STAFF REPORT

PROJECTING LAND USE CHANGES ASSOCIATED WITH SMALL WATERSHED DEVELOPMENT

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U.S. Department of Agriculture

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ABSTRACT

This study determines if projected land use changes and their benefit estimates are biased in favor of project development. Both the base period land use estimates and the projected land use changes in a sample of 40 projects in two contrasting geographical regions were found to be reliable. The differences between projected and observed land use changes, when observed land use changes are measured from aerial photographs, were not statistically significant. Four alternative land use projection techniques examined in the study did not improve upon the reliability of SCS land use projections. The SCS land use projection procedures for small watershed areas provide reliable measures of land use trends for estimating land use benefits due to project measures.

Key words: small watershed development; land use; land use change benefits; land use estimating procedures; aerial photography; land use trends.

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INTRODUCTION

The Small Watershed Program authorized under Public Law 85-566 provides Federal technical and financial aid to local organizations to carry out projects to control flooding, erosion, and sedimentation and for agricultural water management, recreation and fish and wildlife development, and municipal and industrial water supply. The program applies to watersheds of 250,000 acres or less and is administered by the U.S. Department of Agriculture's Soil Conservation Service (SCS).

Since the implementation of the Small Watershed Program in 1954, operational work plans for 1,196 projects in all 50 states and Puerto Rico have been approved as of August 1978. Most work plans emphasize flood protection to agricultural land, although many other benefits have been attributed to the program.

In recent years, projected Flood Damage Reduction Benefits included in watershed work plans have been challenged. The most frequently criticized type of Flood Damage Reduction Benefits is associated with projecting land use changes. Inaccuracies in benefit estimates are attributed to errors in estimating land use changes and concern over the procedures used by SCS to project land use.

Land use benefits accounted for approximately $14.6 million, or 8.1 percent, of the $181.6 million of total estimated average annual benefits shown by work plans dated before June 30, 1975. Although land use benefits make up only a small proportion of the total benefits attributed to P.L. 566 small watershed development, the SCS viewed the examination of the procedures for projecting land use changes as a priority research item, and funding of this research project was provided to the Economic Research Service (ERS).

STUDY DESCRIPTION

Background

Several ex post studies strongly suggest that small watershed work plan estimates of land use change benefits are optimistic and that projected changes due to the program have been higher than those which occurred. The reliability of these projections is important because of the implications they have for the feasibility of the projects, attendant land use impacts, and, more specifically, for the accuracy of the work plan analysis and evaluation.

Sutton (29) found that the activities specified in work plans were achieved in the project areas. However, the successful implementation of the physical components did not always generate the desired outputs and economic effects. In general, agricultural and recreation benefits fell short of projected benefits while municipal/ industrial water and nonagricultural flood protection benefits were higher than projected benefits.

Sloggett (27) examined results in the 56 completed small watersheds out of the 143 planned in the Arkansas-White-Red River basin region. Results indicated that changes in land use could not be attributed to the small watershed program and that there was an overestimation of the average annual acres flooded in the work plans.

Mattson (20) found that projected expansion of cropland on the flood plains projects in the Southeast did not occur although the projected conversion of cropland to permanent grass or forest in the uplands had occurred. A shift to cropland from forest and woodland within the watershed areas in the Mississippi Delta region followed regional trends and this expansion in cropland was made feasible by major drainage and flood control work carried out by the Corps of Engineers. In the Missouri River tributaries region little or no change in land use patterns was projected and changes did not occur.

The joint ERS and SCS study of the Kiowa watershed (36) found that planned economic benefits were generally overestimated by a factor of 2. Economic surveys indicated a trend toward less intensive land use in the watershed as a whole. Feed and forage production increased on the flood plain but the benefits from more intensive use of the flood plains were not as great as estimated in the work plans.

Blood (2) found that projected cropping shifts in the flood plain did not occur to any significant extent. Annual land use records for flood plain and upland fields showed that the acreage of corn and cotton decreased while the acreage of soybeans and sorghum increased on both the flood plain and upland areas. It was found in an interview of farmers that the change in land use was primarily due to increasing returns for those crops rather than the reduction in risk due to flooding.

Objectives and Procedures

Improved estimates of project benefits and costs are expected to provide information to decision makers at all levels to use in making informed judgments of the economic feasibility or desirability of projects. Because of the problems concerning land use projections in small watershed project evaluation, the purpose of the study was to determine if procedures used in projecting land use changes are biased in favor of project development. Specifically, the objectives of the study are to (1) review the methodology and procedures for estimating and projecting land use; (2) identify and examine divergence among land use estimates from various techniques; and (3) compare the divergence among anticipated and realized land use changes in a number of selected case study watersheds.

The following procedure is used to address these objectives. In section one, selected estimating and projecting procedures are examined with particular attention given to those procedures used by the Soil Conservation Service. Regional and county land use trends are compared for selected areas, and basic differences which may exist among counties with or without developed watersheds are assessed. The next two sections assess the accuracy of base land use estimates and projected land use estimates in watershed work plans. This is followed by a comparison of land use estimates and trends using census, air photo and work plan data. Included in this analysis is the measurement of the impacts of watershed development on land use in two study areas and an examination of the importance of land use benefits in watershed justification.

Area and Project Selection

Two areas--the Mississippi Delta region and the Missouri River Tributaries region--were selected for detailed examination and to serve as a basis for assessing SCS land use projection techniques under contrasting circumstances. The Mississippi Delta region, including the states of Arkansas, Louisiana and Mississippi, has been characterized by a rapid expansion of agriculture resulting from the drainage and clearing of flood-plain lands. The projects lie within the Mississippi Delta Cotton and Feed Grain Land Resource Region with most of the benefited areas of these projects within the Southern Mississippi Valley Alluvial Area. Because of the rapid expansion of agricultural cropland in the area, it was deemed important to determine whether land use projection techniques in use by the Soil Conservation Service (SCS) accurately reflect these changes.

The Missouri River Tributaries region, including the loessal hills in the states of South Dakota, Nebraska, Kansas, Iowa and Missouri, is generally characterized by rolling to hilly land with erosion and flooding problems. In contrast to the rapidly expanding agricultural area of the Delta, the Missouri River Tributaries region was characterized by marginal changes in agricultural land use. It was considered important to examine and assess the SCS land use projection techniques in contrasting settings.

The watershed projects studied by Mattson (2) in the Mississippi Delta and Missouri River regions were selected for the study. Based on the Mattson criteria, subgroups of 10 developed and 10 undeveloped watersheds are examined in each region. Developed watersheds are those in which project work plans have been completed. The developed watersheds in the Mississippi Delta region had an average planning date of 1960 while the average planning date for the developed watersheds in the Missouri River region was 1958. The undeveloped watersheds had an average planning date of 1967 in the Delta region and 1969 in the Missouri River region. Project construction was assumed to have been completed 10 years after project planning.

Area Characteristics

Watersheds in the Mississippi Delta region are characterized by large, flat, poorly drained flood plains that are subjected to frequent flooding. Channel development to improve drainage was the principal structural solution for the project area. Land treatment under the Small Watershed Program emphasized erosion control on the uplands and land leveling combined with open and tile drainage on the bottomlands. Feasibility of most of the watershed projects in the Delta area depended on prior channel and levee construction by the Corps of Engineers.

Agriculture in the Delta region is dominated by cash crops including cotton, soybeans, rice, wheat, sugarcane, and corn. Poultry, beef and truck crops are also grown. Forest and woodland continues to be a prominent although diminishing land use on farms. Pasture and rangeland are minor land uses which have been stable through time.

The watershed project areas in the Missouri River region are characterized by moderate to steeply hilly topography with loessal upland soils and deep alluvium deposits in the small flood plains. The major problems of these watersheds are gully and sheet erosion and flooding. Projects in this region concentrate on solving these problems with grade-stabilization structures and flood-retarding dams. Land treatment practices are emphasized for erosion control.

Commercial agriculture is the dominant land use in the Missouri River region. While most of the productive farmland is devoted to the production of corn and soybeans, beef cattle and hog production contribute most to farm income. Pasture and rangeland are important land uses but usually are relegated to the less desirable lands for crop production. Forest and woodlands are generally confined to stream and river banks.

Data Definition and Availability

Watershed work plans and aerial photographs for the planning period and after project completion were available for the 40 selected watersheds. In addition, county agricultural census data were used for the 4 census years 1959, 1964, 1969 through 1974. Land use descriptions vary in the amount of detail provided among watershed work plans. Watershed work plans usually do not show individual crop acres but only indicate general land uses. Therefore, only four general categories of land use were available: cropland, pasture and rangeland, forest and woodland, and miscellaneous or other land uses.

Land use data in work plans are derived from two basic sources: (1) farmer interviews and (2) aerial photographs of the flood plain. Interviews with farmers are conducted to acquire statistically reliable data and usually are confined to farms located on flood plains in the watershed. Land use data are collected in the farm interviews to use in estimating floodwater damages.

Agriculture census data for counties are available every five years. The four census years, 1959-1974, were used for land use, farm income and crop production data. Land use data for 1959 are given for all farms while 1964 through 1974 data are given for class 1-5 farms only. The adjustment in farm numbers and census definition of farms was made in the 1964 census. Census land use data were aggregated into the same major land use categories as the work plan data.

The aerial photo data used in the study were adopted from Mattson (20). The scale and resolution of the photographs were acceptable for that and similar studies of land use change (14). The following land use definitions were used:

Cropland. Includes: (1) fields identifiable by tone, texture, and shape as planted to or being prepared for crops, (2) other fields characterized by sharp corners and distinct boundaries and lack of large vegetation, and (3) areas recently cleared.

Pasture and Rangeland. Consists of open areas generally lacking evidence of recent tillage. Distinguished from idle - transitional by smoother appearance, darker and more even tone, presence of some water source, and usually scattered shade trees. Additional evidence includes paths, trampled areas, and stock ponds.

Forest and Woodland. Areas predominantly covered by trees, including fairly young stands.

Miscellaneous or Other. Roads, small streams and ponds, ditches, gravel pits, railroads, power and pipeline rights-of-way, farmsteads, small villages, cities, industrial sites, mining operations, institutions, airports, golf courses, race tracks, drive-in theaters as well as idle-transitional land. (Idle-transitional land includes areas formerly in crop production which are indicated by irregularly distributed brush and small trees, indefinite field borders, and corners and uneven tone.)

Two sets of aerial photographs were used by Mattson (20) for each watershed within the regions. The average date of the early photographs in the Mississippi Delta region was 1957 while the average date of the later photographs for this region was 1970. The average date of the early photographs in the Missouri River region was 1956, while the average date of the later photographs for this region was 1970.

PROCEDURES FOR ESTIMATING AND PROJECTING LAND USE

The usual rationale for carrying out water and related land resource development is that such development stimulates economic growth by eliminating inhibiting factors or bottlenecks. The threat of flood damage, inadequate water supply, and poor water quality along with inadequate capital availability and natural resource limitations are frequently considered to be important inhibiting factors or bottlenecks to economic growth. According to economic growth theory, the elimination or control of bottlenecks will foster economic growth and give rise to benefits from resource employment. Watershed development is undertaken to obtain these probable economic growth effects.

The impacts of project development on economic growth are determined through an evaluation of economic activities expected with and without the project. Projections of resource use, costs of production and value of output are made for selected land and water development options. Projections and evaluations are based upon available data, economic needs and judgment of the planning staff and local people.

Economic analysis provides information to assist decision makers in determining both the needs and potentialities for development. Development needs may not be closely related to development potentialities of the area. Since the potential of each watershed tends to be unique, the degree of development and the potential for land use changes will not be the same among watersheds. Therefore, planning and evaluation activities need to take into account both the existing situation and the probable future development.

Numerous methodologies and procedures have been developed to assess land use change and project land use. Some procedures can be used to estimate land use changes for small areas while others are designed to project changes at the regional or national level. Several of these projection methodologies were examined. A brief description of methodologies follows.

SCS Procedures

The land use estimating procedures used by the Soil Conservation Service are set forth in Economics Guide (35). The generally accepted analytical technique for attributing effects to a project is the "with" and "without" approach in which differences in expectations provide the basis for identifying appropriate project charges and credits. The "with" and "without" approach is an analytical technique used to determine the likely economic effects of various program features for use in project formulation and evaluation of watershed project performance.

Chapters three, four and fifteen of the Economics Guide outline the basic procedures for projecting and evaluating floodwater damages and benefits. The guidelines distinguish three types of enhancement benefits associated with changes in land use. The benefits for flood protection are classified as "changed land use," "more intensive land use" and restoration of former productivity." "Changed land use" benefits are defined as increases in net income from a shift to more productive uses of land. "Intensified land use" benefits are defined as increases in net income resulting from a reduction in flood hazard to the point that it becomes profitable to intensify management efforts on existing cropland including such effort as improved seeding, double cropping, or shifts to more productive crops. "Restoration of former productivity" benefits refer to increases in net income from a return to more productive use of land as a result of flood protection. Usually this type of benefit is reported as a damage reduction benefit rather than as an enhancement benefit.

Careful distinction among benefits from "restoration of former productivity," "changed land use" and "more intensive use" of agricultural land must be made. The Economics Guide (chapter 4) gives hypothetical examples of how the various benefits are to be separated and distinguished one from the other. A prime concern of this study is to look closely at only one phase of the benefit estimating procedures--land use projections--not to evaluate the overall benefit estimating procedures of SCS.

Farm surveys are used to collect land use data for planning and evaluation of small watershed projects. Questionnaires or schedules are used to obtain information from owners and operators about changes in land use to establish both existing and anticipated or planned land use in the watersheds. The crop distribution in a flood plain is assumed to be the land use acreage during the year planning is begun. 1/ It should be made clear, however, that land use projections are not based solely on farmer intentions. "The intentions of present operators do not necessarily indicate the extent of future enhancement. They are

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1/ Economics Guide, Ch. 3, p. 24.

helpful, however, in determining the delay to be expected in reaching the full level of benefits." 2/

SCS procedures call for the separate examination of each watershed because of policy restrictions, regional differences, the complexity involved in evaluating general land use change, and the variability of benefits resulting from this change. The examination of individual watersheds also enables the identification and separation for evaluation purposes of the benefits due to "restoration of former productivity," "changed land use" and "more intensive use." This separation of impacts is important because of the policy restrictions on the extent to which each kind of benefit may be used for project justification. "Several physical, social and economic factors govern the amount of change, restoration or intensification that will result and when the expected change will occur. Information on at least the following factors should be obtained and evaluated.

1. Potential of the land.
2. Type of farming.
3. Width and topography of the flood plain or area to be benefited.
4. Need for various types of production, whether in agricultural products or in urban and industrial services, as the case may be.
5. Degree of protection or service afforded by the improvements.
6. The change supported by this degree of protection service.

2/ Ibid., Ch. 4, p. 3.

7. Willingness, intentions, financial and managerial ability of present and future operators to develop the land.
8. Availability of markets for any new products.
9. Restrictions imposed by acreage allotments, marketing quotas or zoning regulations." 3/

A major policy constraint in projecting changes in land use has been the consideration of acreage allotments and surplus crops. For many years, the Department of Agriculture policy has severely restricted the inclusion of acreage increases of allotment and surplus crops as benefits from watershed projects. "Extreme caution should be exercised in claiming benefits from increasing the acreages of these crops as a result of project installation. It is essential that benefits from increased acreages of allotment crops be considered conservatively. Only the net effect, after allowance for reduced returns elsewhere in the watershed, can be claimed. Whenever these benefits are claimed, appropriate discounting is required." 4/ The restrictions on counting benefits from the production of additional amounts of allotment and surplus crops is based on the economic criteria that allow only net increases in national income as a real benefit to society from public investments.

The restrictions on counting benefits from changes in acres of allotment crops may introduce elements of error into the land use data. Since the benefits from such land use changes are not allowed for project justification and assessment of acreage changes is difficult, it is

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3/ Ibid., Ch. 4, p. 3.
4/ Ibid., Ch. 4, pp. 4 and 5.

easy to discount or overlook acreage changes which do occur. The economic rationale for discounting benefits from additions to surplus crops is legitimate and theoretically sound. However, changes in restricted crop acres could be the unintended result of the program and, in order to provide an accurate assessment of land use changes, provisions are needed to account for the acreage changes in both restricted and nonrestricted crops. Recent environmental legislation makes it imperative that any program-induced changes are included in project planning.

Benefits attributed to changes in land use are computed from the projections of three variables: (1) acres, (2) yields, and (3) prices. These three projections directly influence the magnitude of estimated benefits. Thus, the projection of an acreage change in land uses is influential in benefit calculation but is only one of the contributing factors. Errors in projecting yields and prices of agricultural products can influence gross benefit estimates as much as errors in projecting acreage changes since gross benefit estimates are a direct multiplication of the projected values of these three factors.

Aerial Photography

Aerial photography is frequently employed to determine the general land use base of an area at a given point in time. Aerial photographs are available for most of the nation and are provided on a periodic basis. Both the Department of Agriculture and the Department of the Interior maintain several series of aerial photographs. Within the Department of Agriculture, ASCS, SCS and the Forest Service have aerial photographs for various parts of the nation. From these photographs general land use information can be determined by a skilled photo-interpreter.

For small areas, a complete interpretation of land use in the area can be made. The procedure involves bounding the areas of like land uses on the photo sheets and measuring these areas with a planimeter or a dot grid. The Soil Conservation Service typically uses this procedure to provide base flood plain land use data in watershed project areas.

For larger areas, a sample point system is frequently used to determine land uses from aerial photos. 5/ The sample point or grid procedure uses a uniform assignment of sample points throughout a watershed area with the density of the sample points based on the physical characteristics of the watershed. Computations are on a per-acre basis with each sample point representing a specified number of acres. Therefore, depending upon the area represented by each sample point, an expansion factor is used to expand the data to an area total.

The sample point methodology has the advantage of providing statistically reliable data for large areas at reasonable cost. However, problems can arise with the interpretation of land use data from aerial photos--especially when information for specific crops is required. 6/

5/ For examples of the use of this methodology see: Vernon R. Eidman and Ronald D. Lacewell, A Model for Estimating Agricultural Flood Damages, Tech. Bulletin T-136, Agric. Exp. Sta., Oklahoma State University, April 1974; also Gordon Sloggett, Evaluating the Upstream Watershed Protection and Flood Prevention Program - Arkansas - White - Red Water Resources Region, ERS-551, ERS, U.S. Dept. of Agriculture, April 1974.

6/ Linda Lee, Estimating Cropland Development by the Use of Satellite Imagery, Working Paper No. 63, NRED, ERS, U.S. Dept. of Agriculture, November 1978.

The interpretation problems associated with aerial photos can be controlled by supplementing the aerial photo data with field observations and interviews with farmers. Because of these requirements, the cost of detailed land use data can increase rapidly. Also, the procedure becomes similar to the direct survey methods used by SCS in their current small watershed assessment procedures.

Trend Analysis

The Census of Agriculture is compiled each five years from individual farm enumerative surveys and provides basic land use data on farms at the county, state and national level. Census data provide the basic information source for most land use projection procedures.

Time series or trend analysis is a common land use projection procedure which relies heavily on census data. Trend analysis displays the general movement of a data series through time to indicate the growth or decline in land uses. Various techniques can be employed in constructing trend lines depending upon the amount and variability of the data. In many cases trends are assumed to be linear. In other cases trends are found to be nonlinear. Examples of techniques for evaluating nonlinear trends include moving averages and nonlinear regression.

Cooperative River Basin Study Procedures

Land use projections are a main concern of river basin studies because they serve as a reference point for considering land and water resource development needs and potential. The projection system used in these studies is largely an extension of historical trends with special consideration given to comparative economic advantage, national markets, changing technology, availability of other economic resources, and institutional forces.

The usual methodology employed in river basin studies is linear programming. A cost minimization procedure determines the optimum land use required to produce a specified level of agricultural output at miniumum cost with prespecified restrictions on resources available in the study area. Profit maximizing procedures have also been employed to specify land use under restricted resource use conditions.

River basin studies usually encompass relatively large areas and are intended to identify general types of resource development potential. Land uses projected by these studies vary considerably in the presentation format and the detail of data included. The lack of detailed land use information and disaggregation problems reduce the reliability of the data when applied to small areas. In addition, river basin studies do not provide a consistently reliable source for land use information for projecting land use changes at the small watershed level.

Markov Process

The Markov process is an effective technique for estimating ex-post land use changes. However, it is considered limited in its potential for making ex-ante projections because the difficulty of quantifying ex-ante transaction probability matrices may be greater than any advantages the methodology possesses. 7/ The procedure becomes complex when

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7/ Lonnie R. Vandeveer and H. Evan Drummond, The Use of Markov Processes in Estimating Land Use Changes, Agric. Exp. Sta., Oklahoma State Univ. Tech. Bulletin T-148, January 1978.

assigning probabilities to future developments which are different from those developed from the history of the area being studied. The technique was not used in this study to verify ex-post changes in land use because of insufficient data.

REGIONAL AND COUNTY TRENDS

Before an assessment of the accuracy of work plan land use estimates and projections is undertaken it is helpful to understand the general trends in land use that have taken place. Therefore, regional and county trends are examined 1) to display the differences in land use between the two regions and 2) to determine if there are any basic land use differences between those counties with completed watershed projects and those with planned but incomplete watershed projects.

Mississippi Delta Region

The Mississippi Delta region has experienced a rapid expansion of cropland and a dramatic decline in forest and woodland since 1959 (table 1). In those counties with developed watersheds, the percent of farm acreage in cropland increased rapidly between census years--57 percent in 1959, 70 percent in 1964, and 79 percent in 1969. By 1974, cropland accounted for 80 percent of all land in farms.

A similar trend in cropland changes on farms existed in counties with undeveloped watersheds. Data for these counties show cropland increasing from 61 percent of land in farms in 1959 to 80 percent in 1974. In the undeveloped watershed counties the rapid increase in cropland also appears to have leveled off during the 1969-1974 five-year period.

Table 1--Land use on farms in developed and undeveloped watershed project county groups, census years 1959-1974

Group	Land use	1959	1964	1969	1974
		Percent			
Mississippi Delta Area					
Counties with developed watershed projects	Cropland	57	70	79	80
	Pasture and Range	8	7	7	6
	Forest and Woodland	30	18	10	9
	Miscellaneous	5	5	4	5
Counties with undeveloped watershed projects	Cropland	61	67	79	80
	Pasture and Range	9	9	6	6
	Forest and Woodland	25	20	11	9
	Miscellaneous	5	5	4	5
Missouri River Area					
Counties with developed watershed projects	Cropland	67	69	76	75
	Pasture and Range	19	19	12	13
	Forest and Woodland	7	6	6	5
	Miscellaneous	7	6	6	6
Counties with undeveloped watershed projects	Cropland	80	80	84	82
	Pasture and range	11	12	8	10
	Forest and Woodland	3	2	2	2
	Miscellaneous	6	6	6	6

There is only a small difference in land use changes between the two groups of Mississippi Delta counties (figure 1). The trend in cropland development was similar during the four census years. The group of counties with developed watersheds experienced their most rapid expansion of cropland during the 1959 to 1964 period while the group of counties with undeveloped watersheds experienced their most rapid expansion during the 1964 to 1969 period. The census data do not allow one to determine if the timing of these rapid changes in land use was facilitated by the watershed activity. However, since the undeveloped watershed projects were initiated during 1966 to 1969 and most were incomplete in 1969, the watershed activity could not be credited with the majority of the changes in land use. Also, since watershed projects directly affect less than 25 percent of the land in farms in these counties, the impact of the projects would not be large enough to influence the land use pattern at the county level to the extent shown by the census data.

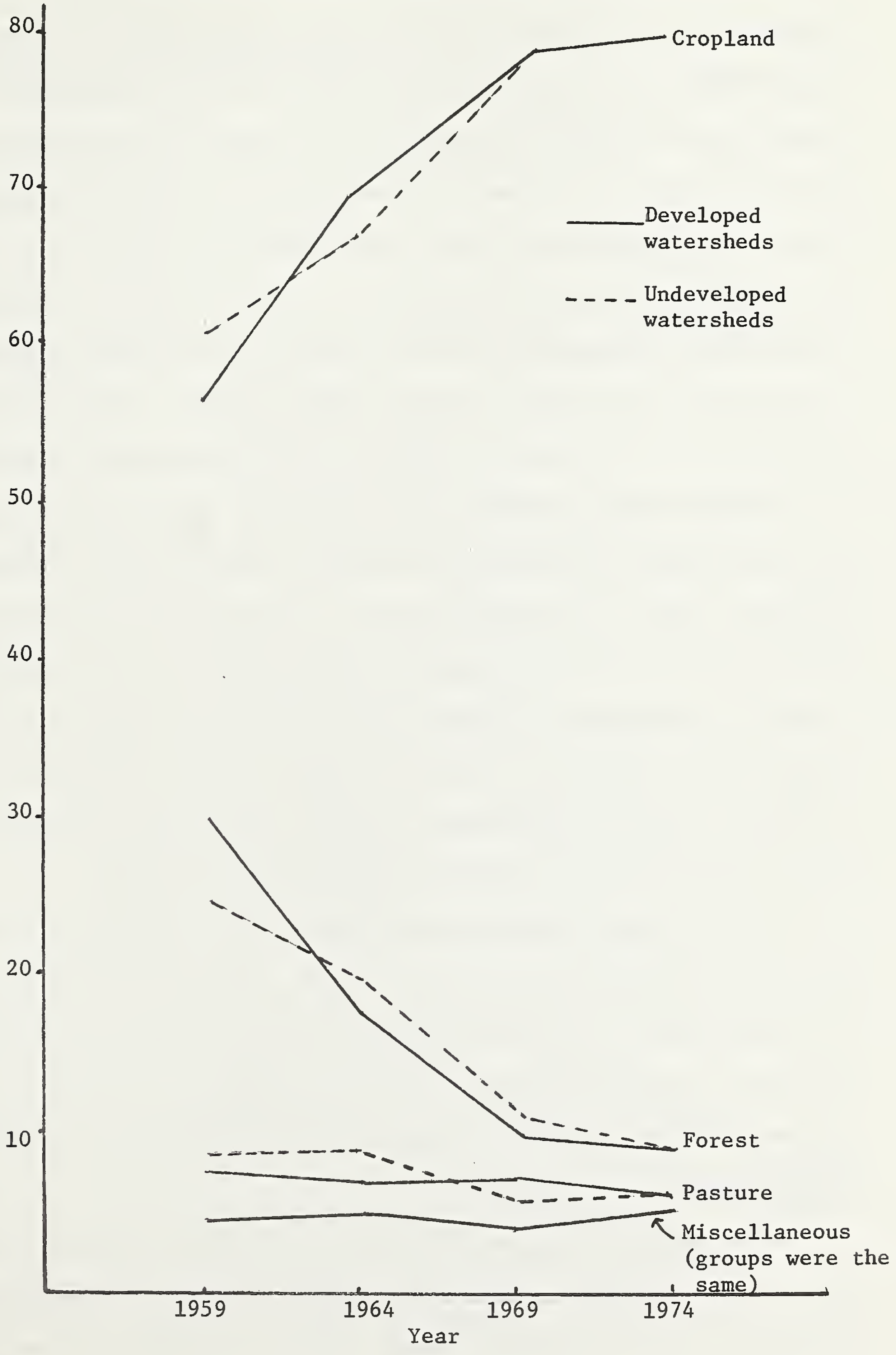
The increase in cropland in the Mississippi Delta region stems primarily from the rapid clearing of forest and woodland. The two groups of counties show the same general pattern of land use in 1974 even though there were slight differences in earlier census years.

Pasture and rangeland held relatively stable over the 15-year period with a slight downward trend in both county groups. The percentage of miscellaneous land use remained constant during the period.

Missouri River Region

The land use pattern of the Missouri River region has been much more stable than that in the Mississippi Delta region. However, there

Figure 1--Land use in developed and undeveloped watershed groups, Mississippi Delta region, 1959-1974 census data



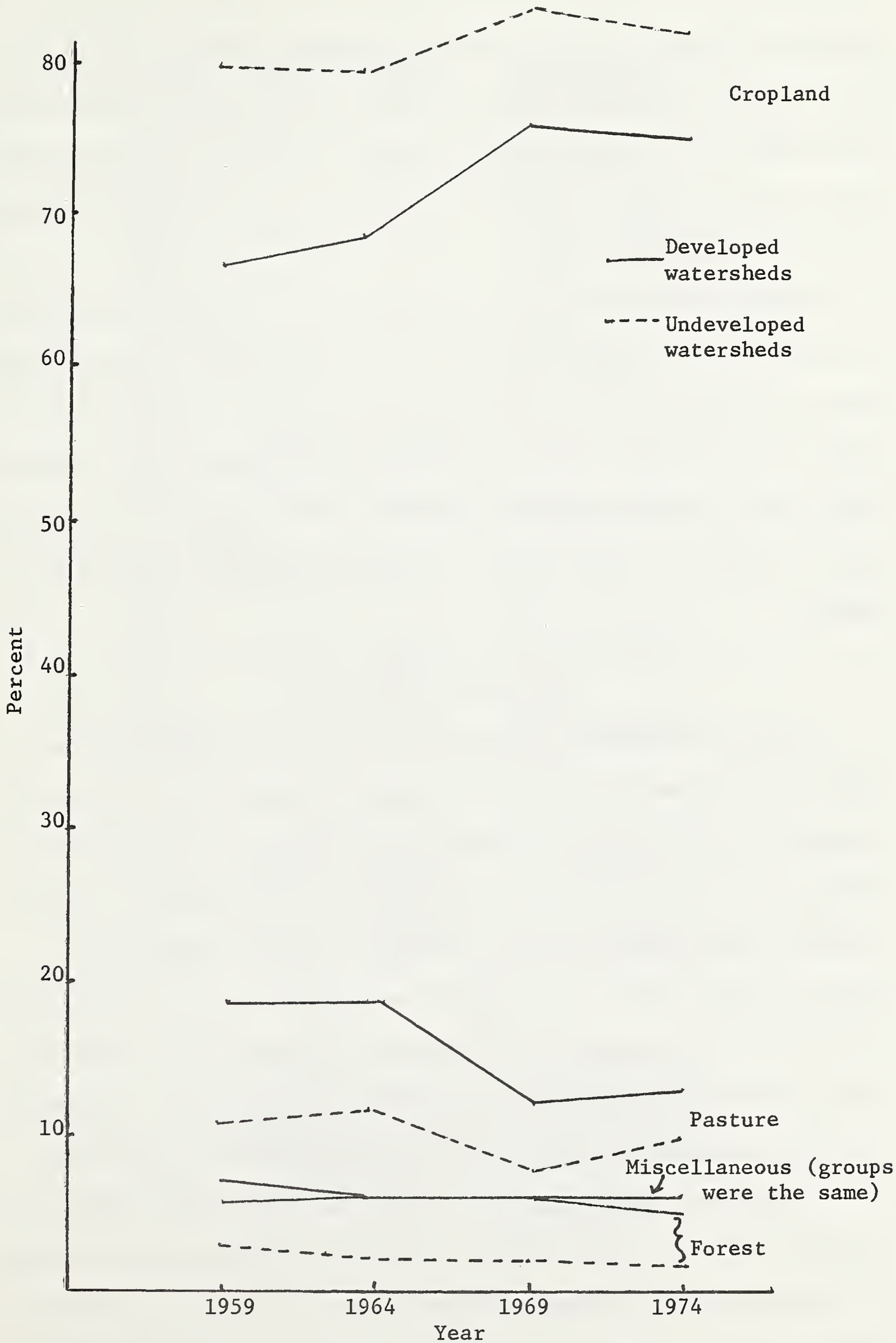
were greater land use differences between county groups in the Missouri River region than between the county groups of the Delta region. The counties with developed watersheds in the Missouri region show a moderate upward trend in cropland over the census data period with 67 percent in 1959, 69 percent in 1964, and 76 percent in 1969 (figure 2). The percentage of cropland slipped to 75 percent in 1974. Data for the counties with undeveloped watersheds indicate that cropland was stable at 80 percent of the land in farms in 1959 and 1964. The percentage of cropland rose to 84 percent in 1969 and fell to 82 percent in 1974.

The percentage of pasture and rangeland in the counties with developed watersheds declined from 19 percent in 1959 and 1964 to 12 percent in 1969, rising to 13 percent in 1974. The increase in cropland between 1964 and 1969 is directly comparable to the decline in the acreage of pasture and rangeland. The percentage of forest and woodland declined slightly from 7 percent in 1959 to 6 percent in 1964 and 1969, then to 5 percent in 1974. Miscellaneous land use held fairly constant throughout the 15-year period, staying at approximately 6 percent.

In the counties with undeveloped watersheds, pasture and rangeland fluctuated slightly during the census years, between 12 and 8 percent. The percentage of forest and woodland in these counties is small and held fairly constant at about 2 percent throughout the 15 years. Miscellaneous land also held constant at 6 percent throughout the entire time period.

Differences in land use between the two groups of Missouri River counties are not large. The group of counties with undeveloped watersheds had a higher level of cropland use and less forest and woodland

Figure 2--Land use in developed and undeveloped watershed groups, Missouri River Tributaries, 1959-1974 census data



use than the counties with developed watersheds. Land use throughout the Missouri River region did not change dramatically throughout the 15-year period. Land uses in the two groups of counties have become more alike, and the region has achieved a rather stable distribution between the various land uses.

Whether or not these land use changes can be directly attributed to watershed development activity cannot be determined from the general nature of the census data. Since the major changes in cropland and pasture land for both sets of counties in the Missouri River region are similar and occurred during the same time period, 1964 to 1969, watershed development activity cannot be credited with initiating these changes.

LAND USE PROJECTIONS

Reliable estimates of land use at the time the work plans are drawn up are needed to assess the accuracy of land use projections developed for the watershed work plans. The accuracy of the land use estimates in the work plans can be determined by comparing work plan and aerial photo data for the base period. In both the Delta and Missouri River regions, the available aerial photos precede information provided in the work plan by approximately two years. This time difference is not considered to be significant since work plan estimates are usually made prior to the work plan preparation and publication.

A comparison of work plan and aerial photo estimates of land use for individual watersheds indicate there are no significant differences in land use in the base period between the two methods of estimation (tables 2 and 3). However, in general, work plans for the developed

Table 2--Land use estimates by watershed for Missouri River Tributaries region

Water-shed number	Watershed name	Cropland: Base work plan	Cropland: Photos	Cropland: Difference	Pasture and rangeland: Base work plan	Pasture and rangeland: Photos	Pasture and rangeland: Difference	Forest and Woodland: Base work plan	Forest and Woodland: Photos	Forest and Woodland: Difference	Miscellaneous Land: Base work plan	Miscellaneous Land: Photos	Miscellaneous Land: Difference	Total acres
		Acres												
	Developed watersheds													
8	Harmony Cr., Iowa	2,650	2,777	127 +	350	225	125 -	0	0	0	100	98	2 -	3,100
62	Rocky Branch, Iowa	4,500	4,990	490 +	3,500	2,954	546 -	370	355	15 -	293	364	71 +	8,663
63	Simpson Cr., Iowa	1,700	1,978	278 +	215	150	65 -	263	74	189 -	215	191	24 -	2,393
83	Thompsonville, Kans.	3,139	2,865	274 -	843	827	16 -	0	198	198 +	80	172	92 +	4,062
140	Platte River Trib., Mo.	9,100	7,570	1,530 -	3,100	3,447	347 +	300	452	152 +	300	1,331	1,031 +	12,800
149	Walnut Cr., Kans.	54,094	62,909	8,815 +	23,480	10,159	13,321 -	1,612	1,663	51 +	1,408	5,863	4,455 +	80,594
234	White Clay et al Creeks, Kans.	3,828	4,825	997 +	3,625	3,299	326 -	114	609	495 +	4,972	3,806	1,166 -	12,539
247	Tabo Cr., Mo.	58,666	59,927	1,261 +	19,744	13,316	6,428 -	2,061	3,446	1,385 +	4,424	8,206	3,782 +	84,895
287	Hamburg, Iowa	1,614	1,516	98 -	330	204	126 -	122	97	25 -	299	548	249 +	2,365
363	Nebo Cr., Kans.	5,990	5,361	629 -	2,635	2,848	213 +	619	628	9 +	116	523	407 +	9,360
	Total acres	145,281	154,718		57,822	37,429		5,461	7,522		12,207	21,102		220,771
	Net difference			9,437 +			20,393 -			2,061 +			8,895 +	
	Percent	65.81	70.08		26.19	16.95		2.47	3.41		5.53	9.56		
	Undeveloped watersheds													
895	Little Sni-a-bar, Mo.	13,294	13,664	370 +	7,743	6,506	1,237 -	2,365	2,115	250 -	1,494	2,611	1,117 +	24,896
917	Harley Cr., S.D.	21,600	23,745	2,145 +	4,050	1,424	2,626 -	540	0	540 -	810	1,831	1,021 +	27,000
937	Mud Cr., S.D.	11,772	12,265	493 +	3,482	3,252	230 -	829	43	786 -	497	1,020	523 +	16,580
963	Ledgewood Cr., Iowa	6,503	6,462	41 -	324	412	88 +	265	196	69 -	408	430	22 +	7,500
984	Aowa Cr., Nebr.	47,810	44,064	3,746 -	5,540	6,382	842 +	280	262	18 -	1,720	4,642	2,922 +	55,350
996	Pioneer, Iowa	4,369	4,267	102 -	520	692	172 +	160	111	49 -	231	210	21 -	5,280
1002	Simon Run, Iowa	2,573	2,422	151 -	1,178	851	327 -	285	479	194 +	114	398	284 +	4,150
1049	Clear Cr., Nebr.	47,690	41,769	5,921 -	4,940	2,058	2,882 -	270	36	234 -	1,920	10,957	9,037 +	54,820
1066	Union Cr., S.D.	23,331	26,191	2,860 +	5,454	1,322	4,132 -	0	179	179 +	1,515	2,608	1,093 +	30,300
1068	Tekamah-Mud, Nebr.	13,550	14,124	574 +	3,700	1,553	2,147 -	400	337	63 -	1,430	3,066	1,636 +	19,080
	Total acres	192,492	188,973		36,931	24,452		5,394	3,748		10,139	27,773		244,956
	Net difference			3,519 -			12,479 -			1,636 -			17,634 +	
	Percent	78.58	77.15		15.08	9.98		2.20	1.53		4.14	11.34		

Table 3--Land use estimates by watershed for the Mississippi Delta region

Watershed number	Watershed name	Cropland			Pasture and rangeland			Forest and Woodland			Miscellaneous Land			Total acres
		Base work plan	Photos	Difference	Base work plan	Photo	Difference	Base work plan	Photos	Difference	Base work plan	Photos	Difference	
		Acres												
	Developed watersheds													
51	Caney Cr., Ark.	24,913	21,900	3,013 -	3,178	5,864	2,686 +	9,442	7,765	1,677 -	2,147	4,151	2,004 +	39,680
84	Camp Bayou, Ark.	14,006	15,039	1,033 +	2,036	739	1,297 -	5,558	3,420	2,138 -	156	2,558	2,402 +	21,756
164	Baker Canal, La.	10,389	13,932	3,543 +	1,608	0	1,608 -	6,436	6,372	201 +	3,167	1,296	1,871 -	21,600
174	Randolph-Walnut Lake, Ark.	10,676	9,421	1,255 -	683	1,694	1,011 +	1,066	240	826 -	1,139	2,209	1,070 +	13,564
285	Fourche Bayou, Ark.	9,088	7,910	1,178 -	800	2,065	1,265 +	2,370	1,495	875 -	2,064	2,852	788 +	14,322
290	Arkansas City, Ark.	9,548	9,380	168 -	1,290	1,195	95 -	3,865	3,712	153 -	1,440	1,856	416 +	16,143
310	Bayou Rapids, La.	9,000	11,360	2,360 +	3,400	13,128	9,728 +	81,731	62,261	19,470 -	2,839	10,221	7,382 +	96,970
370	Chicot, Desha, Drew, Ark.	24,231	25,062	831 +	2,065	1,182	883 -	12,970	10,870	2,100 -	1,961	4,113	2,152 +	41,227
426	Crooked Bayou, Ark.	13,874	5,884	7,990 -	1,030	341	689 -	12,500	23,264	10,764 +	4,095	2,010	2,085 -	31,499
546	Canal 18, Ark.	25,991	20,185	5,806 -	466	5,029	4,563 +	8,508	8,973	465 +	3,885	4,663	778 +	28,850
	Total acres	151,716	140,073		16,556	31,237		144,446	128,372		22,893	35,929		335,611
	Net difference			11,643 -			14,681 +			15,809 -			13,036 +	
	Percent	45.21	41.74		4.93	9.30		43.04	38.25		6.82	10.70		
	Undeveloped watersheds													
849	Larkin Cr., Ark.	24,157	24,208	51 +	1,650	2,360	710 +	6,596	5,721	875 -	3,355	3,469	114 +	35,758
879	Central Madison, La.	31,870	33,713	1,843 +	2,500	1,075	1,425 -	57,650	59,381	1,731 +	5,180	3,031	2,149 -	97,200
880	Upper Bayou Teche, La.	101,350	103,044	1,694 +	24,450	5,668	18,782 -	70,000	71,462	1,462 +	14,200	29,826	15,626 +	210,000
893	Tri-county Hopaon Bayou, Miss.	22,980	17,267	5,713 -	2,324	3,447	1,123 +	2,278	3,766	1,488 +	1,388	4,490	3,102 +	28,970
939	Poinsett, Ark.	29,384	24,591	4,793 -	3,050	7,093	4,043 +	8,415	11,455	3,040 +	10,477	8,187	2,290 -	51,326
943	Chatlin Lake Canal, La.	44,000	42,371	1,629 -	28,125	6,238	21,887 -	11,750	18,555	6,805 +	15,625	32,336	16,711 +	99,500
944	Walnut-Roundaway, La.	130,000	143,855	13,855 +	5,000	8,556	3,556 +	78,900	57,696	21,204 -	13,800	17,593	3,793 +	227,700
949	Des Arc Bayou, Ark.	16,640	11,575	5,065 -	33,985	28,113	5,872 -	11,860	23,389	11,529 +	3,000	2,408	592 -	65,485
979	N. Concordia, La.	87,750	117,000	29,250 +	20,250	13,723	6,527 -	101,250	73,574	27,676 -	15,750	20,703	4,953 +	225,000
998	Fish Bayou, Ark.	26,820	25,527	1,293 -	400	0	400 -	1,200	4,092	2,892 +	7,822	6,623	1,199 -	36,242
	Total acres	514,951	543,151		121,734	76,273		349,899	329,091		90,597	128,666		1,077,181
	Net difference			28,200 +			45,461 -			20,808 -			38,069 +	
	Percent	47.81	50.42		11.30	7.08		32.48	30.55		8.41	11.94		

watersheds in the Missouri River region underestimated the amount of cropland, forest and woodland and miscellaneous land uses. Pasture and rangeland uses were overestimated. In the undeveloped watersheds, cropland, pasture, rangeland, and forest and woodland uses were overestimated in the work plans while miscellaneous land uses were underestimated.

In the developed watersheds of the Mississippi Delta region, the work plans underestimated pasture and rangeland and miscellaneous land uses while cropland and forest and woodland uses were overestimated. In the undeveloped watersheds the work plans overestimated pasture and rangeland and forest and woodland uses. Cropland and miscellaneous land uses were underestimated. Work plan estimates of land use in the developed watersheds of both regions were generally less accurate than the work plan estimates made in the undeveloped watersheds.

Work plan estimates of land use were expected to differ from aerial photo analysis data because (1) the time frame for each estimate was not exactly the same, (2) the estimating procedures used in each case are not the same, and (3) neither estimating procedure can be guaranteed to be 100 percent accurate. In order to determine the significance of the differences in the raw data, a paired comparison of the percentages of land in each use was made for the two estimating procedures. The null hypothesis was that the mean of the population of differences was zero. No significant statistical differences were found between the work plan and aerial photo estimates at the .01 level of significance except for miscellaneous land use in nondeveloped watersheds (appendix table 1). Work plan estimates of land use within the watersheds are expected to be as reliable as aerial photo estimates.

ASSESSMENT OF WORK PLAN PROJECTED LAND USE

A comparison of land use projections and aerial photograph data for the developed watershed was made to assess the reliability of projected land use changes in the work plans. An average of 11 years had elapsed from the time the land use projections were made for the work plans until the aerial photograph estimates were made. This time span is sufficiently long for watershed projects to bring about the land use impacts that were anticipated.

Work plan and aerial photo data for watersheds in the Missouri River and Mississippi Delta regions were available and used to make a comparison of the magnitude of the differences between projected and actual land uses. In general, the projections of land use in the project work plans for both the Missouri River and the Mississippi Delta regions are not different from measurements made from the aerial photo data.

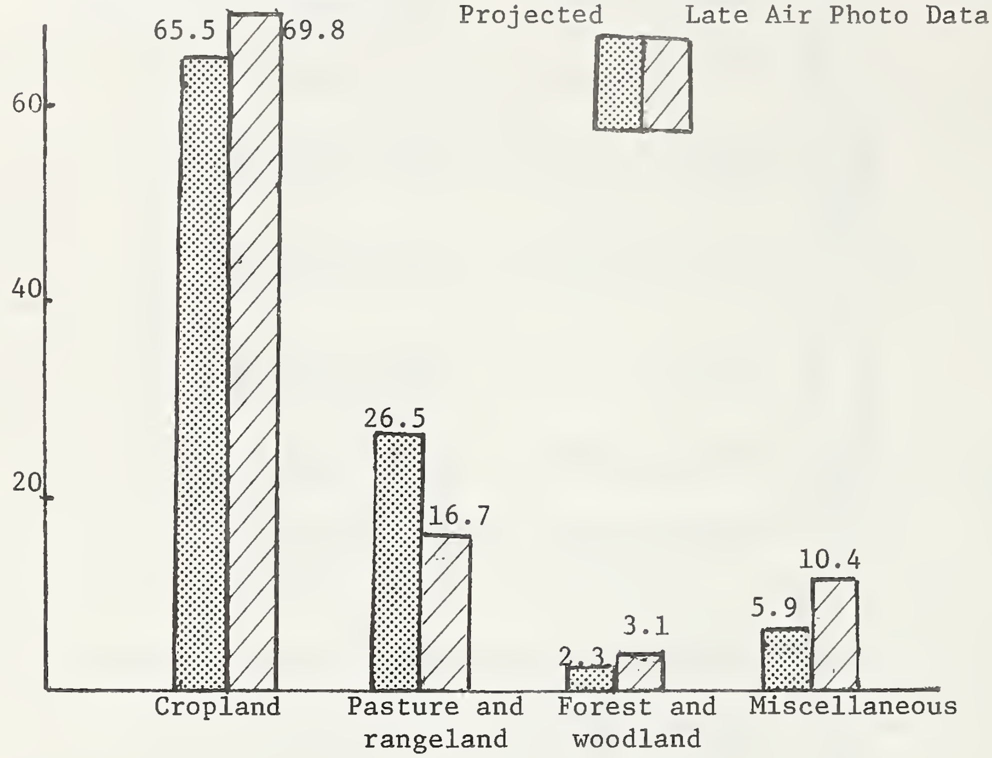
A paired comparison of the work plan and aerial photo land use estimates in the ten watersheds in each region was performed. The data were paired in order to eliminate any source of variance that existed between watersheds. The testing of differences between the two data sets shows that in each of the four land uses there was no statistically significant difference between the two procedures except for forest land use in developed watersheds in the Mississippi Delta (appendix table 2). Projected land use changes within the watersheds are reliable estimates when follow-up aerial photo data are used as the standard for the comparison.

Table 4--Comparison of projected and late air photo land use estimates--Developed watersheds

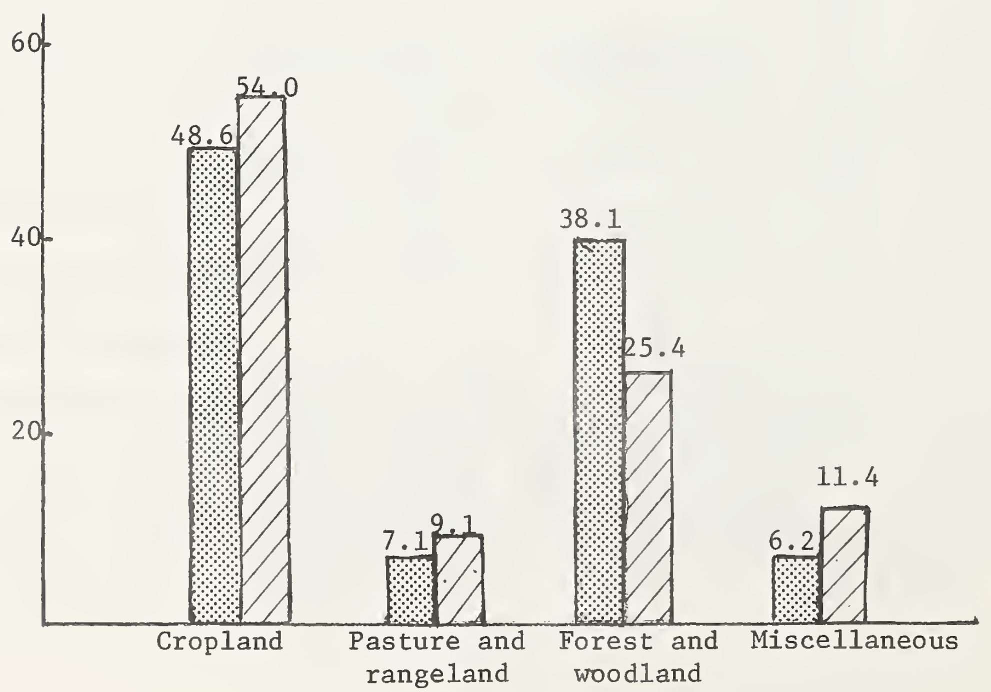
Watershed number	Watershed name	Cropland: Projected	Cropland: Late photo	Cropland: Difference	Pasture and rangeland: Projected	Pasture and rangeland: Late photo	Pasture and rangeland: Difference	Forest and Woodland: Projected	Forest and Woodland: Late photo	Forest and Woodland: Difference	Miscellaneous Land: Projected	Miscellaneous Land: Late photo	Miscellaneous Land: Difference	Total acres
		Acres												
	Missouri River Region													
8	Harmony Cr., Iowa	2,600	2,747	147 +	400	211	189 -	0	0	0	100	142	42 +	3,100
62	Rocky Branch, Iowa	4,515	5,111	596 +	3,485	2,954	531 -	370	234	136 -	293	364	71 +	8,663
63	Simpson Cr., Iowa	1,703	1,974	271 +	224	150	74 -	263	58	205 -	203	211	8 +	2,393
83	Thompsonville, Kans.	3,139	2,823	316 -	843	824	19 -	0	183	183 +	80	232	152 +	4,062
140	Platte River Trib., Mo.	9,400	7,614	1,786 -	2,800	3,420	620 +	300	401	101 +	300	1,365	1,065 +	12,800
149	Walnut Cr., Kans.	50,388	62,937	12,549 +	27,509	9,903	17,606 -	1,409	1,346	63 -	1,288	6,408	5,120 +	80,594
234	White Clay et al Creeks, Kans.	2,749	4,542	1,793 +	4,650	3,080	1,570 -	168	582	414 +	4,972	4,335	637 -	12,539
247	Tabo Cr., Mo.	62,416	59,518	2,898 -	15,323	13,316	2,007 -	1,743	3,446	1,703 +	5,413	8,615	3,202 +	84,895
287	Hamburg, Iowa	1,614	1,495	119 -	330	204	126 -	122	82	40 -	299	584	285 +	2,365
363	Nebo Cr., Kans.	6,027	5,338	689 -	2,598	2,839	241 +	619	576	43 -	116	607	491 +	9,360
	Total acres	144,551	154,099		58,162	36,901		4,994	6,908		13,064	22,863		220,771
	Net difference			9,548 +			21,261 -			1,914 +			9,799 +	
	Percent	65.48	69.80		26.54	16.71		2.26	3.13		5.92	10.36		
	Mississippi Delta Region													
51	Caney Cr., Ark.	22,510	24,899	2,389 +	6,456	5,576	880 -	8,567	4,289	4,278 -	2,147	4,916	2,769 +	39,680
84	Camp Bayou, Ark.	15,345	16,224	879 +	2,921	739	2,182 -	3,334	2,235	1,099 -	156	2,558	2,402 +	21,756
164	Baker Canal, La.	10,699	14,429	3,730 +	1,439	0	1,439 -	6,436	5,832	604 -	3,026	1,339	1,687 -	21,600
174	Randolph-Walnut Lake, Ark.	11,269	9,393	1,876 -	690	1,630	940 +	466	159	307 -	1,139	2,382	1,243 +	13,564
285	Fourche Bayou, Ark.	9,676	7,982	1,694 -	1,022	2,065	1,043 +	1,560	1,319	24; -	2,064	2,956	892 +	14,322
290	Arkansas City, Ark.	10,766	12,124	1,358 +	1,617	1,195	422 -	2,320	952	1,368 -	1,440	2,822	1,382 +	16,143
310	Bayou Rapids, La.	12,400	14,175	1,775 +	3,400	12,955	9,555 +	78,331	58,534	19,797 -	2,839	10,356	7,517 +	96,970
370	Chicot, Desha, Drew, Ark.	27,463	32,050	4,587 +	3,493	1,182	2,311 -	8,310	3,882	4,428 -	1,961	4,113	2,152 +	41,227
426	Crooked Bayou, Ark.	16,969	24,509	7,540 +	2,070	341	1,729 -	9,875	4,639	5,236 -	2,585	2,010	575 -	31,499
546	Canal 18, Ark.	26,068	25,664	404 -	855	5,029	4,174 +	8,508	3,494	5,014 -	3,419	4,663	1,244 +	38,850
	Total acrea	163,165	181,449		23,963	30,712		127,707	85,335		20,776	38,115		335,611
	Net difference			18,284 +			6,749 +			42,372 -			17,339 +	
	Percent	48.62	54.06		7.14	9.15		38.05	25.43		6.19	11.36		

Figure 3--Percentage of land use as projected by work plans compared to late air photo data, developed watersheds

Missouri River Region



Mississippi Delta Region



Watershed Development Impacts

The land use trends are similar for both the developed and undeveloped groups of watersheds (tables 5 and 6). The land use impacts of watershed development appear to be small, and it is difficult to attribute changes in land use to watershed project development.

In the Missouri River region no acreage changes can be attributed to watershed development. The percentage of land in each use between the early and late aerial photo years are almost identical (table 5). Even though the level of each land use for the developed watersheds is somewhat different from that shown by the undeveloped watersheds, there is no discernible difference in the land use trends.

In the Mississippi Delta region land use trends between developed and undeveloped watersheds show some difference (figures 4 and 5). Cropland acres appear to be 3 percent less as a result of watershed development than they would have been without development. Forest and woodland acres are about 4.2 percent larger with development than they would have been without development. Pasture and rangeland acres are about 1.4 percent less with development than they would have been without development. Miscellaneous land uses show no difference between the trend lines.

Importance of Land Use Benefits

Land use benefits make up a relatively small part of the benefits of small watershed development at the national level. Land use benefits accounted for 8.1 percent of total watershed development benefits in 1975 with 6.1 percent credited to "more intensive land use" and 2.0 percent due to "changed land use." However, the relative contribution of

Table 5--Comparison of major land use with and without small watershed development--Missouri River Tributaries region

	Developed watersheds		Undeveloped watersheds	
	Early	Late	Early	Late
	Percent			
Cropland	70.08	69.80	77.43	77.15
Pasture and rangeland	16.95	16.71	10.10	9.98
Forest and woodland	3.41	3.13	1.72	1.53
Miscellaneous	9.56	10.36	10.75	11.34

Table 6--Comparison of major land use with and without small watershed development--Mississippi Delta region

	Developed watersheds		Undeveloped watersheds	
	Early	Late	Early	Late
	Percent			
Cropland	41.74	54.06	35.20	50.42
Pasture and rangeland	9.30	9.15	6.12	7.08
Forest and woodland	38.25	25.43	47.50	30.55
Miscellaneous	10.70	11.36	11.17	11.94

Figure 4--Comparison of cropland and miscellaneous land use trends with and without small watershed development--Mississippi Delta region

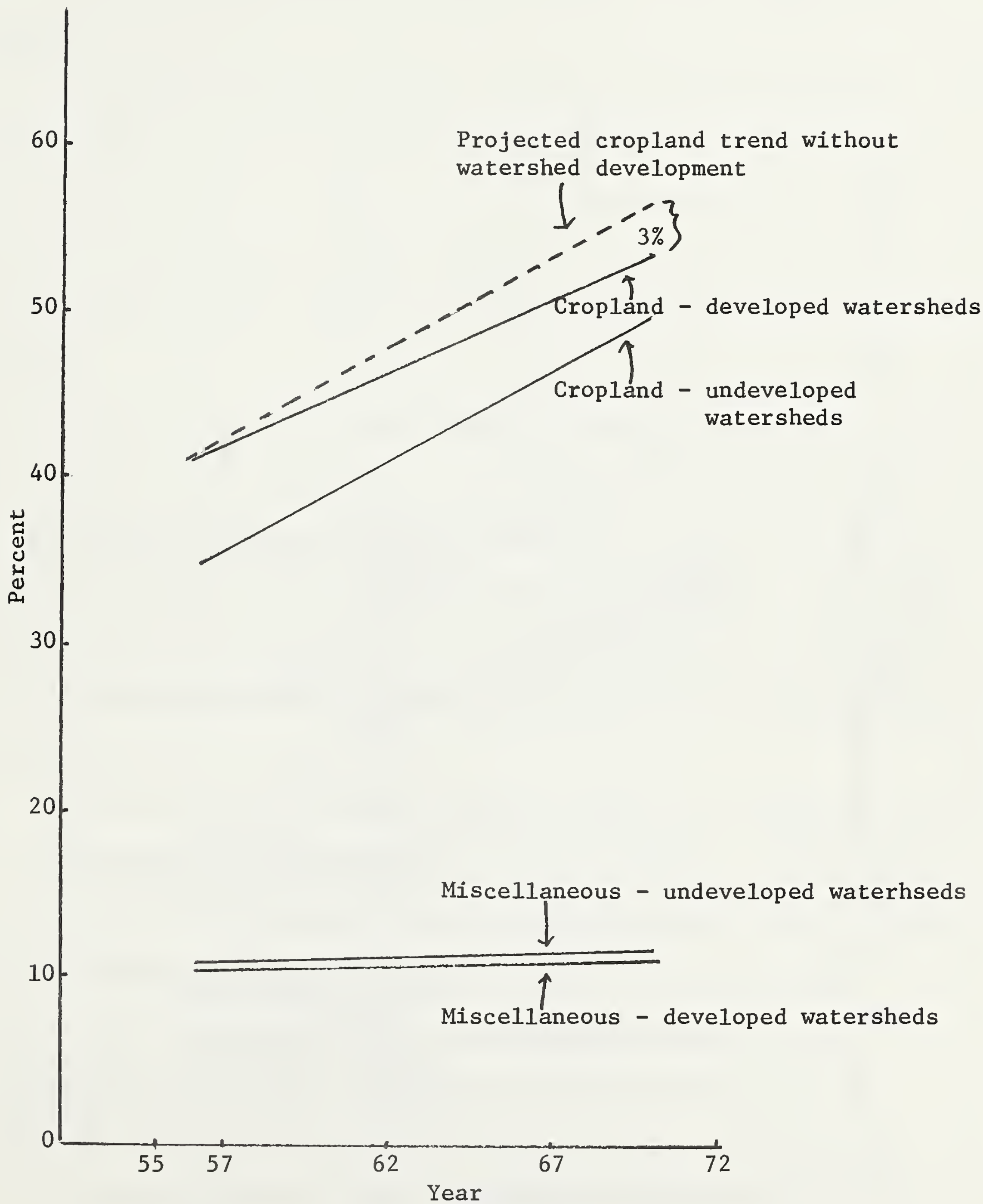
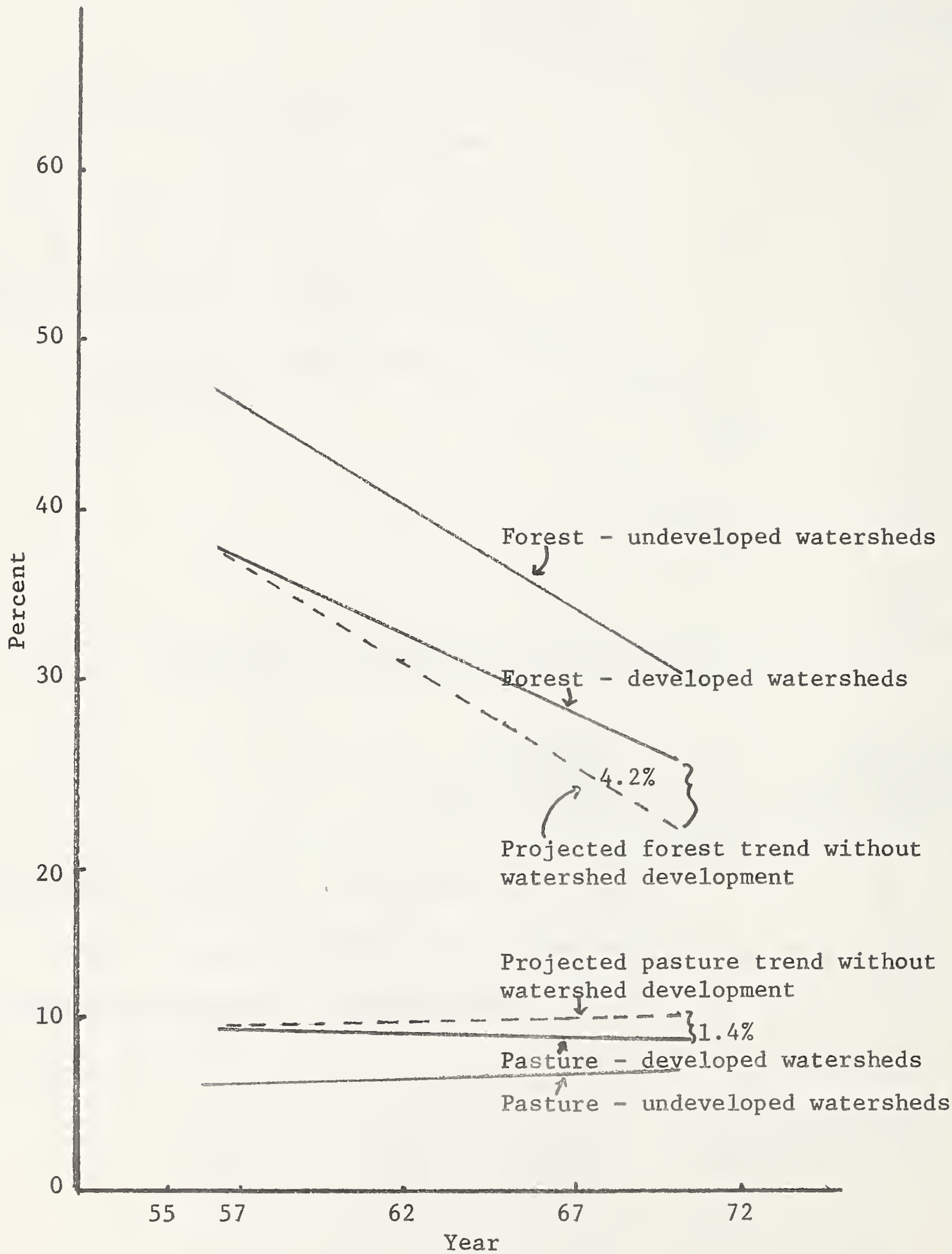


Figure 5--Comparison of forest and pasture land use trends with and without small watershed development--Mississippi Delta region



land use benefits varies considerably among individual watershed projects. Do the 40 projects examined in this study follow the benefit levels claimed nationally? The following analysis tries to answer this question.

The amounts of "more intensive" and "changed land use" benefits varied widely in the 40 watershed projects (table 7). These benefits are also presented as a percent of total structural benefits. "More intensive" and "changed land use" benefits were claimed in 24 of the 40 watershed projects. Only 4 of the watersheds claimed both types of benefits.

Land use benefits provided a total of $310,705 of benefits in the 40 watershed projects and made up 5.03 percent of total flood damage reduction benefits. The average land use benefits claimed in these watersheds are less than the benefits in watersheds nationwide. "More intensive land use" benefits accounted for 3.71 percent while "changed land use" benefits amounted to 1.32 percent of total flood damage reduction benefits.

The distribution of land use benefits among the watersheds as well as among watershed groups shows considerable variation. In 10 percent of the individual watersheds land use benefits amounted to over 30 percent of total flood damage reduction benefits. In the developed Missouri River Tributaries group of watersheds, land use benefits amounted to 9.73 percent of total flood damage reduction benefits (table 8). These benefits were divided so that "more intensive land use" benefits accounted for 1.59 percent and "changed land use" benefits accounted for 8.14 percent of total benefits. Land use benefits for

Table 7--The amount of land use benefits claimed in watershed work plans and land use benefits as a percent of flood damage reduction benefits

Watershed number	Land use benefits: More intensive	Land use benefits: Changed	Land use benefits: Total	Flood damage reduction benefits	Proportion of flood damage reduction benefits: More intensive	Proportion of flood damage reduction benefits: Changed	Proportion of flood damage reduction benefits: Total
	Dollars				Percent		
8	0	1,146	1,146	6,953	0.00	16.48	16.48
51	0	0	0	149,166	0.00	0.00	0.00
62	0	234	234	21,412	0.00	1.09	1.09
63	0	231	231	6,095	0.00	3.79	3.79
83	0	0	0	7,362	0.00	0.00	0.00
84	0	10,695	10,695	133,164	0.00	8.03	8.03
140	0	0	0	16,760	0.00	0.00	0.00
149	0	23,792	23,792	91,539	0.00	25.99	25.99
164	0	0	0	48,806	0.00	0.00	0.00
174	0	3,827	3,827	81,057	0.00	4.72	4.72
234	0	0	0	151,677	0.00	0.00	0.00
247	3,861	12,610	16,471	160,465	2.40	7.86	10.26
285	0	2,920	2,920	59,650	0.00	4.89	4.89
287	0	0	0	5,720	0.00	0.00	0.00
290	0	1,636	1,636	62,931	0.00	2.60	2.60
310	0	0	0	359,006	0.00	0.00	0.00
363	3,832	1,508	5,340	17,352	22.08	8.69	30.77
370	0	10,570	10,570	197,010	0.00	5.36	5.36
426	0	0	0	140,330	0.00	0.00	0.00
546	67,055	0	67,055	178,109	37.65	0.00	37.65
849	0	0	0	128,500	0.00	0.00	0.00
879	8,970	0	8,970	224,112	4.00	0.00	4.00
880	16,030	0	16,030	393,329	4.08	0.00	4.08
893	0	0	0	105,949	0.00	0.00	0.00
895	777	2,937	3,714	65,777	1.18	4.47	5.65
917	19,200	0	19,200	82,100	23.39	0.00	23.39
937	5,750	0	5,750	17,560	32.80	0.00	32.80

Table 7 (cont'd.)

Watershed number	Land use benefits: More intensive	Land use benefits: Changed	Land use benefits: Total	Flood damage reduction benefits	Proportion of flood damage reduction benefits: More intensive	Proportion of flood damage reduction benefits: Changed	Proportion of flood damage reduction benefits: Total
	Dollars				Percent		
939	0	0	0	466,800	0.00	0.00	0.00
943	12,538	0	12,538	331,528	3.78	0.00	3.78
944	32,319	0	32,319	756,336	4.27	0.00	4.27
949	0	6,100	6,100	93,060	0.00	6.55	6.55
963	8,180	3,370	11,550	32,820	24.92	10.27	35.19
979	37,817	0	37,817	865,848	4.37	0.00	4.37
984	0	0	0	157,420	0.00	0.00	0.00
996	1,300	0	1,300	80,020	1.62	0.00	1.62
998	0	0	0	210,550	0.00	0.00	0.00
1002	0	0	0	29,860	0.00	0.00	0.00
1049	0	0	0	36,100	0.00	0.00	0.00
1066	11,500	0	11,500	90,800	12.67	0.00	12.67
1068	0	0	0	112,100	0.00	0.00	0.00
Total	229,129	81,576	310,705	6,175,133	3.71	1.32	5.03

Table 8--The amount and percentage of land use benefits claimed: regional groupings

Watershed	Land use benefits			Flood damage reduction benefits	Proportion of flood damage reduction benefits		
	More intensive	Changed	Total		More intensive	Changed	Total
	- - - - - - Dollars - - - - - -				- - Percent - -		
Developed tributaries	7,693	39,521	47,214	485,335	1.59	8.14	9.73
Developed delta	67,055	29,648	96,703	1,409,229	4.76	2.10	6.86
Undeveloped tributaries	46,707	6,307	53,014	704,557	6.62	0.90	7.52
Undeveloped delta	107,674	6,100	113,774	3,576,012	3.01	0.17	3.18
All developed	74,748	69,169	143,917	1,894,564	3.95	3.65	7.60
All undeveloped	154,381	12,407	166,788	4,280,569	3.60	0.29	3.89
All tributaries	54,400	45,828	100,228	1,189,892	4.57	3.85	8.42
All delta	174,729	35,748	210,477	4,985,241	3.50	0.72	4.22
All watersheds	229,129	81,576	310,705	6,175,133	3.71	1.32	5.03

the developed Mississippi Delta group of watersheds made up 6.86 percent of total benefits with 4.76 percent credited to "more intensive land use" and 2.10 percent credited to "changed land use."

The land use benefits made up a smaller proportion of flood damage reduction benefits in the undeveloped watersheds than in the developed watersheds. The undeveloped Missouri River Tributaries group of watersheds show "more intensive land use" benefits amounted to 6.62 percent of total benefits while "changed land use" benefits accounted for .90 percent of total benefits. The two categories total 7.52 percent of total flood damage reduction benefits. The undeveloped Mississippi Delta group of watersheds show total land use benefits of 3.18 percent with 3.01 percent due to "more intensive land use" and only .17 percent due to "changed land use." The low amounts of "changed land use" benefits claimed in the nondeveloped Delta watersheds indicate that even though large amounts of changed land use were taking place in the area, little, if any, was being attributed to watershed development.

CONCLUSIONS

Procedures used by SCS to project land use changes in small watershed areas were examined to evaluate the reliability and accuracy of the projections. Land use projections were compared to land use information obtained from aerial photographs in selected watersheds in the Missouri River and Mississippi Delta regions. The land use projections provided in watershed work plans were not significantly different from measurements made from aerial photographs. The procedures as outlined in the Economic Guide (35) provide an adequate basis for developing projections of land use changes.

County agricultural census data are useful in estimating land use trends. Aggregating data from several counties provides a reliable estimate of land use trends. However, the variability among watersheds is difficult to account for in any general land use projection procedure. The lack of detail in county data makes the trend analysis for estimating land use change for small watershed areas unreliable unless one can supplement the census data with primary data (as in SCS surveys) for the watershed under consideration.

Current projection techniques used in small watershed evaluation appear to consider the important factors that impact on land use in these small areas. The nine factors identified in the Economics Guide (35) provide a rational basis for estimating the land use changes at the watershed level. However, trying to incorporate these and other factors into a fixed national formulation does not provide the flexibility that is necessary to deal with small areas. Even though the overall trends in land use may apply on a large regional base, individual watersheds possess unique features which cannot be quantified in a general model.

Since land use related benefits at the national level account for only about 8 percent of the total floodwater reduction benefits attributable to small watershed development, an error factor of 10 percent or less in estimates of land use change is difficult to detect. This is true because land use data are subject to error and land use is dynamic rather than static. Agricultural land use varies from year to year because of normal crop rotations, economic consideration and climatic and related production factors. These variations tend to equalize over large areas, but in small areas these variations may not necessarily average out. Therefore, fluctuations in overall land use is a normal occurrence over small areas.

The two regions examined in this study depict a contrast in the magnitude of land use change taking place in each region. Land use in the Missouri River Tributaries region has been rather constant through time. There have been no major shifts in general land uses. Agricultural cropland has been the dominant use and continues to be the dominant use. Land use in the Mississippi Delta region has been and is continuing to undergo a dramatic transformation. The clearing and draining of forest and woodland and converting the acreage to cropland has occurred rapidly. Large amounts of land use change can be attributed to Corps of Engineer projects, but most of the general regional transformation has been accomplished through private investment.

Major changes in land use in the study areas cannot be attributed to small watershed development projects. This implies that the watershed projects did not influence land uses sufficiently to change the pattern or trend in land use developments. This conclusion has major implications for the watershed programs. A broader and more detailed study would be required to determine the impact of watershed projects on land use in project areas.

Factors that need to be considered in future projections of changes in land use include federal legislation and policy with regard to water quality and the preservation of various ecosystems. Since changes in agricultural land use often involve drainage and irrigation, legislation that impacts on water quality and wetlands preservation plays an important role in the projection of changes in land use.

Section 404 of P.L. 92-500, the 1972 Amendments to the Federal Water Pollution Act and the Clean Water Act of 1977 which amended the 1972 law provide the U.S. Army Corps of Engineers with the responsibility for issuing permits for the discharge of dredged or fill materials into navigable waters. Even though most discharges by agriculture are not exempt from the permit system, authority is retained when such discharges are incidental to bringing areas of navigable waters into new uses. Therefore, the section 404 permit program makes the projection of future wetland conversion into agricultural cropland uses somewhat uncertain.

The Secretary of Agriculture's Memorandum No. 1827 revised, Statement of Land Use Policy, declares that the policy of the department will "Advocate the retention of Important Farmlands and Forestlands, Prime Rangeland, Wetlands, or other lands designated by State or local governments. . . . Provisions will be sought to assure that such lands are not irreversibly converted to other uses unless other national interests override the importance of preservation or otherwise outweigh the environmental benefits derived from their protection."

The Secretary's Memorandum indicates that any extensive draining and clearing activities will not be furthered by Department of Agriculture programs. Thus, projection of new cropland from cleared and drained wetlands will need to take these legislative and policy statements into consideration. Past policy restrictions on counting enhancement type benefits from land use change on restricted crop acres imposed limitations on the Small Watershed Program, but these new water quality and environmental policies appear to impose greater limitations. Therefore, small watershed projects must be designed to avoid these new policy restrictions.

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Appendix table 1--Test of significance of differences between work plan estimates and aerial photograph measurements of land use for watersheds in selected regions, 1959

Region and land use	Developed watersheds	Undeveloped waterhseds
	- - "t" values - -	
Missouri River Tributaries		
Cropland	0.45	0.05
Pasture	-2.31	-2.60
Forest	2.66	0.69
Miscellaneous	1.48	3.46*
Mississippi Delta		
Cropland	1.11	-0.71
Pasture	1.19	-1.12
Forest	-0.38	0.96
Miscellaneous	-1.59	1.37

*Different at the .01 level of significance.

* * *

Appendix table 2--Test of significance of differences between work plan projections and aerial photograph measurements of land use changes, 1959-1970, for developed watersheds in selected regions

Land use	Region	
	Missouri River	Mississippi Delta
	- - "t" values - -	
Cropland	0.48	1.23
Pasture	-2.08	0.08
Forest	-0.13	-4.57*
Miscellaneous	2.47	2.74

*Different at the .01 level of significance.