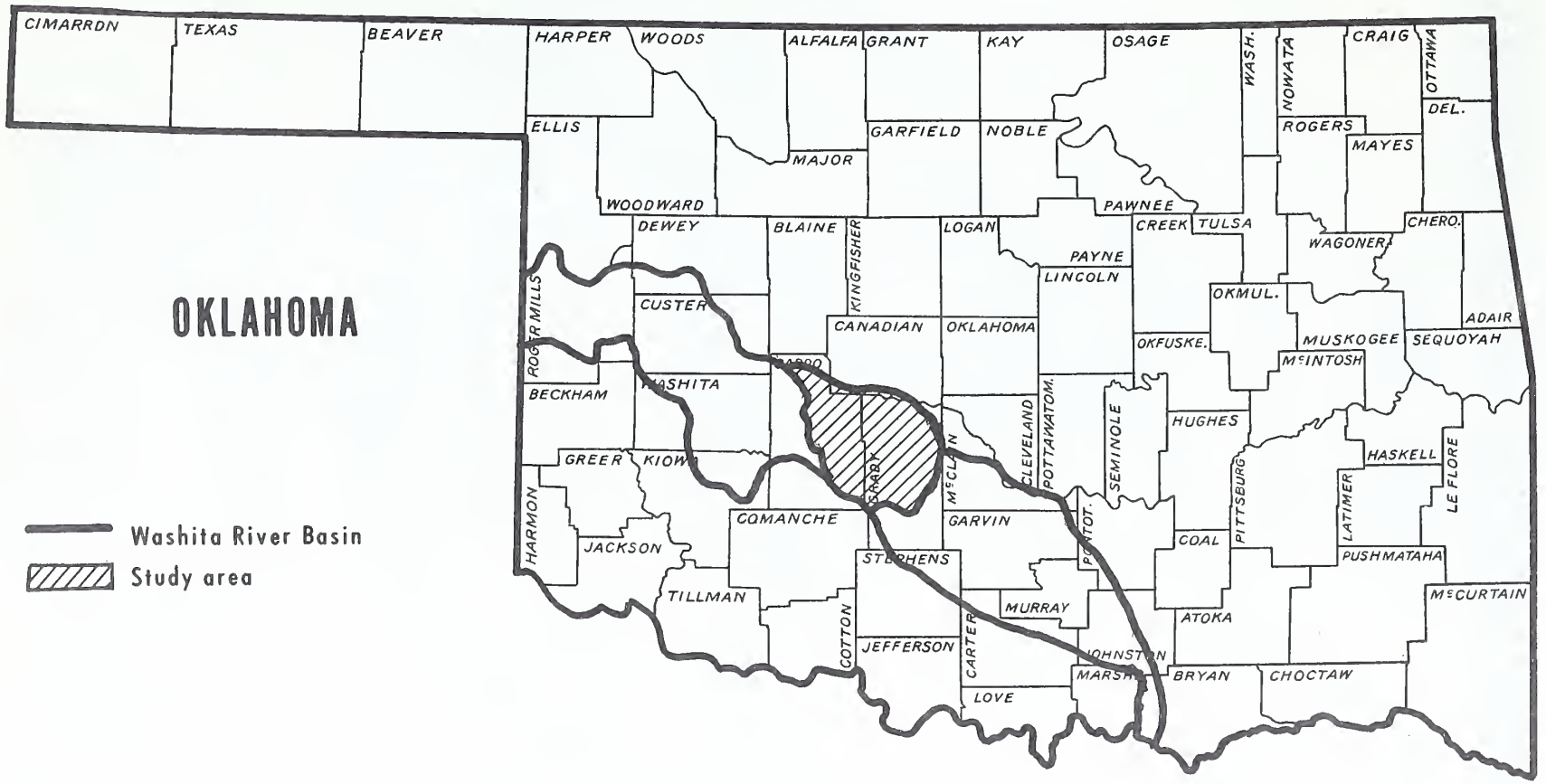
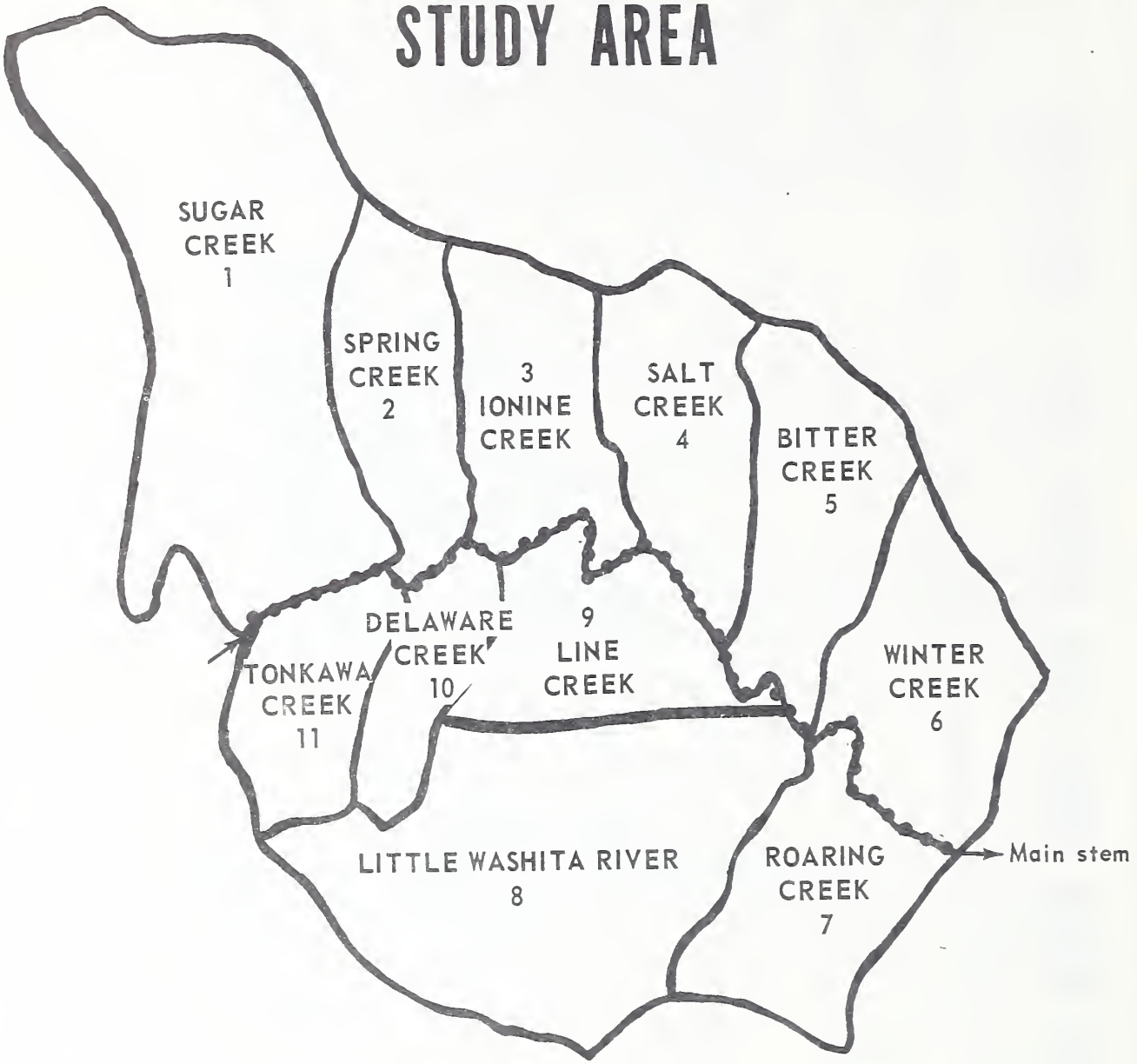


Figure 1

SUBWATERSHEDS IN OKLAHOMA STUDY AREA



Subwatersheds in Study Area

1-Sugar Creek
2-Spring Creek
3-Ionine Creek
4-Salt Creek
5-Bitter Creek
6-Winter Creek
7-Roaring Creek
8-Little Washita River
9-Line Creek
10-Delaware Creek
11-Tonkawa Creek

Figure 2

The sample unit is a point on the floodplain. To ascertain any physical attribute of the point, the sample unit is defined as the area surrounding the point that is uniform with respect to the physical attribute being measured.

Sampling Scheme

A systematic, stratified, unaligned sample of points was used. It was concluded in an earlier study that this sampling scheme could be up to 5 times more efficient than a simple random sample of points. 3/

The appropriate sampling rate, which fixes the sample size, n, is derived by assuming a simple random sample of points. This assumption is necessary because the frequency distribution of p, the proportion of floodplain with a particular attribute, is not known except for simple random samples. Using this assumption, n should be equal to or larger than that needed to obtain a specified degree of accuracy by the more efficient sampling scheme. Arbitrarily, it was decided to use a sample large enough that the probability was 0.95 that the estimate of p would not be in error more than 5 percentage points. The sample number so determined was 384. At a sampling rate of 1 point per quarter section, the final sample size was 446. 4/ This constitutes the prime sample. 5/

In addition a secondary sample of 1 point per 40 acres was drawn which includes the prime sample. This rate of sampling is being used on floodplains where flooding occurs in the year preceding the observation. The secondary sample is necessary to obtain sufficient information for a statistical analysis of the relationship between specific floods and flood damages to specific crops.

PROCEDURE

Floodplain boundaries were transferred to aerial photos of the bottomland within the 11 watersheds in the Washita Basin. Sample points were then selected and marked on the photos for identification in the field. For crop year 1964, operators of land on which sample points fell were interviewed and a schedule was filled out (see form in appendix). In 1968, another survey of the prime sample will be completed. Secondary sample points in areas where there has been flooding the previous year are being surveyed annually during the study period.

Additional information on the sample points was secured from the Agricultural Research Service at Chickasha, Okla., and from the files of the Flood Prevention Office of the Soil Conservation Service, Chickasha.

3/ Ibid., p. 8.

4/ 27 points were on stream channels, lakes, or farm ponds. The remaining 419 points on floodplain land represent the 67,040-acre study area discussed in this report.

5/ For more details of determining sample size, see appendix.

Information from the schedules was transferred to punch cards for ease of handling and compact storage. General information on the farms, and other information including land use, was tabulated and summarized with a computer. Information gathered on flooding was handled in the same manner.

CHARACTERISTICS OF FARMS IN THE STUDY AREA

The characteristics of farms on which sample points fell give a general indication of agriculture in the study area. Four farm types were identified according to their major source of income: (1) Cash crop farms--including, in order of importance, alfalfa, wheat, cotton, peanuts, and broomcorn, (2) livestock farms, (3) dairy farms, and (4) general farms (table 1).

Table 1.--Farm types in the bottomlands of the Central Washita River Basin of Oklahoma, 1964

Farm type	Number of farms	Proportion of total farms
		Percent
Cash crop	102	35.1
Livestock	53	18.2
Dairy	28	9.6
General	108	37.1
Total	291	100.0

Farm sizes in the area ranged from 40 to 5,000 acres. The average farm size was 634 acres. The distribution of land resources on farms in the study area is given in table 2.

The proportions of arable land on floodplain and on other bottomland are almost the same--81 percent and 82 percent, respectively. Floodplain land is a significant resource on these 291 farms since 42 percent of their arable land is floodplain.

POINT SAMPLE ESTIMATES OF LAND USE, FLOODING, AND DAMAGES

Floodplain Land Use and Intensity

Alfalfa and wheat are the principal floodplain crops (table 3). More than 15 percent of the floodplain is improved pasture, primarily Bermudagrass. The amount of land devoted to farmsteads is small because most of the farmsteads for the 291 farms represented are located on upland.

Table 2.--Distribution of agricultural land resources of farms sampled in the study area, 1964

Type of land	Area of land by type	Proportion of land	
		Arable	Nonarable
	Acres	Percent	Percent
Bottomland:			
Floodplain 1/	84,552	81	19
Other bottom	49,131	82	18
Total bottomland	133,683	81	19
Upland	164,970	26	74
Total land	298,653	50	50

1/ Floodplain acreage used here is the farmers' estimate of number of acres on which they believed there was a threat of flooding.

Fertilizer use is one measure of land use intensity (table 4). About 30 percent of the crops and pastures on the floodplain were fertilized.

Changes in Floodplain Land Use

To measure changes in land use, it was necessary to obtain data from other sources. The Agricultural Research Service made an inventory of land use in this area in 1962. Its land use inventory map was overlaid with the point sample used in this study. Land uses estimated in this manner are presented in table 5. 6/

The purpose of the ARS land use inventory was to estimate rainfall-runoff relationships. Hence, the categories are broader than those required for calculating benefits from changes in land use. 7/

Comparisons between the 1962 and 1964 land use can be made by combining land use categories (table 6). The changes indicated are within the 95-percent confidence interval estimates, so they may be due to sampling error.

6/ The ARS inventory could not be used directly because it did not distinguish the floodplain from other land.

7/ Data were collected for the ARS study by flying over the area and recording the land use on aerial photographs.

Table 3.--Floodplain land use in the Central Washita River Basin, 1964

Land Use	Area 1/	Proportion of total area
	Acres	Percent
Alfalfa	14,720	22.0
Wheat	13,280	19.8
Cotton	2,720	4.2
Peanuts	1,120	1.7
Broomcorn	1,120	1.7
Barley	2,080	3.1
Oats	800	1.2
Sorghum	2,400	3.6
Hay	2,080	3.1
Temporary pasture	2,080	3.1
Improved pasture	10,240	15.3
Other pasture	5,760	8.6
Government programs	2,560	3.8
Farmstead	160	3/
Idle	800	1.2
Waste 2/	4,320	6.4
No response	800	1.2
Total	67,040	100.0

1/ Area determined by multiplying number of observations (sample points) times the 160 acres represented by each observation.

2/ Does not include 24 observations which were in creek or river channels and 3 observations on lakes or farm ponds.

3/ Less than 0.05 percent.

Comparisons between land use changes on protected and unprotected floodplain are shown in tables 7 and 8. The protected floodplain is in Sugar Creek and Roaring Creek Watersheds. Neither of these creeks was protected in 1962, but both were about half completed in 1964. It appears that alfalfa acreage is increasing on the floodplain of the protected watersheds (table 7) and decreasing on the floodplain of the unprotected watersheds (table 8). As noted earlier, however, the sample number is smaller for subareas of the study area; thus the 95-percent confidence limits on the estimates are wider, and the apparent difference may be due to sampling error.

Flooding

Flooding in the area is estimated by multiplying the number of points inundated by the number of acres represented by each point--40 acres in this case. Point sample estimates of the acres flooded in 1964 and 1965 are given in table 9. In 1964, only one watershed was flooded, and in 1965 three of the 11 watersheds and the main stem were flooded.

Table 4.--Fertilizer use in the floodplain of the Central Washita River Basin, 1964

Crop	Proportion of total crop fertilized	Area fertilized	Average application per acre		
			N	P	K
	Percent	Acres	Lb.	Lb.	Lb.
Alfalfa	30.4	4,480	14	33	20
Wheat	61.4	8,160	37	27	8
Cotton	11.8	320	8	30	15
Peanuts	42.9	480	16	42	37
Broomcorn	14.3	160	10	20	10
Barley	53.8	1,120	20	23	9
Sorghum	40.0	960	20	14	19
Hay	30.8	640	22	30	7
Temporary pasture	30.8	640	15	40	2
Improved pasture	14.1	1,440	20	21	12
Total acres fertilized	---	18,400	--	--	--
Pounds used per fertilized acre 1/	---	---	26	28	13

1/ Weighted by acres in each crop.

Table 5.--Floodplain land use in the Central Washita River Basin, 1962

Land use	Area 1/	Proportion of total area
	Acres	Percent
Alfalfa	15,680	23.4
Row crops	8,480	12.6
Sowed crops	19,360	28.9
Pasture	15,200	22.7
Waste	3,520	5.5
Farmstead	160	2/
Not available	4,640	6.9
Total	67,040	100.0

1/ Area determined by multiplying number of observation (sample points) by the 160 acres represented by each observation.

2/ Less than 0.05 percent.

Table 6.--Change in floodplain land use in the Central Washita River Basin, 1962 and 1964

Land use 1/	1962	1964	Difference
	Percent	Percent	Percentage points
Alfalfa	23.4	22.0	-1.4
Row crops	12.6	11.0	-1.6
Sowed crops	28.9	28.6	- .3
Other	35.1	38.4	3.3
Total	100.0	100.0	0.0

1/ 419 observations (sample points).

Table 7.--Protected floodplain land use in the Central Washita River Basin, 1962 and 1964

Land use 1/	1962	1964	Difference
	Percent	Percent	Percentage points
Alfalfa	16.8	20.6	3.8
Row crops	20.6	20.6	0.0
Sowed crops	29.9	24.2	-5.7
Other	32.7	34.6	1.9
Total	100.0	100.0	0.0

1/ 107 observations (sample points).

The Agricultural Research Service estimated the area flooded in 1965 from aerial photos taken during the floods in two separate reaches in the study area (cited in footnote 12). One reach was a portion of Sugar Creek in which 3,410 acres were estimated to have flooded. The other reach was on the main stem and 2,320 acres flooded. The point sample estimates in these same reaches are 3,600 and 2,400 acres, respectively. Considering the small number of sample points, less than 100 in each case, the point sample procedure appears to be a reasonably good method of estimating area flooded.

Table 8.--Unprotected floodplain land use in the Central Washita River Basin, 1962 and 1964

Land use 1/	1962	1964	Difference
	Percent	Percent	Percentage points
Alfalfa	25.4	22.2	-3.2
Row crops	9.9	7.6	-2.3
Sowed crops	28.2	29.8	1.6
Other	36.5	40.4	3.9
Total	100.0	100.0	0.0

1/ 312 observations (sample points).

Table 9.--Point sample estimates of flooding in the Central Washita River Basin, 1964 and 1965

Watershed	1964	1965
	Acres	Acres
Bitter Creek	0	400
Line Creek	320	280
Little Washita River	0	0
Sugar Creek	0	1/ 9,320
Main stem	0	4,680
Total	320	14,680

1/ Excluding White Bread Creek (tributary).

At the time of planning the total watershed program, relationships between rainfall, runoff, and land inundated were developed for conditions both preceding and following the installation of improvements. For any particular storm, the final estimate of land inundated is subject to large error because many factors are not accounted for in developing these average relationships. For instance, in 1964, the above relationships indicate that

14,300 acres would have been flooded in Sugar Creek compared with the point sample estimate of zero flooding (table 9). 8/

Using similar relationships, the expected flooding in 1965 would have inundated 2,600 acres in Bitter Creek and 675 acres in Little Washita River. Since Line Creek has not been planned yet, no estimate of expected flooding could be made. No estimate of the land inundated in Sugar Creek in 1965 was made because the 1965 flood was caused by a rain which in many places exceeded the maximum rain considered during planning and only part of the planned water detention structures were in place. However, following the 1965 flood, the Soil Conservation Service estimated that the area flooded in Sugar Creek was 10,410 acres. 9/

In the planning process, estimates of flood damages depend on depth of flooding and the season of the year. Since this relationship, as well as the relationships mentioned earlier, is subject to error, the final estimate of flood damages to be expected from a specific storm is subject to a rather large error. If bias exists at any stage of the planning process, the overall benefits of the watershed program may be seriously distorted. The point sample method of evaluating damages from each storm can be used to check for bias in at least two stages of the planning process--the estimate of acres inundated and the estimate of damages per acre inundated. However, many more observation of storms and subsequent flooding than are presented here are required to arrive at a firm conclusion.

The hydrologic relationships developed at the time of planning are not intended to predict the area flooded for each particular storm. Rather, they are intended to predict total flooding by depth increment during the evaluation period (20 to 25 years usually). However, estimates of the total are derived by summing estimates for individual storms. The important point is to determine whether there is a bias, and if so, whether it is consistently upward or downward.

Crop and Pasture Damage

There was no crop and pasture damage from flooding in 1964. In 1965, crop and pasture damage was estimated to be $146,427. 10/ The distribution of damage by area is shown in table 10. Average annual damages to crops and pasture in 1964 and 1965 were $1.09 per floodplain acre.

Per acre damage on the main stem was lower than on Sugar Creek because there is a lower per acre damageable value on the main stem. No conclusion

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8/ This estimate includes 3 separate potential flood producing rains, and assumes that all planned structures are in place and that normal antecedent soil moisture conditions prevailed.

9/ White Bread Creek, a tributary to Sugar Creek, is excluded from the estimate because it was inadvertently excluded from the point sample estimate.

10/ Unit prices and yields used in computing crop and pasture damages are

was drawn about the low damage per acre on Bitter Creek because of the small amount of flooding.

Table 10.--Crop and pasture damage in the Central Washita River Basin, 1965

Watershed	Crop and pasture damage	
	Total watershed	Per acre flooded
	Dollars	Dollars
Bitter Creek	353	0.88
Line Creek 1/	0	0
Main stem	24,668	5.27
Sugar Creek	121,406	2/ 13.02
Total	146,427	9.97

1/ No damage was reported.

2/ This compares with an estimate of $11.21 crop and pasture damage per acre made by the Soil Conservation Service. Special Storm Report--Storms of September 19 and 20, 1965--Sugar Creek Watershed, Oklahoma--Tributary of the Washita River. 19 pp., illus. U.S. Soil Conserv. Serv., Stillwater, Okla., Feb. 1966.

Average annual crop and pasture damage as estimated in the watershed work plans and the degree of protection provided by completed floodwater retarding structures are shown in table 11. The estimated adjusted average annual damage for planned watersheds in the study area is $417,400 or $9.11 per acre of flood plain. 11/ This is $270,973 more than the observed damage on these seven watersheds in 1965. One reason for the difference is the less than normal rainfall in the study area. 12/ In only one case, Sugar Creek, did the observed crop and pasture damage exceed the adjusted average annual damages. Probably this is partly because rainfall which caused the flood exceeded the

11/ Average annual damage is adjusted by multiplying the percentage of drainage area planned to be controlled by not yet controlled times the difference between the damage before and after the project and adding the product to the estimated average annual damage with the project installed. For example, Roaring Creek would be: [100.0% - 37.8% ($59.4 thousand - $12.7 thousand)] + $12.7 thousand = $41.7 thousand.

12/ A 20- or 25-year series of rainfall observations is often the "normal" rainfall information used in preparing watershed work plans. Average annual rainfall at Chickasha, near the center of the study area, is 31.60 inches (1931-60 average) but in 1965 it was only 26.72 inches. The range over the entire study area in 1965 was 37.72 inches to 19.72 inches. Source: Washita River Watershed, Southern Plains Hydrology Research Center, 1965 Annual Research Report. Agr. Res. Serv., U. S. Dept. Agr., Chickasha, Okla., p. 3c.

Table 11.--Work plan estimates of annual crop and pasture damage for selected watersheds in the Central Washita River Basin

Watershed 1/	Without project	With project and land treatment	Proportion of planned drainage area controlled 2/	Adjusted average annual damage 3/
	1,000 dollars	1,000 dollars	Percent	1,000 dollars
Bitter Creek 4/	74.0	12.7	0	74.0
Ionine	29.9	3.4	0	29.9
Little Washita River 4/	118.5	9.7	0	118.5
Roaring Creek	59.4	12.7	37.8	41.7
Sugar Creek	164.1	80.5	58.9	114.9
Tonkawa Creek	26.6	3.4	0	26.6
Winter Creek	27.5	3.5	65.4	11.8
Total	500.0	125.9	---	417.4

1/ No work plan has been made on Delaware, Line, Salt, or Spring Creeks.
2/ Ratio of drainage area controlled on December 31, 1965, to drainage area to be controlled when project installation is complete.
3/ See text footnote 11.
4/ New work plans are in progress.

largest rainfall evaluated in the planning process. 13/ In individual watersheds or small areas, the difference between year-to-year observed damage and average annual damage should not be alarming since no year is "average."

Individual Crop and Pasture Damage

Refining estimates of damages to individual crops and pastures is a secondary objective of this study. Table 12 shows land use on the acres flooded in 1965 and floodwater damages for each use category. The importance of some of the "minor" crops in evaluating crop and pasture damage reduction

13/ The difference may also be due to the different estimating procedures used. The Soil Conservation Service used projected prices and damage factors (see next section) whereas this report used present prices and on-the-spot estimates of physical damage (141 farm operators reporting).

benefits is illustrated by the fact that floodwater damage to cotton represents 27.2 percent of the total damage, although cotton occupied only 6 percent of the flooded area.

Table 12.--Land use and individual crop and pasture damage, 1965

Land use	Area	Proportion of area inundated	Damage		
			Total	Proportion of total for study area	Per acre of land inundated
	Acres	Percent	Dollars	Percent	Dollars
Alfalfa	3,320	22.6	28,982	19.8	8.73
Prepared seedbed	3,040	20.7	18,760	12.8	6.17
Bermuda pasture	2,200	15.0	5,738	3.9	2.61
Other pasture	1,000	6.8	1,388	.9	1.39
Cotton	880	6.0	39,844	27.2	45.27
Grain sorghum	520	3.5	18,097	12.4	34.80
Peanuts	440	3.0	16,669	11.4	37.88
Idle 1/	920	6.3	0	0	0
Waste 2/	1,440	9.8	0	0	0
Other 3/	920	6.3	16,949	11.6	18.42
Total	14,680	100.0	146,427	100.0	---
Average 4/	---	---	---	---	9.97

1/ Includes land not farmed or pastured and land in Government programs.
2/ Does not include stream channel.
3/ Includes oats, sudan, hay, rye, soybean, watermelon, and farmstead.
4/ Weighted by acres in each crop.

Damage factors (percentage reduction in yield due to flooding) are used in planning watershed projects to determine floodwater damages to individual crops and pastures. Commonly, damage factors vary by depth of flooding and season and/or stage of plant growth. Table 13 shows net damage factors by depth-of-flooding increments for September as estimated from this study . 14/ The relatively few observations from a rather small geographic area limit the applicability of the estimates to other areas. However, the number of observations was sufficient in most cases to show the general trend of increased damages with increases in depths of flooding. As more information on damages to individual crops and pastures becomes available, it will be possible to combine it with damage factors presently in use, thereby improving planning estimates.

14/ Damage factors are considered net because additional expenses incurred or expenses not incurred due to flooding were taken into account. The factors were computed from data collected in the study area for 1965.

Table 13.--Estimated net damage factors for the month of September

Crop	Number of observations	Net damage factors from inundation of (feet)--		
		0 - 1.0	1.1 - 3.0	3.1 and over
		Percent	Percent	Percent
Alfalfa	83	3.5	8.7	9.7
Cotton	22	19.8	24.1	45.9
Grain sorghum	13	21.0	59.0	51.2
Peanuts	11	12.8	18.9	63.9
Bermuda pasture	54	8.3	29.7	19.7
Prepared seedbed	76	8.1	13.8	22.0

ENLARGEMENT OF STUDY AREA

After the first year, it became apparent that few of the possible weather conditions for which the projects were planned would be represented in the 5-year evaluation period, 1964-68, in the Central Washita River Basin. Several years might elapse between flood-producing rains. Instead of extending the evaluation period, it was decided to enlarge the study area, thus increasing the chances of observing more kinds of weather conditions during a specific time period. The results of the study will apply to a broader geographic area. Research efficiency will be increased because floods in the broader geographic area will likely be more evenly distributed over time, thus distributing the workload more evenly over time. Also the short evaluation period will give more timely results than a longer one. The study area was enlarged effective for the crop year 1966.

The revised study area includes the floodplains of all the planned watersheds in the Upper and Lower Arkansas-White-Red Water Resource Regions as the population to be sampled. The 143 watersheds in the population contain approximately 893,700 acres of floodplain. The population of watersheds was stratified into developed watersheds (construction in progress or completed) and undeveloped watersheds. A sample of watersheds was drawn randomly from each category. The number of sample watersheds in each category and their associated floodplain acres are shown in table 14. Construction is in progress or completed in about half of them.

Figure 3 shows the boundaries of the Upper and Lower Arkansas-White-Red Water Resource Regions and the locations of the sample watersheds selected

for study. 15/ The shaded portion is the area encompassed by the 11 original watersheds which are all included in the sample of watersheds. The identity of the original 11 watersheds is being retained because of the potential for more intensified study in this well-instrumented area.

The objectives and procedures of the revised study are the same as they were for the original study. However, the results will have more general applicability and greater statistical accuracy. 16/ Also, the sample watersheds in the revised study area will allow evaluation of surface drainage projects.

Table 14.--Sample watersheds in the Arkansas-White-Red Water Resource Regions

Item	Undeveloped watersheds 1/	Developed watersheds 2/	Total
Number of watersheds	24	21	45
Acres of floodplain 3/	165,366	164,144	329,510

1/ Watersheds where construction has not begun.
2/ Watersheds where construction has started or is completed.
3/ As reported in the watershed work plans.

The revised study includes the 446 prime sample points in the original study area plus an additional 2,208 prime sample points--a total of 2,654 points. 17/ The larger number of sample points may be divided into several categories for analytical purposes while maintaining the designated statistical reliability. This was not possible with the original study because of small sample size. The initial survey of points in the revised study area is scheduled for completion by mid-1967.

15/ The sample of watersheds is geographically distributed in about the same manner as the population of planned watersheds.

16/ See appendix, Sample Size and Estimated Accuracy.

17/ At a rate of 1 point per 160 acres, the 2,208 prime sample points represent 353,280 acres of floodplain or 23,770 acres more than reported in the watershed work plans (table 14). The point sample estimates include the stream channel, whereas the work plan estimates do not. Therefore, the point sample estimate of floodplain will be adjusted downward when the number of points in stream channels is known.

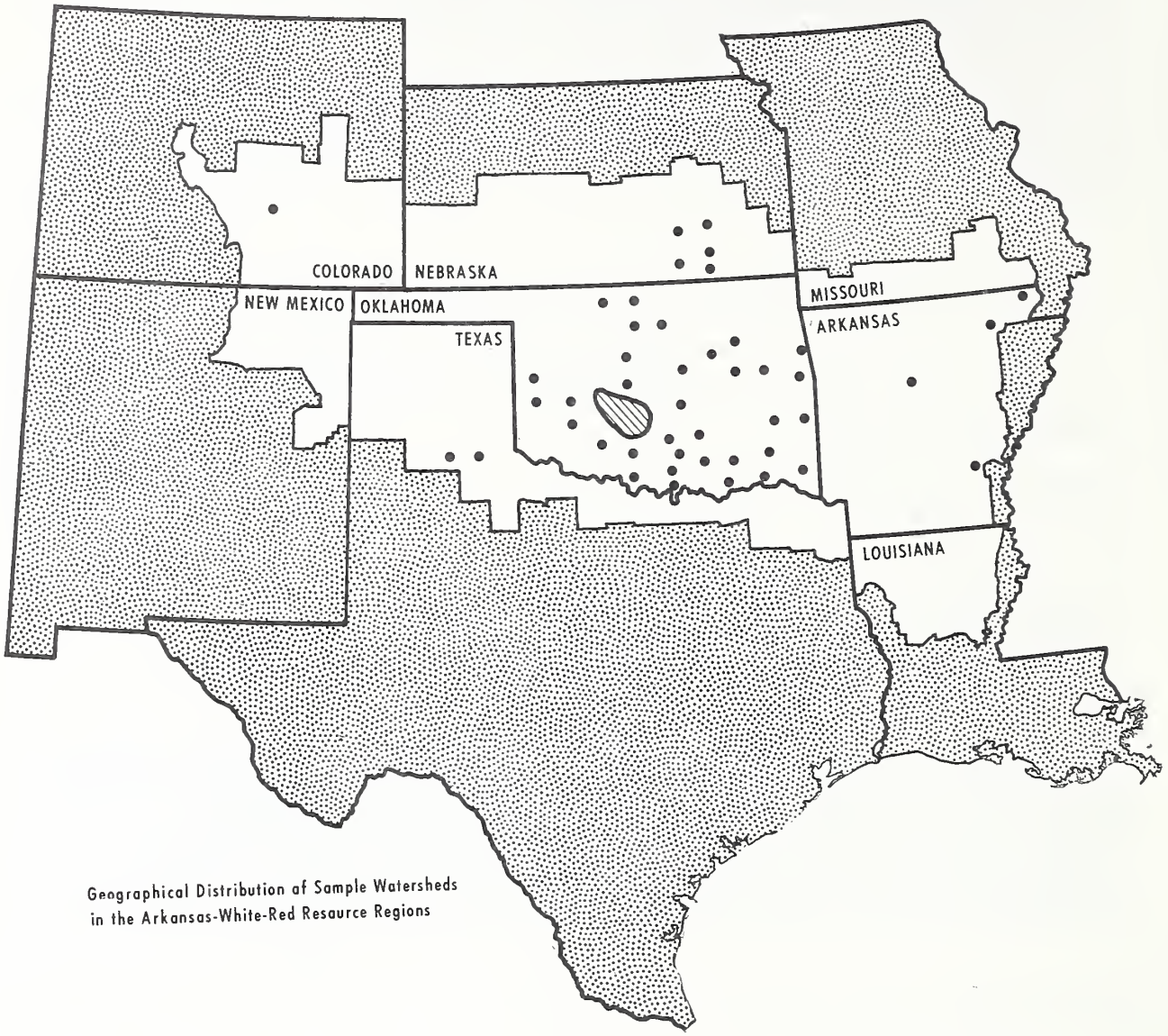
COLORADO
NEBRASKA
NEW MEXICO
OKLAHOMA
TEXAS
MISSOURI
ARKANSAS
LOUISIANA
Geographical Distribution of Sample Watersheds
in the Arkansas-White-Red Resaurce Regions

Figure 3

APPENDIX

Sample Size and Estimated Accuracy

For a random sample of points, estimates of the proportion of floodplain with a particular attribute are distributed approximately normally, $(\mu = p, \sigma \sqrt{\frac{p\ (1-p)}{n}})$. Thus a 1.96 σp range on either side of the estimated p will cover the true p 95 percent of the time. Since σp is largest when the estimated p = 0.50, this value of p was used in computing the sample size, n, consistent with a maximum allowable sample error of 0.05--both the confidence level and maximum allowable sample error are arbitrarily chosen (see equations 1 and 2).

Eq. (1) $$AE \leq 1.96 \sqrt{\frac{p\ (1-p)}{n}}$$

or

Eq. (2) $$n \geq \frac{(1.96)^2\ p(1-p)}{AE^2}$$

where AE = allowable sample error,

1.96 = tabular value from student's t distribution for 95% confidence level
p = proportion of floodplain with a particular attribute,
n = sample size.

Relative sample error is equal to sample error divided by the estimated p times 100. Expected sample error, expected relative sample error, p, and sample size are related to one another (table 15). For a given sample size the expected sample error increases up to p = 0.50 while the expected relative sample error decreases. As sample size increases, both the expected sample error and the expected relative sample error decrease.

Conclusions about the value of the watershed program are based on comparisons between the attributes of developed and undeveloped watersheds within study areas, and between floodplain attributes at various points in time. Estimates of the difference between the proportions of floodplain with a particular attribute are distributed approximately normally, $(\mu = p_1 - p_2, \sigma = \sqrt{\frac{p_1\ (1-p_1)}{n_1} + \frac{p_2\ (1-p_2)}{n_2}})$, where the subscripts refer to either preselected time periods or groupings of watersheds. 18/

18/ Assuming there were no correlations between individual estimates.

Table 15.--Expected sample and relative sample errors consistent with selected estimates of sample size and the proportion of the sample with a particular attribute, assuming a 95-percent confidence level

Sample size (n)	Proportion of sample with a particular attribute (p)	Expected sample error + and -	Expected relative sample error + and -
			Percent
400	0.01	0.0097	98
	.05	.0214	43
	.10	.0294	29
	.25	.0423	17
	.50	.0490	10
1,000	.01	.0062	62
	.05	.0135	27
	.10	.0186	19
	.25	.0269	11
	.50	.0310	6
2,000	.50	.0220	4

The standard error of the differences could be used to calculate the required sample sizes, n_1 and n_2, but the required sample sizes so calculated would not be very accurate. The above statements apply only to the binomial population. The proportion of floodplain with a particular attribute is compared with all the rest of the floodplain. Estimates of $p_1, p_2, \ldots p_n$ (where $\sum_i^n p_i = 1$) can be made, but no joint statement about the accuracy of all the parameters taken simultaneously can be made. Second, the sample of points are not randomly chosen as assumed in the above statements. Rather, they are systematically drawn from a stratified population in an unaligned manner. The standard error of the estimated differences can be used, however, to give some indication of the accuracy of comparisons.

Prices and Yields

Prices and yields used in determining damages to crops are shown in table 16.

Yields and prices of pasture were estimated after consulting farm management specialists at Oklahoma State University, county agents, and available secondary sources. Estimated yields and values for pasture are shown in table 17. Table 18 shows average monthly pasture values.

Table 16.--Yields and prices received by Oklahoma farmers for selected crops, 1965

Crop	Yield per acre 1/	Price per unit 2/
		Dollars
Cotton	561 lb.	0.265
Peanuts	1,956 do.	.112
Wheat	25 bu.	1.80
Grain sorghum	75 do.	1.02
Soybeans	25 do.	2.25
Rye	20 do.	1.05
Alfalfa	4.6 tons	24.00
Other hay	3.1 do.	20.50

1/ Average flood-free yield as reported by respondents. Wheat yield is estimated.

2/ Statistical Reporting Service, Crop Reporting Board. Agricultural Prices. U. S. Dept. of Agr. PR 1 (N-65). Nov. 1965.

Table 17.--Estimated animal unit month yields and values for bottomland pastures in Southwestern Oklahoma, 1965

Type of pasture	Yield per acre	Annual value per acre
	AUM	Dollars
Bermuda	3.5	8.75
Small grain		
Graze out	2.0	20.00
Winter	.8	8.00
Native	2.0	5.00
Timbered	.8	2.00

In cases where flooding caused a change in production costs, foregone or additional, custom rates 19/were used to determine net damages.

19/ From Oklahoma State Univerity. OSU Extension Facts. No. 118. Stillwater, Okla. July 1966.

Table 18.--Average monthly pasture values per acre for bottomland pasture in Southwestern Oklahoma, 1965

Month	Type of pasture			
	Bermuda	Small grain	Native	Timbered
	Dollars	Dollars	Dollars	Dollars
January	0.26	2.00	0.27	0.16
February	.26	2.00	.26	.16
March	.26	3.00	.27	.17
April	1.75	4.00	.50	.17
May	1.75	4.00	.50	.17
June	1.75	1.00	.50	.17
July	.55	0	.50	.17
August	.55	0	.50	.17
September	.55	0	.50	.17
October	.55	0	.40	.17
November	.26	2.00	.40	.16
December	.26	2.00	.40	.16
Annual value	8.75	20.00	5.00	2.00

Use _____
Photo _____
Reference _____

LAND USE - FLOOD DAMAGE STUDY
Department of Agricultural Economics
Oklahoma State University
in Cooperation with the
Economic Research Service
U. S. Department of Agriculture

Budget Bureau No. 40-R3408.1
Approval Expires June 30, 1971
Date _____
Enumerator _____

Operator _____ Address _____

Farm Size (acres) _____ Major Source of Income _____ Upland (acres) _____

(Cropland _____) Bottomland (acres) _____ (Cropland _____) Flood Plain (acres) _____

(Cropland _____) Allotments (Crop and acres) _____, _____, _____, _____

Note: Complete this page if crop (hay, grain, etc.) on sample field; complete page 2 if in pasture.

SAMPLE FIELD /_____/ Owned /_____/ Rented

Acres	Crop	Date Planted	Date Harvested	Yield Unit No.	Fertilizer Analysis	Fertilizer lb/acre	Fertilizer No. App.	Irrigation Dates	Irrigation Tot. Ac. In.	Remarks

If land use changed, why? _____

SAMPLE AREA IN FIELD

	Record of Flooding: Date	Depth Ft.	Duration Hrs.	Backwater or Flow 1/	Yield: With Flood Units	With Flood No.	Flood Free Units	Flood Free No.	Effect of Flood on Production Practices	Substitute Crop: Name	Substitute Crop: Yield	Remarks
1st									(List Practices)			
2nd					XXX		XXX	XXX				
3rd					XXX		XXX	XXX				
4th					XXX		XXX	XXX				

Degree of erosion present _____
Special factors affecting use of sample areas _____
Any special factors (hail, disease, insects, etc.) affecting this year's Yield (specify) _____ Damage _____%
Remarks _____

1/ Indicate backwater "B", flow "C".

Budget Bureau No. 40-R3408.1
Approval Expires June 30, 1971

Pasture Information

SAMPLE FIELD /_____/ Owned /_____/ Rented

Acres	Type Pasture 1/	Capacity: Kind of Animal	Capacity: Acres/head	Fertilized: Date	Fertilized: Analysis	Fertilized: Amt.	Irrigated: Dates	Irrigated: Ac. In.	Remarks

Formerly cultivated (yes or no) _____ If yes, is flooding responsible for it being in pasture (yes or no) _____

SAMPLE AREA IN FIELD

	Record of Flooding: Date	Depth Ft.	Duration Hrs.	Backwater or Flow 2/	Type of Damage 3/	Loss of Days Grazing Due to Flooding: No. A.U.	Kind	Days Lost	Effect of Flood on Production Practices	Substitute Pasture Available	Additional Feed Required
1st											
2nd											
3rd											
4th											

Remarks _____

1/ (1) Temporary pasture (annual grasses and clovers).
(2) Improved pasture (Bermuda, perennial grasses and clovers, usually irrigated or fertilized grass mixtures).
(3) Open native pasture (few trees and brush -- less than 50% in mixed pastures).
(4) Wooded native pasture (brushy and/or timbered -- more than 50% in mixed pastures).

2/ Indicate backwater by "B", flow by "C".

3/ Wetness only, sediment on leaves, trash in pasture, removal of plants, etc.