10

STIF

Special

E7.6 10342

CR-147234

(E76-10342) THE OHIO LAND ALLOCATION MODEL: REPORT ON PHASE 1 (Ohio Dept. of Economic and Community) 81 p HC $5.00 CSCL 08B

N76-24662

Unclas

G3/43 00342

20900

The Ohio Land Allocation Model: Report on Phase I

by

Oscar Fisch and Steven I. Gordon

State of Ohio
James A Rhodes, Governor

Department of Economic and Community Development

James A. Duerk, Director

Scientific Investigation Support,
Code 902.6
Contract No. NAS5-22399
ERTS Investigation No. 20900
ITEMS No. 1&2

The Ohio Land Allocation Model: Report on Phase I

by

Oscar Fisch and Steven I. Gordon

Submitted to the Department of Economic and Community Development, January, 1976

ACKNOWLEDGEMENTS

We would like to acknowledge the contributions of several people without whom this project would not be possible. The sometimes impossible, sometimes boring, and oftentimes frustrating task of data gathering and data analysis was made successful by our two interns, Harvey Curran and Richard Hoffman.

We must also give credit to Thomas Martin and Charles Weber of the Department of Economic and Community Development who supervised the execution of this project. Their advice was invaluable throughout the course of the study.

Credit must also go to Debbie Brehm who patiently typed and retyped the report.

Finally, we must credit the Department of Economic and Community Development of the State of Ohio and the National Aeronautics and Space Administration for funding this research. None of the above are responsible for any errors contained herein which, alas must fall to the authors.

This research and its publication was made possible through the funding of the National Aeronautics and Space Administration Goddard Space Flight Center under a contract, NAS5-22399 to the State of Ohio. Additional coordinative and computer support was provided through a comprehensive planning grant from the Department of Housing and Urban Development under the provisions of Section 701 of the Housing Act of 1954, Project Number P-335.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF ILLUSTRATIONS

Chapter I - Overview

Planners and public officials are increasingly aware that economic and population growth can result in untimely, poorly located, and undesirable growth patterns in urban and rural areas. Recognition of this problem has focused attention on changes in land use, property values and tax revenues, and necessary capital expenditures for public services.[1] Concern over such impacts has led several states to require the evaluation of the impacts of land development.[2] Although such regulations can be an effective planning tool, problems often arise due to an incomplete understanding of the land conversion process and the effect that tax policies, land use regulations, and the provision of key facilities have on this process.

At the present time, little theoretical or empirical evidence has been assembled on the factors affecting the land conversion process. A better understanding of this process could serve to alert public officials to the potential land impacts of their decisions and allow planners to recommend policies which would best serve the interests of their communities.

The purpose of this project is to construct a model or models of land conversion among counties in the state of Ohio based on available projections of economic and population growth. As will be shown below, a number of potential approaches are available for this type of task. These include the use of many data sources - tax data, census information, aerial photography, and LANDSAT satellite imagery.

This report reviews the progress made on this project between December, 1975, and January, 1976. The next section reviews the tasks undertaken thus far. This is followed by a more in depth description of these tasks and the work proposed for Phase II of this project.

Tasks Undertaken - Phase I

A number of activities were undertaken for Phase I of the project. The first task was to review models of land use change developed for other areas. This was necessary in order to take advantage of the experiences of other researchers and to put the current modeling effort into perspective. These models are reviewed in the first section of this report.

Given an overview of land use models, the second major task was to review the data available for the current modeling effort. A number of data sources have been assessed thus far. These include data from the State Board of Tax Appeals on land parcels and assessed value in various land categories, census information, employment data, and land use information. Each of these data sources is reviewed in various parts of this report with regard to the quality, comparability, and usefulness of the data in the modeling effort.

Next, a review is made of the potential uses of LANDSAT satellite imagery in land use study. Past attempts to utilize these data are presented. The possible uses of the data in Ohio are reviewed along with some of the potential problems associated with using it in a modeling effort.

Following a review of LANDSAT data, a detailed analysis is made of the methods by which these data will be incorporated into Phase II of this study. This task necessitated a review of the OCAP computer programs of the Ohio Department of Natural Resources which will be utilized to handle and analyze LANDSAT interpretations provided to the State by Bendix Corporation.

The present modeling effort is, of course, dependent on reliable projections of population and employment by industry as inputs. At the present time, the Department of Economic and Community Development (DECD) is utilizing the DEMOS model formulated by Battelle Columbus Laboratories, for this purpose. This model is calibrated with 1970 as the base year. Since data is now available on employment and population through 1974, the next task undertaken in Phase I was to assess the reliability of projections made using the DEMOS model.

Finally, a presentation is made of the general approach utilized in modeling land use change in Ohio. A description is given of several operational models of assessed value and land parcels. A detailed presentation is then made of the models which will be pursued and developed in Phase II of this project.

Review - Models of Land Use Change

Many attempts have been made to model land use changes. Several researchers have attempted only to present the nature of the problems associated with land conversion. Others have sought to review the potential techniques which might be utilized in a modeling effort. Several models of land use change have been developed which center about particular metropolitan areas. This section reviews several of these studies and analyzes their potential applicability to the present study of land use change in Ohio.

The Land Conversion Process

Very little is known about the land conversion process. As one report points out, "Given the popularity of the subject among government officials, urban analysts, and laymen alike, we know surprisingly little about how the land conversion process functions or its real impact."[3] The national Land Use Subcommittee points out that data concerning the rationing of land among competitive urban uses or even from farm to non-farm uses remains very imprecise.[4] Thus, a study of growth in U.S. metropolitan regions could only give general trends concerning population densities, rates of growth and the potential impacts on land.

Yet, land conversion remains one of the most critical determinants of the future quality of life in and around our cities. For this reason, a number of attempts have been made to model land use in urban areas. Many of these empirical models are intimately associated with changes in the transportation network. A review of such models is given by Brown et al.[6] These models do not relate directly to the current research effort and so are not reviewed here. One offshoot of this review was an attempt at an economic model of the land market.[7] This model was not translated into actual land conversion. Thus, the nature of this conversion process was not identified by the model. Several other models have attempted to define the magnitude of land conversion based on various assumptions of urban growth, density, and land competition. These are reviewed below.

The Bay Area Simulation Study (BASS)

One of the first attempts to model urban growth and land use change was undertaken for the area of metropolitan San Francisco.[8] The study encompassed a nine county region around this city. The BASS model utilizes economic projections as inputs and produces as an output the effects of economic change on land absorption. The model operates at the micro level dealing with data by 777 census tracts in the region.

The BASS model assumes that development in the region is driven by changes in industrial location and employment. Thus, given a set of employment projections by industry, the first sector of the model seeks to allocate industries into census tracts. This is done through a combination of two methods. First, a number of regression equations are estimated relating the historical location of each industry to a series of industrial location criteria. Second, opinions of local industrialists and real estate brokers are obtained as to the importance of different factors in the industrial location process. These two pieces of information are utilized to generate a series of binary tests for each census tract on each new industry. The binary test simply asks whether an "essential" characteristic for the location of a particular industry exists in a certain census tract. If not, the industry will not locate there. If the census tract passes the binary test, a group suitability index for the industry is calculated. In order for the industry to be allocated to the tract, BASS requires that this index exceed some minimum value. Once the locations of each industry have been determined, an average size firm is located in the tract requiring land area determined by a land allocation coefficient (LAC) derived from the literature.

At each step in the industrial allocation process of the BASS model, a number of subjective, unconfirmed, and unvalidated decisions are made. Each of the binary tests for "essential" locational factors and each of the indices used to determine locational suitability is derived subjectively. None of the coefficients from the regression equations is reported. Thus, one cannot determine either the statistical significance or the variability of the estimates of these equations. Finally, this industrial allocation submodel does not take into account the competition of different land uses for the same finite land supply.

In the next step of the BASS model, retail employment is allocated based on a gravity model formulation of the willingness of customers (based on job site data) to travel to a retail establishment. Finally, housing sites are located based on a complex algorithm related to existing housing units, demolition of older units, density of development, and demand by employees in industrial and commercial employment.

As was the case with the industrial allocation model, the basis and reliability of the equations in these submodels is not given. The final output of the model is not tested against existing or historical land use trends. Overall, the BASS model remains untested and very poorly documented. Thus, its structure and approach in modeling land use is not usuable or transferable to other areas.

The Harvard Land Use Allocation Model

In a study for the National Science Foundation, the Harvard University Landscape Architecture Research Office (Harvard model) has derived a set of models relating urbanization trends to changes in land use.[9] The study area for this project consists of 756 square kilometers of the southeast sector of the Boston Metropolitan Area. The model begins with exogenous forecasts of population and employment for sections of the study area. As was the case with the BASS model, this is a set of site oriented models driven primarily by changes in industry and then in housing. In this case, sites are classified on the basis of a one hectare grid which was superimposed on the study area. The first part of the industrial allocation model is to forecast the distribution of new firms based on data on firm and site size. However, up until the time of the third year report, no algorithm for performing this distribution has been derived. Given an allocation of firm sizes, firms are located on particular sites "on the basis of the site characteristics important for that particular industrial site selection." (p. 45) No list of such characteristics is given by the authors. Thus, the Harvard model is completely non-operational. In fact, to this point, the modeling team has only derived one structural equation for use in the model. This is a regression equation estimating the expected selling price of a single family house given data on education, taxes, distances from services, the CBD, employment centers, transportation modes, and the visual quality of the site. Since no estimates have been derived for other housing types or for competing land uses, this portion of the model is also non-operational. Thus, this second large scale land use change modeling effort cannot be depended on for guidance in deriving such a model for the State of Ohio.

The Oak Ridge Model

A third major attempt at land use modeling has been undertaken at Oak Ridge National Laboratory.[10] This model recognizes the errors which may accumulate in making local forecasts if they are not constrained by regional and state totals. Thus, their model begins with a step down procedure which allocates growth from the state to the region, local communities, and finally, the 40-acre cell.

Given the total amount of new development which must be distributed in a region, allocation to the cell level is accomplished through an algorithm that utilizes relative attractiveness scores to define where development will occur. Attractiveness is related to the cost, availability, and quality of land, transportation accessibility, utilities, compatability with existing land uses, and industrial park space. Data for 33 variables related to these attractiveness measures were gathered for each cell in the study area around Knoxville, Tennessee. The data are summed into a composite attractiveness score and rank ordered for the community under consideration. The scores are then subdivided into six category groups. These groups represent blocks of cells with different amounts of attractiveness for development. The demands for land in different categories are input to the model by the user. This determination is based on subjective judgement. These land demand totals are then distributed to developments of different density and size. For example, in housing, demand may be satisfied by single family housing or multiple dwelling units. The model allows one to manipulate the distribution of units in particular size and density categories. Similar parameters are input for commercial and industrial developments.

At this stage, the Oak Ridge model has taken regional projections of land use change, calculated the attractiveness of 40-acre cells, and distributed demand to density and size classes. The model then begins with the block of most attractive cells to satisfy the demand for land. Within an attractiveness category, cells are chosen randomly along with a development size and density. If land is available in a cell, that demand is satisfied. If not, another cell is chosen in the next iteration. Demand is satisfied in the order of industrial, commercial, public, and then residential land. The data bases are updated after each iteration of the model to incorporate changes in land use.

One major improvement of the Oak Ridge model over other attempts at land conversion modeling is explicitness. Model components are clearly defined. In addition, each decision made in the model is explained in such a way that the user knows the degree of subjectivity involved with it. Still, this model suffers from some of the same pitfalls found in previous work. The basic problem remains one of little theoretical understanding of the land conversion process. Thus, the model user must subjectively determine the amount of land which will be required by particular industrial, commercial, and residential uses. The Oak Ridge model attempts to control for this subjectivity by utilizing Delphi methods to quantify the opinions of experts in this field.

A second problem with this model is its failure to incorporate the notion of competition among land uses for the same land. It is easy to imagine that in certain areas, residential uses will precede or supercede industrial development as a reflection of suburbanization. The acquisition of public land may lag many years behind private development. The Oak Ridge model provides no method of deciding among these alternative outcomes.

Land Use Modeling Problems

It is evident from the above discussion, that there are a number of common problems which have prevented researchers from formulating an accurate, comprehensive land use modeling system. Foremost among these is a lack of understanding of the process of land conversion. Modeling efforts have had to depend on subjective decisions relating to the amount of land conversion associated with the growth of industry and population. A large error is therefore introduced into the modeling process. For this reason, any future research should first identify the scale and nature of the land conversion process before proceeding to allocate actual changes in use to particular areas.

Another common defect of land conversion models is their failure to consider the complex competition among land uses in urbanizing areas. All the models allocate changes to different uses sequentially, without regard to the interrelationships among uses. It remains impossible to completely model the complex land system. However, an effort must be made to assess the interconnections among land uses in the conversion process in several types of urban and rural areas.

The final, and perhaps most critical, problem associated with land use modeling is the very poor data base available for most areas. Each of the studies cited above notes problems with the modeling process associated specifically with the limitations of the data. These problems range from the lack of information on land use over time to problems with data on land value, population, land quality, and other socio-economic variables.

Land Use Data in Ohio

Given the major problems associated with data on land use cited in other studies, the first task of the present research effort was to undertake an inventory of land use data in Ohio. In order for a predictive model of land use change to be formulated, a consistent data base must be compiled. Such a data base must be accurate, have the same land use categories, and must be compiled for more than one date.

Unfortunately, traditional land use inventories performed as a portion of the comprehensive planning process vary greatly in their accuracy, consistency, and frequency. Nevertheless, these are generally only the source of land use data available for a modeling effort. A review of all the comprehensive plans undertaken in Ohio showed that the land use data base is indeed poor. Table 1 summarizes the results of this survey.

As can be seen from the table, a large number of counties have no land use data available. Thirty-three counties are included in this category. Of the remaining counties, eight counties have land use information in map form only. The other counties have data compiled on the acreage devoted to particular land uses in at least five categories - agricultural, residential, commercial, industrial, undeveloped. Only five counties have data available in more than one year or from more than one source. One can see the wide variation in the time distribution of these data.

It is evident from this review that land use inventories are not an adequate data base from which to derive a model of land use change. It is for this reason that LANDSAT satellite imagery is being considered for this purpose. The characteristics of this data base is given below.

TABLE 1

Land Use Inventories Available For Ohio Counties

County Name	Land Use Data*	Date	County Name	Land Use Data*	Date
Adams	No data	--	Licking	No data	--
Allen	Acreage data	1965	Logan	Acreage data	1968
Ashland	Map only	1972	Lorain	Acreage data	1957,1963
Ashtabula	Acreage data	1971	Lucas	Acreage data	1970
Athens	Acreage data	1969	Madison	No data	--
Auglaize	No data	--	Mahoning	Acreage data	1963
Belmont	No data	--	Marion	Map only	1965
Brown	No data	--	Medina	Acreage data	1957
Butler	Acreage data	1965	Meigs	Acreage	1971
Carroll	Unavailable	--	Mercer	Acreage	1969
Champaign	Acreage data	1968	Miami	Acreage	1965
Clark	No data	--	Monroe	Acreage	1972
Clermont	Acreage data	1965	Montgomery	Acreage	1965
Clinton	No data	--	Morgan	No data	--
Columbiana	Map only	1967	Morrow	No data	--
Coshocton	Acreage data	1968	Muskingum	No data	--
Crawford	Acreage data	1971	Noble	No data	--
Cuyahoga	Acreage data	1959,1971	Ottawa	Acreage	1970
Darke	Acreage data	1965	Paulding	No data	--
Defiance	No data	--	Perry	Map only	1965
Delaware	Acreage data	1969	Pickaway	No data	--
Erie	Acreage data	1969	Pike	No data	--
Fairfield	Acreage data	1973	Portage	Acreage	1959
Fayette	Acreage data	1964	Preble	Acreage	1965
Franklin**	Map only	1964	Putnam	No data	--
Fulton	Acreage data	1970	Richland	No data	--
Gallia	Acreage data	1972	Ross	No data	--
Geauga	Acreage data	1962,1970	Sandusky	Acreage	1972
Greene	Acreage data	1965	Scioto	No data	--
Guernsey	Acreage data	1964	Seneca	No data	--
Hamilton**	Acreage data	1965	Shelby	No data	--
Hancock	Acreage data	1962	Stark**	Acreage	1962
Hardin	No data	--	Summit	Acreage	1959
Harrison	Acreage data	1968	Trumbull	Acreage	1959
Henry	Unavailable	--	Tuscarawas	No data	--
Highland	No data	--	Union	Acreage	1968
Hocking	Acreage data	1966	Van Wert	No data	--
Holmes	Acreage data	1969	Vinton	Acreage	1969
Huron	No data	--	Warren	Acreage	1965
Jackson	Acreage data	1966	Washington	No data	--
Jefferson	No data	--	Wayne	No data	--
Knox	Acreage data	1972	Williams	Acreage	1965
Lake	Acreage data	1957	Wood	Acreage	1960
Lawrence	Acreage data	1971	Wyandot	No data	--

* Data may be available compiled in statistical format (acreage type), in the form of a map, or unavailable.

** Data available from other sources.

LANDSAT Data Review

One potential answer to the unavailability of land use data is the use of LANDSAT (Land Satellite) imagery of land cover. This data has been utilized for several types of land use studies and its advantages and disadvantages have been delineated. According to one study,

> The advantages are:
> 1. High speed processing
> 2. Frequently obtained new data
> 3. Unbiased and uniformly repetetive classification
> 4. Production of print-out maps at a large map scale at relatively low cost (once the system becomes operational)
> 5. The inherent digitizing of land-use data retrievable in virtually any form or combinations of forms.[11]

As this list of advantages states, the major benefit of LANDSAT imagery is its repeatability in time and space and compatability with computer processing. The ERTS-1 satellite passes over the United States with a frequency of once in eighteen days. The cost of compiling and interpreting the LANDSAT data available on computer compatable tapes (CCT's) compares favorably with the cost of conventional aerial photography.[12] Interpretation of land cover is accomplished through the classification of picture elements or pixels based on multispectral data. The data on four bands of the spectrum available from the LANDSAT satellite is first grouped using cluster analysis. This defines groups of pixels with similar spectral signatures. Then, through the identification of areas of known land use, each spectral signature is assigned a land use category. All pixels with spectral signatures within a statistically acceptable range of these values are tabulated with the equivalent land use. Since the data is handled, analyzed, and stored on the computer, convenient manipulation for use in many situations is possible.

The question which must be answered with regard to the current project is whether or not and in what way LANDSAT data can be utilized to model land use change in Ohio.

Several studies give an indication of the potential uses of and, problems with these data. Joyce illustrates several examples of the use of ERTS data in land use studies, one of which recorded land use changes around Washington, D.C.[13] In addition, Joyce points out the need to tie ERTS land use data to other, socioeconomic data bases.

Wray summarizes several projects which seek to combine ERTS data, high altitude photography, and socioeconomic data bases.[14] One major project entitled the "Census Cities" Project will tie ERTS observations with data from the 1970 Census of Population for several major metropolitan areas in the U.S. This information will be utilized to help monitor changes in these urban areas and should serve to aid planners in the delineation and control of urban growth.

These brief examples illustrate the great potential of ERTS imagery for the study of land use. At the present time, however, such studies are not without their technical problems. As Ellefson et al. point out about this data,

> The disadvantages are:
> 1. The inability of the system to discriminate with consistent success between functionally dissimilar but spectrally similar land uses.
> 2. The impossibility of detecting parcel ownership.
> 3. Generalization by resolution element: at 80 meter resolution the complexity of the urban landscape cannot be shown fully.
> 4. Identifications dependent on vegetation vary seasonally.
> 5. Uncontrollable incidence of cloud cover.[15]

In a study using conventional interpretation methods with satellite data, Vegas showed that "... it was found that although major categories are reasonably well defined from ERTS, a significant number of lesser features were incorrectly identified or unidentifiable."[16]

He goes on to say that

> Therefore, only cells that fall upon a uniform, homogeneous area will give representative readings. In essence, for ERTS data, any target area of less than 79 meters (260 feet) in diameter cannot give a true representation in its recorded signal but is averaged with the adjacent cell area automatically.[17]

The highest proportion of errors were found in urban areas. It is for this reason that Ohio-Kentucky-Indiana Regional Council of Governments found that "Urban land use types were similarly confused in LANDSAT categories."[18] Due to the detailed land use categorization requirements of this agency, LANDSAT data had to be supplemented with aerial photo interpretation and field checks.

It is also for these reasons that Wiedel and Kleckner recommend prior ground reconnaissance and follow-up field checks and air photo checks for detailed land use studies using ERTS data.[19] Other studies using computer interpretation of ERTS data have found similar problems.[20] Certain rural and urban uses with similar spectral signatures were not distinguished from one another.

Several methods of dealing with these misclassification problems are currently being developed. One group of researchers has found that utilization of data from two contrasting seasons substantially reduces the errors in identification between urban and rural categories.[21] Another study has geographically subdivided the urban and rural areas and automatically programmed two sets of allowable categories.[22] These and other techniques currently being studied promise to improve the accuracy of LANDSAT interpretation.

One additional technical problem with the utilization of ERTS data is related to the overlay of satellite images for two different years. Due to the distortion of the original data pixels and the subsequent rescanning, readjustment, and reclassification, an error in the range of ± 1 pixel in ground orientation may result.[23]

Thus, there are two major types of errors which occur with LANDSAT data, errors which are due to misalignment (hereafter called Error 1) and errors due to misclassification (hereafter called Error 2). Although ERTS data offers many potential advantages, it is unclear whether or not these errors would allow one to formulate a reliable, predictive model of land use change. The first priority in the study of land use with ERTS data in Ohio must therefore be a characterization of the order of magnitude of each of these errors. A quantification of these errors will delineate the overall reliability of these data and will also serve to indicate where improvement in the techniques related to LANDSAT data analysis are required. The use of LANDSAT in the formulation of predictive land use models must await the quantification of these errors. A major goal of this project is, therefore to quantify Error 1 and Error 2. The methods for doing this are discussed below in Chapter 2.

Using LANDSAT in Ohio

In order to make use of the interpreted Computer Compatible Tapes (CCT's) which will be supplied by Bendix Corporation, a number of additional operations will have to be performed. These operations must be undertaken regardless of the ways in which these data will be input to the land use change models.

OCAP Review

The interpreted tapes from Bendix Corporation will record land use codes for geographic areas in Ohio, one code for each interpreted pixel of LANDSAT. These data will be stored on tape and subdivided by U.S.G.S. 7-1/2 minute quadrangles row by row. One method of handling and analyzing these data is through the use of the Ohio State Department of Natural Resources OCAP programs. Thus, one of the major tasks of Phase I was to review this system of models in terms of their compatability with the data analysis required in modeling land use and assessing the accuracy of LANDSAT.

The first analysis requirement with the LANDSAT data is the superimposition of political boundaries on the U.S.G.S. quadrangle information. This step must be followed by a tabulation of the total amount of land in each category of land use in each political subdivision (in this case counties). OCAP is able to perform both of these tasks once the Bendix data is converted to the proper form. One potential problem which must be born in mind is that DNR does not as yet have all county boundaries digitized. This process could slow down the analysis of LANDSAT data for the land use modeling project. Thus, one of the first steps of Phase II will be to establish a priority list of county boundaries to be digitized.

Another potential problem with the boundary program of OCAP is data loss along the boundaries. Due to the method by which OCAP stores data, pixels along the boundary will be averaged due to scale changes. The potential magnitude of the error caused by this routine is presently unknown and will have to be analyzed.

The next requirement for analysis of LANDSAT data is the mapping of land use data. This will allow the visual comparison of LANDSAT data with land use maps compiled by aerial photo interpretation. OCAP allows such maps to be printed at variable scales. The major problem with the mapping routine is the time consuming printing involved. Thus, use of the routine will be minimized to save computer funds.

The final use of LANDSAT data will potentially require the summarization of categories into new, larger classes. This too is possible using the RECODE options in OCAP.

Other Potential Analysis Techniques

It is evident from the brief discussion of OCAP that these programs will be very useful in analyzing LANDSAT data. An alternative to the use of OCAP is the formulation of new programs designed expressly for the purposes of this project. This may become necessary if the errors associated with the BORDER programs are unacceptably large. Such programs would use matrix formulations to compare LANDSAT data categories from two different years or to compare LANDSAT with other data bases. Part of the work involved in Phase II of this project will be to make an on-line evaluation of OCAP and to write any additional programs which may be required.

A Standard Set of Land Categories

A number of alternative land use classification schemes are possible. Before proceeding to study land use change in Ohio, it is important to establish a standard set of land use categories. One such set has been suggested by the U.S. Geological Survey.[24]

The U.S.G.S. proposes nine "Level I" categories for use with remote sensor data. These are:

(1) Urban and Built-up Land

(2) Agricultural Land

(3) Rangeland

(4) Forest Land

(5) Water

(6) Nonforested Land

(7) Barren Land

(8) Tundra

(9) Permanent Snow and Icefields.

These categories may further be subdivided into more specific "Level II" categories. For the purposes of the present study, the only Level I category for which a finer breakdown is required is "urban and built-up land". Changes within other categories are not related to changes of land use considered here. The Level II categories to be used, if available, are:

Urban and Built-up Land

(1) Residential

(2) Commercial

(3) Industrial

(4) Extractive

(5) Major Transportation, Communication, and Utility Corridors

(6) Institutional

(7) Mixed Urban (urban uses not resolvable)

(8) Open Spaces and Other Urban

Also, major discernable patterns of development (e.g. strip and clustered) will be analyzed.

As previously discussed it will not be possible to accurately determine all of these categories from LANDSAT. Therefore, large scale (i.e., high resolution) aerial photography will be utilized to augment LANDSAT data in order to obtain a finer level of land use categories. The minimum urban categories which will be extracted from aerial photographs are:

Residential

Commercial

Industrial

Major Transportation, Communication, and Utility Corridors

Undeveloped.

Data on these categories should prove adequate for all tasks undertaken in Phase II of this project.

Chapter II - The Land Use Conversion Models

The major task for Phase I of this study was to identify, evaluate, and collect data related to land use conversion in Ohio. The foremost criterion for a variable in this study is some theoretical, empirical relationship to changes in land use. Based on the review of other land use models above, this includes an array of variables on tax base, land value, employment, industrial output, and services.

The major requirement for a variable to be utilized in the modeling effort is that it be consistent through time. This implies that the definition of the variable remain constant. In addition, it must be collected at regular intervals through time and for consistent geographic areas. The types of policy questions which can be answered and the counties which appear in any final model formulations must be dictated by the data base. Thus, before a discussion of the land conversion models which are being developed, the data sources utilized in the study are briefly summarized.

Data Sources

The quality of land use information in Ohio has already been reviewed above. Given the poor quality of such data an attempt was made to find other sources of related information in tax records. The first major source of such data which was reviewed are data available from the State Board of Tax Appeals.

One advantage to utilizing these data are their continuous availability over time. Data on assessed value for land and buildings are available for all 88 Ohio counties in five categories - residential, commercial, industrial, agricultural, and mining. A model constructed from such data would be an indirect indicator of changes in land use over time. A side benefit of such a model is the potential prediction of tax base changes over time. Thus, these data from 1962, 1967, 1972 and 1974 were collected, coded, and placed on computer tape. Data for 1975 will be forthcoming. The analysis of these data are discussed below in the section on Model 2.

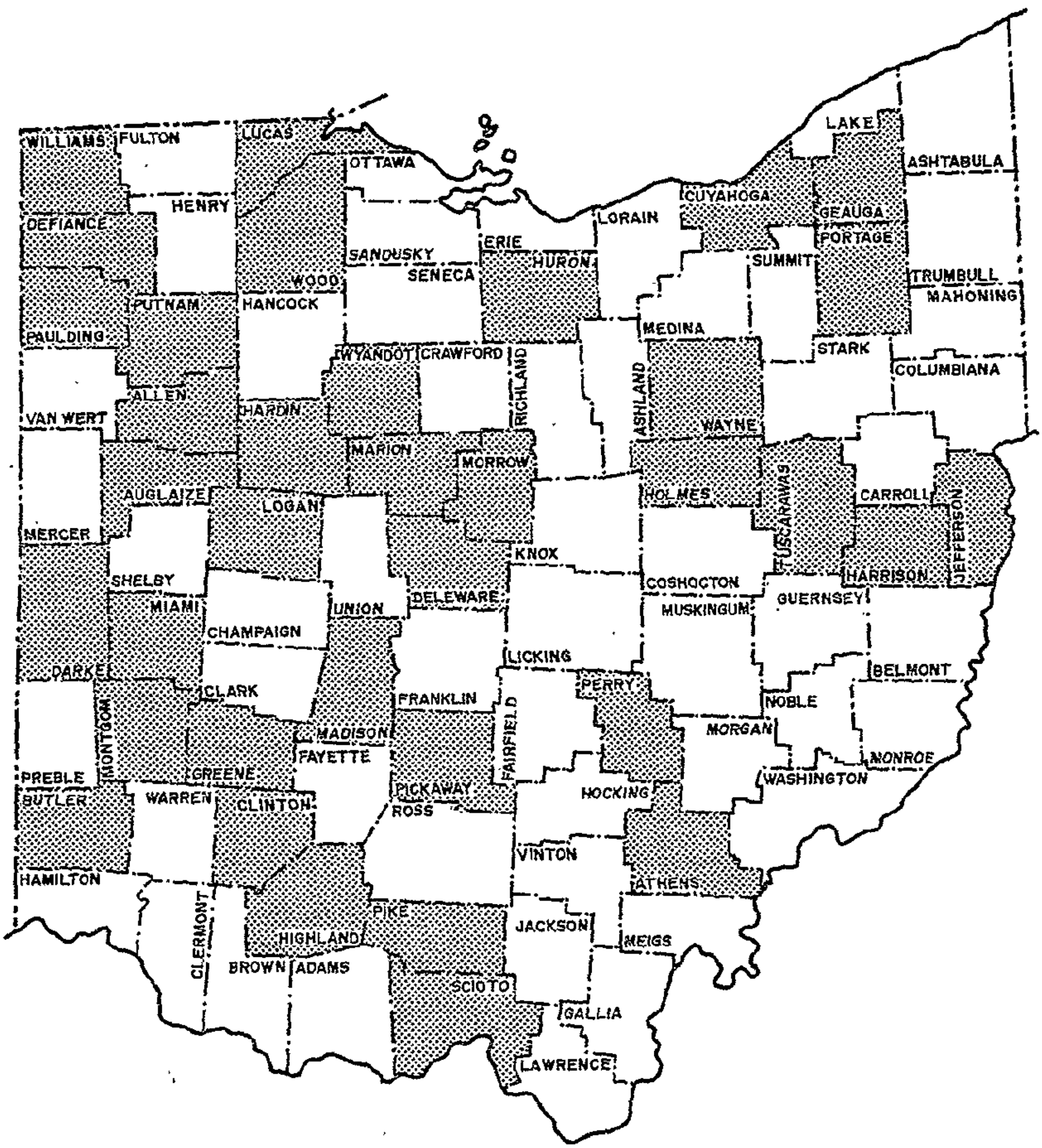
Another subset of tax data are available on parcels in each of the above use categories. Agricultural acreage is also given. The number of parcels are potentially more directly translatable into actual acreages. Unfortunately, these data are only available from 1967 on for 36 counties in Ohio. These counties are shown in Figure 1. These data have also been coded, punched, and placed on computer tape. Their analysis is given under the discussion for Model 1.

Given this set of tax data, an effort was made to establish whether or not parcel data could be translated into actual land use categories. It was thought that a sample of parcel sizes could be taken in each county. This would give a mean distribution of sizes which could then be applied to the parcel data to transform it into actual acreages. Thus, an investigation was made of the manner in which data on tax parcels is stored by county tax authorities. Unfortunately, it was found that the methods of storing such data are inconsistent from county to county and that a sampling of such data would be very tedious and time consuming, yielding very inaccurate results. Thus, this idea was dropped for the present time.

Another idiocyncracy of the tax board data is the categorization of land uses. For tax purposes, a residential parcel is only one with fewer than six units. All other, larger residential units are classified as commercial. Again, an investigation was made into potential methods of subdividing the commercial category into its actual commercial and residential components. One source of information investigated was census data on multiple housing units. It was found that the census categorizes multiple units

FIGURE I.

MAP OF 36 COUNTIES WITH
TAX PARCEL DATA AVAILABLE



of five or more. This of course, does not correspond to the six or more categorizations made for tax purposes. Similarly, building inspections are carried out for buildings with four or more units making use of this data impossible. Thus, the tax data had to be utilized in the models in their present, unadjusted format.

The next major data base investigated was census materials. The Censuses of Business, Retail Trade, Wholesale Trade, and Manufacturers were carried out in 1967 and 1972. Data included employment and output by industry by county. Here, it was found that due to rules on disclosure of information, many pieces of data were missing, even at two digit SIC code level for counties. This makes utilization of this data base very difficult.

Another census related data source which has been investigated is County Business Patterns. This publication is annual and presents data on employment by industry by county. Although there is less missing data, the problem with County Business Patterns is that the most current information is for 1973.

Thus, the next source of economic data investigated was information on employees covered by unemployment insurance available from the Ohio Bureau of Employment Services. The major advantage of these data is their availability on an annual basis through 1974. Data for 1975 will be available by February, 1976. This represents the most current set of information. Correspondence between covered and non-covered employees is good except for government workers. This is illustrated by Table 2.

These data have been assembled for 1962, 1967, 1972, 1973 and 1974. Coupled with 1972 and 1973 estimates of population by the Bureau of the Census, this information has been used to assemble an economic profile of Ohio. In this way, one can see those areas where the most land use changes

TABLE 2

Difference between Covered Employment and Total Employment in Ohio, 1973.[a]

Employment (1000's)

Sector	Total	Covered	Difference	% Difference
Total	4112	3503	609	14.8
Mining	23	23	0	0
Contract Construction	167	168	-1	- 0.6
Manufacturing	1422	1424	-2	- 0.1
Transp. & Util.	224	190	34	15.2
Wholesale & Retail	857	853	4	0.5
Finance	174	168	6	3.4
Services	648	553	95	14.7
Government	596	115	481	80.7
Total w/o Govt.	3516	3388	128	3.6

[a]Employment covered by unemployment insurance. Data from Ohio Bureau of Employment Services, 1973. Total employment data from the Statistical Abstract of the United States, U. S. Dept. Commerce, Bureau of the Census, Table 565, p. 346.

are probably occurring. Tables 3 to 7 summarize the analysis of these data. Counties were ranked based on the changes in total employment, employment in each category, population, and overall change for the period in question.

These tables illustrate a number of trends in Ohio's economy and population. First, one can see that the largest amount of growth is concentrated in and around the largest SMSA's - Cleveland, Columbus, Cincinnati and Toledo. Two counties, Cuyahoga and Hamilton, had large gains in employment and small gains in population. In contrast, surrounding counties experienced a large amount of population growth. This illustrates the effect of commuting and suburbanization. Finally, it should be noted that service, financial, and trade employment, the non-basic industries, were the largest gainers in the urban counties. Based on this analysis, a sample of counties most representative of economic, population, and land use change in Ohio can be drawn for the modeling effort.

One other data question which must be discussed is a method of projection for population and employment which can be used as inputs for future use of the models developed in this study. One model which has been used extensively for this purpose is the DEMOS model developed by Battelle. The model projects population and employment by county to 1985 with a 1970 base year. The question remains whether this model is accurate enough to utilize as the basis for projections of land use change made with the models developed in this study. One method of assessing this accuracy is to test DEMOS projections for 1972 and 1974 against currently available data for these years. DEMOS projections have been made for all Ohio counties for these years in order to make this test. Data are currently being coded and the test will be made as a part of Phase II of this project.

TABLE 3

ECONOMIC PROFILE OF OHIO:

VARIABLE NAMES

TOT-72	1972	
TOT-74	1974	TOTAL EMPLOYMENT
DEL-TOT	Change in	
POP-72	1972	
POP-73	1973	POPULATION
DEL-POP	Change in	
E01-72	1972	
E01-74	1974	MINING EMPLOYMENT
DEL-01	Change in	
E02-72	1972	
E02-74	1974	CONTRACT CONSTRUCTION EMPLOYMENT
DEL-02	Change in	
E03-72	1972	
E03-74	1974	MANUFACTURING EMPLOYMENT
DEL-03	Change in	
E04-72	1972	
E04-74	1974	TRANSPORTATION & UTILITIES EMPLOYMENT
DEL-04	Change in	

TABLE 3 (Continued)

ECONOMIC PROFILE OF OHIO:

VARIABLE NAMES

E05-72	1972	
E05-74	1974	WHOLESALE & RETAIL TRADE EMPLOYMENT
DEL-05	Change in	
E06-72	1972	
E06-74	1974	FINANCE, INSURANCE, AND REAL ESTATE EMPLOYMENT
DEL-06	Change in	
E07-72	1972	
E07-74	1974	SERVICES EMPLOYMENT
DEL-07	Change in	

TABLE 4

SUMMARY STATISTICS, ECONOMIC PROFILE OF OHIO

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

VARIABLE	N	MEAN	STANDARD DEV	VARIANCE	SUM	CORRECTED SS	LOW	HIGH	C.V. %
TOT_72	88	37580.227273	88798.611375	0.788519D 10	3307060.0000	0.686012D 12	1360.000000	638427.00000	236.291
E01_72	88	252.181818	530.302051	0.281220D 06	22192.0000	0.244662D 08	1.000000	3354.00000	210.286
E02_72	88	1737.363636	4078.411242	0.166334D 08	152888.0000	0.144711D 10	19.000000	25208.00000	234.747
E03_72	88	15267.215909	32906.921140	0.108287D 10	1343515.0000	0.942093D 11	365.000000	238566.00000	215.540
E04_72	88	2116.875000	5755.715236	0.331283D 08	186285.0000	0.288216D 10	59.000000	42307.00000	271.897
E05_72	88	9189.659091	23120.683325	0.534566D 09	808690.0000	0.465072D 11	187.000000	167919.00000	251.595
E06_72	88	1836.977273	5562.158768	0.309376D 08	161654.0000	0.269157D 10	40.000000	38560.00000	302.789
E07_72	88	5901.295455	15722.840115	0.247208D 09	519314.0000	0.215071D 11	61.000000	113418.00000	266.430
E08_72	88	1172.443182	3414.433229	0.116584D 08	103175.0000	0.101428D 10	41.000000	29460.00000	291.224
TOT_74	88	43584.818182	100926.068496	0.101861D 11	3835464.0000	0.886188D 12	1818.000000	729088.00000	231.562
E01_74	88	270.500000	546.232509	0.298370D 06	23804.0000	0.259582D 08	1.000000	3534.00000	201.934
E02_74	88	1814.238636	4094.858582	0.167679D 08	159653.0000	0.145880D 10	30.000000	27120.00000	225.707
E03_74	88	16060.965909	33883.799296	0.114811D 10	1413365.0000	0.998857D 11	441.000000	246229.00000	210.970
E04_74	88	2180.272727	5781.859242	0.334299D 08	191864.0000	0.290840D 10	66.000000	42752.00000	265.195
E05_74	88	9830.761364	24506.162563	0.600552D 09	865107.0000	0.522480D 11	206.000000	176717.00000	249.280
E06_74	88	1943.215909	5780.786449	0.334175D 08	171003.0000	0.290732D 10	42.000000	39358.00000	297.486
E07_74	88	6502.681818	17247.625898	0.297481D 09	572236.0000	0.258808D 11	72.000000	124308.00000	265.239
E08_74	88	4866.647727	10496.881106	0.110185D 09	428265.0000	0.958605D 10	322.000000	70503.00000	215.690
POP_72	88	121845.454545	232327.076670	0.539759D 11	10722400.0000	0.469590D 13	10000.000000	1670100.00000	190.674
POP_73	88	122089.772727	230214.916101	0.529989D 11	10743900.0000	0.461090D 13	10200.000000	1645300.00000	188.562
DEL_08	88	3694.204545	8006.898631	0.641104D 08	325090.0000	0.557761D 10	277.000000	60002.00000	216.742
DEL_TOT	88	2310.386364	4397.262645	0.193359D 08	203314.0000	0.168222D 10	2.000000	30659.00000	190.326
DEL_POP	88	244.318182	3277.224013	0.107402D 08	21500.0000	0.934397D 09	-24800.000000	9600.00000	1341.375
DEL_01	88	18.318182	110.785964	0.122735D 05	1612.0000	0.106780D 07	-260.000000	664.00000	604.787
DEL_02	88	76.875000	391.947006	0.153622D 06	6765.0000	0.133652D 08	-2085.000000	1912.00000	509.850
DEL_03	88	793.750000	1511.995258	0.229613D 07	69850.0000	0.198893D 09	-4243.000000	8281.00000	190.488
DEL_04	88	63.397727	157.070636	0.246712D 05	5579.0000	0.214639D 07	-718.000000	628.00000	247.754
DEL_05	88	641.102273	1493.844912	0.223157D 07	56417.0000	0.194147D 09	-98.000000	9013.00000	233.012
DEL_06	88	106.238636	266.662212	0.711087D 05	9349.0000	0.618646D 07	-35.000000	2083.00000	251.003
DEL_07	88	601.386364	1539.232735	0.236924D 07	52922.0000	0.206124D 09	-5.000000	10970.00000	255.947

TABLE 5

COUNTY RANKS FOR EACH CHANGE VARIABLE

OBS	NAME	DEL_POP	DEL_TOT	DEL_01	DEL_02	DEL_03	DEL_04	DEL_05	DEL_06	DEL_07	SUM
1	ADAMS	74.0	8.0	40.0	4.0	31	68.0	10.0	6.0	2.0	243.0
2	ALLEN	7.5	77.0	55.5	53.0	82	78.0	65.0	71.0	73.0	562.0
3	ASHLAND	38.5	39.0	63.0	60.0	54	50.5	18.0	2.0	26.0	351.0
4	ASHTABULA	10.0	75.0	70.0	42.5	80	42.5	70.5	49.0	66.0	505.5
5	ATHENS	5.0	13.0	20.0	12.0	14	39.5	23.0	80.0	14.0	220.5
6	AUGLAIZE	64.0	51.0	20.0	54.5	57	8.0	54.5	37.5	50.0	396.5
7	BELMONT	12.0	19.0	86.0	28.0	3	55.0	36.0	50.5	57.0	346.5
8	BROWN	46.0	15.0	40.0	17.0	28	5.0	25.0	5.0	20.0	201.0
9	BUTLER	86.0	78.0	51.0	77.0	76	85.0	78.0	83.0	69.0	683.0
10	CARROLL	69.5	26.0	76.0	29.0	26	26.0	42.0	69.0	9.0	372.5
11	CHAMPAIGN	64.0	17.0	40.0	35.0	21	24.0	37.0	21.0	12.0	271.0
12	CLARK	10.0	32.0	29.0	7.0	10	80.0	19.0	74.0	70.5	331.5
13	CLERMONT	83.5	69.0	40.0	85.0	49	69.0	64.0	56.0	54.0	569.5
14	CLINTON	46.0	44.0	40.0	66.0	61	30.0	34.0	7.0	3.0	331.0
15	COLUMBIANA	64.0	74.0	81.0	63.0	79	42.5	72.0	60.0	44.0	579.5
16	COSHOCTON	32.5	30.0	84.0	3.0	48	62.0	50.0	28.0	47.0	379.5
17	CRAWFORD	38.5	62.0	40.0	30.0	75	45.5	46.0	40.0	39.0	416.0
18	CUYAHOGA	1.0	88.0	7.5	88.0	87	84.0	87.0	86.0	88.0	616.5
19	DARKE	64.0	41.0	58.5	70.0	42	57.0	21.5	27.0	61.0	442.0
20	DEFIANCE	28.5	36.0	40.0	36.0	37	15.0	47.0	58.0	47.0	344.5
21	DELAWARE	82.0	58.0	70.0	19.0	56	61.0	73.0	67.5	45.0	531.5
22	ERIE	38.5	63.0	24.0	59.0	44	9.0	74.0	62.0	76.0	449.5
23	FAIRFIELD	79.5	56.5	30.0	67.0	55	45.5	59.0	50.5	64.0	507.0
24	FAYETTE	19.0	22.0	40.0	41.0	33	11.0	31.0	12.0	18.5	227.5
25	FRANKLIN	79.5	86.0	13.0	1.0	77	87.0	88.0	88.0	87.0	606.5
26	FULTON	28.5	38.0	40.0	74.0	32	63.5	52.0	42.0	23.5	393.5
27	GALLIA	38.5	70.0	14.0	87.0	8	3.0	60.0	46.0	43.0	369.5
28	GEAUGA	78.0	56.5	51.0	13.0	68	53.0	45.0	17.5	60.0	442.0
29	GREENE	64.0	31.0	58.5	21.5	45	7.0	7.5	21.0	49.0	304.5
30	GUERNSEY	28.5	59.0	1.0	61.0	73	19.0	54.5	3.5	63.0	362.5
31	HAMILTON	3.0	87.0	40.0	2.0	88	1.0	86.0	87.0	86.0	460.0
32	HANCOCK	50.0	54.0	6.0	10.0	59	71.5	67.0	43.5	62.0	423.0
33	HARDIN	46.0	46.0	11.0	72.0	64	28.0	3.0	31.0	22.0	323.0
34	HARRISON	38.5	5.0	60.5	31.0	13	21.0	21.5	35.0	1.0	226.5
35	HENRY	38.5	35.0	40.0	44.0	29	70.0	43.0	25.5	37.0	362.0
36	HIGHLAND	57.0	4.0	28.0	8.5	9	15.0	35.0	64.5	5.5	226.5
37	HOCKING	17.0	7.0	74.0	25.5	4	42.5	28.0	31.0	25.0	254.0
38	HOLMES	38.5	29.0	78.0	49.0	36	32.5	26.0	33.5	17.0	339.5
39	HURON	57.0	53.0	40.0	47.0	63	37.5	56.0	57.0	37.0	442.5
40	JACKSON	69.5	42.0	18.0	14.0	65	39.5	17.0	14.5	10.0	289.5
41	JEFFERSON	14.0	50.0	3.0	81.0	34	81.0	51.0	8.5	48.0	370.5
42	KNOX	32.5	18.0	65.5	52.0	15	73.0	30.0	29.0	41.0	356.0
43	LAKE	83.5	84.0	12.0	46.0	84	71.5	83.0	75.0	80.0	619.0
44	LAWRENCE	14.0	20.0	10.0	51.0	17	66.0	38.0	37.5	40.0	293.5
45	LICKING	28.5	60.0	7.5	57.0	46	50.5	75.0	64.5	72.0	461.0
46	LOGAN	53.5	47.0	26.0	54.5	60	59.5	33.0	43.5	29.5	406.5
47	LORAIN	85.0	83.0	60.5	82.0	85	79.0	80.0	73.0	79.0	706.5
48	LUCAS	7.5	81.0	72.0	86.0	43	77.0	79.0	82.0	85.0	612.5
49	MADISON	46.0	21.0	57.0	40.0	25	31.0	44.0	31.0	15.0	310.0
50	MAHONING	14.0	80.0	63.0	49.0	83	52.0	70.5	78.0	81.0	570.5
51	MARION	23.0	66.0	26.0	56.0	69	49.0	62.0	48.0	67.0	466.0
52	MEDINA	87.0	73.0	22.0	76.0	67	47.0	77.0	77.0	59.0	585.0
53	MEIGS	59.5	45.0	87.0	24.0	19	83.0	4.0	17.5	16.0	355.0
54	MERCER	59.5	48.0	40.0	65.0	53	56.0	48.0	67.5	33.0	470.0
55	MIAMI	64.0	76.0	26.0	45.0	81	4.0	61.0	70.0	68.0	495.0
56	MONROE	53.5	25	88.0	25.5	7	19.0	2.0	14.5	4.0	238.5
57	MONTGOMERY	2.0	65	17.0	5.0	1	2.0	85.0	85.0	83.0	345.0
58	MORGAN	19.0	2	83.0	15.0	11	25.0	5.0	8.5	7.0	175.5
59	MORROW	53.5	12	54.0	38.0	6	23.0	27.0	72.0	27.5	313.0
60	MUSKINGUM	23.0	49	82.0	42.5	35	82.0	58.0	25.5	46.0	443.0
61	NOBLE	28.5	14	20.0	27.0	30	6.0	6.0	12.0	21.0	164.5
62	OTTAWA	69.5	28	75.0	83.0	5	67.0	20.0	40.0	36.0	423.5
63	PAULDING	38.5	6	40.0	16.0	12	36.0	7.5	17.5	38.0	211.5
64	PERRY	77.0	9	77.0	21.5	20	15.0	11.0	12.0	18.5	261.0
65	PICKAWAY	50.0	24	40.0	11.0	38	12.5	39.0	17.5	29.5	261.5
66	PIKE	23.0	11	40.0	19.0	23	28.0	13.0	40.0	8.0	205.0
67	PORTAGE	76.0	72	70.0	23.0	70	63.5	66.0	23.5	75.0	539.0
68	PREBLE	16.0	27	40.0	37.0	39	12.5	32.0	52.5	13.0	269.0
69	PUTNAM	19.0	16	53.0	39.0	22	17.0	29.0	36.0	11.0	242.0
70	RICHLAND	23.0	1	15.5	78.0	2	75.0	53.0	79.0	52.0	375.5
71	ROSS	28.5	64	5.0	80.0	58	59.5	68.0	52.5	58.0	473.5
72	SANDUSKY	53.5	23	2.0	34.0	24	34.5	14.0	46.0	53.0	284.0
73	SCIOTO	10.0	43	40.0	19.0	40	54.0	57.0	54.0	55.0	372.0
74	SENECA	57.0	52	79.0	6.0	71	32.5	15.0	61.0	56.0	429.5
75	SHELBY	74.0	61	55.5	68.0	72	37.5	49.0	55.0	35.0	507.0
76	STARK	88.0	85	85.0	84.0	86	86.0	84.0	84.0	82.0	764.0
77	SUMMIT	4.0	82	65.5	73.0	78	76.0	81.0	1.0	84.0	544.5
78	TRUMBULL	6.0	79	80.0	79.0	62	88.0	82.0	81.0	78.0	635.0
79	TUSCARAWAS	74.0	67	67.5	71.0	66	65.0	69.0	59.0	65.0	603.5
80	UNION	64.0	33	4.0	69.0	50	22.0	16.0	46.0	23.5	327.5
81	VAN WERT	46.0	40	40.0	49.0	47	19.0	40.0	63.0	34.0	378.0
82	VINTON	38.5	3	15.5	32.5	18	34.5	9.0	10.0	5.5	166.5
83	WARREN	69.5	55	23.0	32.5	41	58.0	63.0	3.5	77.0	422.5
84	WASHINGTON	50.0	37	9.0	75.0	51	42.5	1.0	23.5	51.0	340.0
85	WAYNE	72.0	71	67.5	62.0	74	74.0	24.0	66.0	70.5	581.0
86	WILLIAMS	38.5	10	51.0	8.5	16	28.0	41.0	21.0	27.5	241.5
87	WOOD	81.0	68	73.0	64.0	27	48.0	76.0	76.0	74.0	587.0
88	WYANDOT	23.0	34	63.0	58.0	52	10.0	12.0	33.5	31.0	316.5

TABLE 6

COUNTIES RANKED BY 1972 POPULATION

OBS	NAME	SUM *
1	VINTON	2.0
2	NOBLE	1.0
3	MORGAN	3.0
4	MONROE	11.0
5	HARRISON	8.5
6	PAULDING	6.0
7	PIKE	5.0
8	MEIGS	37.0
9	ADAMS	14.0
10	HOCKING	15.0
11	CARROLL	44.0
12	WYANDOT	26.0
13	MORROW	25.0
14	HOLMES	31.0
15	UNION	28.0
16	FAYETTE	10.0
17	GALLIA	41.0
18	PERRY	16.0
19	JACKSON	21.0
20	HENRY	39.0
21	BROWN	4.0
22	MADISON	24.0
23	HIGHLAND	8.5
24	VAN WERT	45.0
25	CHAMPAIGN	19.0
26	CLINTON	29.0
27	HARDIN	27.0
28	PUTNAM	13.0
29	WILLIAMS	12.0
30	COSHOCTON	47.0
31	FULTON	48.0
32	PREBLE	18.0
33	LOGAN	50.0
34	MERCER	63.0
35	DEFIANCE	33.0
36	OTTAWA	54.0
37	SHELBY	68.5
38	GUERNSEY	40.0
39	AUGLAIZE	49.0
40	PICKAWAY	17.0
41	KNOX	38.0
42	ASHLAND	36.0
43	DELAWARE	70.0
44	DARKE	56.5
45	HURON	58.0
46	CRAWFORD	51.0
47	ATHENS	7.0
48	WASHINGTON	32.0
49	LAWRENCE	22.0
50	SENECA	55.0
51	ROSS	64.0
52	HANCOCK	53.0
53	SANDUSKY	20.0
54	GEAUGA	56.5
55	MARION	62.0
56	FAIRFIELD	68.5
57	ERIE	60.0
58	TUSCARAWAS	80.0
59	SCIOTO	43.0
60	MUSKINGUM	59.0
61	BELMONT	35.0
62	WARREN	52.0
63	MEDINA	78.0
64	MIAMI	66.0
65	WAYNE	77.0
66	WOOD	79.0
67	JEFFERSON	42.0
68	CLERMONT	74.0
69	ASHTABULA	67.0
70	ALLEN	73.0
71	COLUMBIANA	76.0
72	LICKING	61.0
73	GREENE	23.0
74	PORTAGE	71.0
75	RICHLAND	46.0
76	CLARK	30.0
77	LAKE	84.0
78	BUTLER	86.0
79	TRUMBULL	85.0
80	LORAIN	87.0
81	MAHONING	75.0
82	STARK	88.0
83	LUCAS	82.0
84	SUMMIT	72.0
85	MONTGOMERY	34.0
86	FRANKLIN	81.0
87	HAMILTON	65.0
88	CUYAHOGA	83.0

*Counties are sorted by their 1972 population (column 1, OBS and NAME). They are then ranked by the sum of total change in population and all employment categories given in Table 5 (SUM).

TABLE 7

'COUNTIES RANKED BY 1972 EMPLOYMENT'

OBS	NAME	SUM *
1	VINTON	2.0
2	NOBLE	1.0
3	MEIGS	37.0
4	CARROLL	44.0
5	PAULDING	6.0
6	ADAMS	14.0
7	MORGAN	3.0
8	MORROW	25.0
9	BROWN	4.0
10	PIKE	5.0
11	PERRY	16.0
12	HOLMES	31.0
13	MADISON	24.0
14	MONROE	11.0
15	PREBLE	18.0
16	HOCKING	15.0
17	JACKSON	21.0
18	WYANDOT	26.0
19	PUTNAM	13.0
20	FAYETTE	10.0
21	HARRISON	8.5
22	CHAMPAIGN	19.0
23	HIGHLAND	8.5
24	HARDIN	27.0
25	UNION	28.0
26	GALLIA	41.0
27	CLINTON	29.0
28	HENRY	39.0
29	VAN WERT	45.0
30	LOGAN	50.0
31	OTTAWA	54.0
32	LAWRENCE	22.0
33	CLERMONT	74.0
34	PICKAWAY	17.0
35	DARKE	56.5
36	MERCER	63.0
37	FULTON	48.0
38	KNOX	38.0
39	COSHOCTON	47.0
40	AUGLAIZE	49.0
41	DELAWARE	70.0
42	GEAUGA	56.5
43	GUERNSEY	40.0
44	WILLIAMS	12.0
45	WARREN	52.0
46	ATHENS	7.0
47	ROSS	64.0
48	DEFIANCE	33.0
49	ASHLAND	36.0
50	SHELBY	68.5
51	HURON	58.0
52	WASHINGTON	32.0
53	CRAWFORD	51.0
54	SCIOTO	43.0
55	SANDUSKY	20.0
56	BELMONT	35.0
57	MEDINA	78.0
58	GREENE	23.0
59	HANCOCK	53.0
60	FAIRFIELD	68.5
61	SENECA	55.0
62	TUSCARAWAS	80.0
63	MARION	62.0
64	MUSKINGUM	59.0
65	COLUMBIANA	76.0
66	MIAMI	66.0
67	JEFFERSON	42.0
68	ASHTABULA	67.0
69	WOOD	79.0
70	PORTAGE	71.0
71	WAYNE	77.0
72	ERIE	60.0
73	LICKING	61.0
74	ALLEN	73.0
75	CLARK	30.0
76	LAKE	84.0
77	RICHLAND	46.0
78	BUTLER	86.0
79	LORAIN	87.0
80	TRUMBULL	85.0
81	MAHONING	75.0
82	STARK	88.0
83	LUCAS	82.0
84	SUMMIT	72.0
85	MONTGOMERY	34.0
86	FRANKLIN	81.0
87	HAMILTON	65.0
88	CUYAHOGA	83.0

*Counties are sorted by their 1972 employment (column 1, OBS and NAME). They are then ranked by the sum of total change in population and all employment categories given in Table 5 (SUM).

General Approach to Land Conversion Modeling

Given a data base with several types of land use, economic, population, and tax data, the approach which will be taken to define models of land use change in Ohio must be delineated. We may first define a set of land use change or tax change categories

$$Y_i = \quad \text{land, category } i;\ i = 1,2,3\ldots n.$$

These categories are defined by the nature of land use or tax information and may include residential, commercial, industrial, etc.

We may also define a set of employment categories

$$X_j = \quad \text{employment, category } j;\ j = 1,2,3\ldots m.$$

Employment is used as the economic indicator because it appears to be the most readily available and complete data set.

Changes in land use (or tax base) Y_i is then given as

$$Y_i = f_1\ (Y_k \neq i,\ \tfrac{X}{V}j).$$

In this equation, changes in land use for category are explained by the endogenous variables Y_k not equal to i (all other land use changes) and all changes in employment.

Not only will competition among uses and employment effect land use and tax structure changes, but also the absolute size of a county's employment, population, and land base will effect land conversion. Then, we can define function 2

$$Y_i = f_2\ (Y_k \neq i,\ \tfrac{X}{V}j,\ Z,\ A)$$

where: Z = total employment or population in the base year

A = total area of the county

Equations of this type can be defined using regression analysis. The advantage of this technique is the output of measures of reliability and statistical accuracy for all resultant equations.

In the sections below, preliminary results for several models are given along with a presentation of the design for Phase II of this study.

Model 1 - Tax Board Data, 36 Counties

Regression equations were defined for the 36 counties with parcel information for 1967 and 1972. The variables list is given by Table 8. Tables 9 to 11 show the intercorrelations amongst the variables used in the analysis. Here, it can be seen that many variables are heavily intercorrelated. Thus, several variables were summed into combined indicators to eliminate redundancy. This was done for household related employment (Tables 12 to 14).

Tables 19 to 21 show the results of the regression analyses. In each tables, the dependent variable is given on the top of the page in capital letters. Then, the regression coefficients are given for the indicated variables and years. The F statistic of significance is given in parentheses after each beta coefficient. At the bottom of each section of the table are given the R^2 statistic and the adjusted R^2, $R^2(a)$. This indicates the amount of variance explained by each regression equation. The constant in each equation (C) is also given in the table. A better understanding of how to interpret each table is given on page 54, explanation of tables.

Model 2 - Tax Board Data, 88 Counties

The second set of regressions were run with the assessed value of land and total assessed value for the 88 counties in Ohio, 1967, 1972, and

1967-1972. Tables 23 to 38 give the results for these models. The tables are constructed in the same fashion as those for Model 1 above. One can see that each of these models is very strong, explaining a minimum of almost 90% of the variance. At this stage, it is not possible to discuss in detail the reasons why certain variables have entered the equations. Several additional tests of the data and equations need to be made in Phase II in order to define a final set of tax base models. What is indicated at this stage is the possibility of constructing very strong explanatory models of the changes in Ohio's tax base.

Model 3 - Land Use Changes

Given the strong relationships found in the other two models, the primary task of Phase II is to construct a model of land use change. This will be accomplished using the same basic equation structure and set of independent variables on employment and population. In Model 3, the dependent variables will be changes in land use in a sample of Ohio counties. These changes will be tabulated from available aerial photographs. At the present time, the reliability of LANDSAT data has not been tested. Thus, this data will not be used in Model 3 to construct a predictive model. These data will be used instead in Model 4.

In order to tabulate the data from aerial photographs required for this model, additional labor input will be required. A methodology for sampling from the aerial photographs to minimize the time required is currently being developed. Once this method is finalized, an estimate can be made of the number of hours required to perform this task. The total will of course vary with the final number of counties in the sample.

TABLE 8

LIST OF VARIABLES

VAR001: COUNTY INDEX NUMBER

VAR002: POPULATION 1967

VAR003: POPULATION 1972

VAR004: TOTAL EMPLOYMENT 1967 (EXCLUDED GOVERNMENT)

VAR005: MINING EMPLOYMENT 1967

VAR006: CONSTRUCTION EMPLOYMENT 1967

VAR007: MANUFACTURING EMPLOYMENT 1967

VAR008: TRANSPORTATION UTILITIES EMPLOYMENT 1967

VAR009: WHOLESALE AND RETAIL EMPLOYMENT 1967

VAR010: FINANCE INSURANCE EMPLOYMENT 1967

VAR011: SERVICES EMPLOYMENT 1967

VAR012: TOTAL EMPLOYMENT 1972 (EXCLUDED GOVERNMENT)

VAR013: MINING EMPLOYMENT 1972

VAR014: CONSTRUCTION EMPLOYMENT 1972

VAR015: MANUFACTURING EMPLOYMENT 1972

VAR016: TRANSPORTATION UTILITIES EMPLOYMENT 1972

VAR017: WHOLESALE AND RETAIL EMPLOYMENT 1972

VAR018: FINANCE INSURANCE EMPLOYMENT 1972

VAR019: SERVICES EMPLOYMENT 1972

IND020: ASSESSED VALUE AGRICULTURAL LAND 1967

IND021: ASSESSED VALUE INDUSTRIAL LAND 1967

IND022: ASSESSED VALUE COMMERCIAL LAND 1967

IND023: ASSESSED VALUE RESIDENTIAL LAND 1967

IND024: ASSESSED VALUE ALL TAXABLE LAND 1967

IND025: ASSESSED VALUE AGRICULTURAL LAND 1972

TABLE 8 (Continued)

IND026: ASSESSED VALUE INDUSTRIAL LAND 1972

IND027: ASSESSED VALUE COMMERCIAL LAND 1972

IND028: ASSESSED VALUE RESIDENTIAL LAND 1972

IND029: ASSESSED VALUE ALL TAXABLE LAND 1972

IND030: ASSESSED VALUE AGRICULTURE BUILDINGS 1967

IND031: ASSESSED VALUE INDUSTRIAL BUILDINGS 1967

IND032: ASSESSED VALUE COMMERCIAL BUILDINGS 1967

IND033: ASSESSED VALUE RESIDENTIAL BUILDINGS 1967

IND034: ASSESSED VALUE ALL TAXABLE BUILDINGS 1967

IND035: ASSESSED VALUE AGRICULTURE BUILDINGS 1972

IND036: ASSESSED VALUE INDUSTRIAL BUILDINGS 1972

IND037: ASSESSED VALUE COMMERCIAL BUILDINGS 1972

IND038: ASSESSED VALUE RESIDENTIAL BUILDINGS 1972

IND039: ASSESSED VALUE ALL TAXABLE BUILDINGS 1972

IND060: TOTAL AG ASSESSED VALUE 1967

IND061: TOTAL IND ASSESSED VALUE 1967

IND062: TOTAL COMM ASSESSED VALUE 1967

IND063: TOTAL RES ASSESSED VALUE 1967

IND065: TOTAL AG ASSESSED VALUE 1972

IND066: TOTAL IND ASSESSED VALUE 1972

IND067: TOTAL COMM ASSESSED VALUE 1972

IND068: TOTAL RES ASSESSED VALUE 1972

V002: DELTA POPULATION 1967-72

V004: DELTA TOTAL EMPLOYMENT (EXCLUDED GOVERNMENT) 1967-72

V005: DELTA MINE EMPLOYMENT 1967-72

V006: DELTA CONSTRUCTION EMPLOYMENT 1967-72

V007: DELTA MANUFACTURING EMPLOYMENT 1967-72

TABLE 8 (Continued)

V008: DELTA TRANSPORTATION EMPLOYMENT 1967-72

V009: DELTA WHOLESALE-RETAIL EMPLOYMENT 1967-72

V010: DELTA FINANCE-INSURANCE EMPLOYMENT 1967-72

V011: DELTA SERVICES EMPLOYMENT 1967-72

V012: DELTA HOUSEHOLD EMPLOYMENT 1967-72

DAR012: HOUSEHOLD EMPLOYMENT 1967

DAR013: HOUSEHOLD EMPLOYMENT 1972

I020: DELTA AG LAND ASSESSED VALUE 1967-72

I021: DELTA IND LAND ASSESSED VALUE 1967-72

I022: DELTA COMM LAND ASSESSED VALUE 1967-72

I023: DELTA RES LAND ASSESSED VALUE 1967-72

I024: DELTA TOTAL LAND ASSESSED VALUE 1967-72

I029: DELTA RES AND COMM LAND A-VALUE 1967-72

I030: DELTA AG BUILDINGS ASSESSED VALUE 1967-72

I031: DELTA IND BUILDINGS ASSESSED VALUE 1967-72

I032: DELTA COMM BUILDINGS ASSESSED VALUE 1967-72

I033: DELTA RES BUILDINGS ASSESSED VALUE 1967-72

I034: DELTA TOTAL BUILDINGS ASSESSED VALUE 1967-72

I060: DELTA TOTAL AG ASSESSED VALUE 1967-72

I061: DELTA TOTAL IND ASSESSED VALUE 1967-72

I062: DELTA TOTAL COMM ASSESSED VALUE 1967-72

I063: DELTA TOTAL RES ASSESSED VALUE 1967-72

I069: DELTA RES AND COMM TOTAL A-VALUE 1967-72

Changes in Urban Land Assessed Values 1967-72

Table 9 - Correlation Coefficients Among Change Variables 1967-72

	I021	I022	I023
I021	1.00000	.89452	.88701
I022		1.00000	.74707
I023			1.00000

Table 10 - Correlation Coefficients of Change Variables with State Variables 1967

	VAR002	VAR004	VAR007	VAR008	VAR009	VAR010	VAR011
I021	.90904	.92279	.91420	.91786	.91407	.92421	.91996
I022	.84145	.83399	.80151	.82698	.84109	.88617	.86053
I023	.95904	.96597	.95858	.96343	.96550	.93449	.95986

Table 11 - Correlation Coefficients of Change Variables with Change Variables 1967-72

	V002	V004	V007	V008	V009	V010	V011
I021	-.66230	.71660	-.81784	.71611	.81608	.78282	.89767
I022	-.31793	.87747	-.61213	.86607	.90241	.86760	.87179
I023	-.73841	.70094	-.91562	.68426	.82666	.84528	.94328

Cases: 88
All Coefficients Significance = 0.001

Aggregation of household oriented employment

Table 12 Correlation Coefficients State Variables 1967

	VAR002	VAR008	VAR009	VAR010	VAR011
VAR002	1.00000	0.98379	0.99333	0.96761	0.98997
VAR008		1.00000	0.99373	0.97374	0.99052
VAR009			1.00000	0.98129	0.99833
VAR010				1.00000	0.98779
VAR011					1.00000

Table 13 Correlation Coefficients State Variables 1972

	VAR003	VAR016	VAR017	VAR018	VAR019
VAR003	1.00000	0.9826	0.9938	0.9677	0.9919
VAR016		1.0000	0.9921	0.9710	0.9899
VAR017			1.0000	0.9825	0.9989
VAR018				1.0000	0.9865
VAR019					1.0000

Table 14 Correlation Coefficients Change Variables 1967-72

	V008	V009	V010	V011
V008	1.00000	0.92942	0.89463	0.85984
V009		1.00000	0.96902	0.95325
V010			1.00000	0.94359
V011				1.00000

Cases: 88
All Coefficients Significance = 0.001

TABLE 15

RESIDENTIAL PARCELS*

	1967	1972	
VAR002	.38724 (72.54)	.39467 (101.91)	VAR003
DAR012	- 1.02500 (12.52)	- .72120 (15.86)	DAR013
C	2252.39	2339.35	
R^2	.99043	.99274	
R^2(a)	.99015	.99253	
VAR002	.22692 (2540.76)	.23963 (3131.02)	VAR003
C	7519.91	7374.84	
R^2	.98679	.98926	
Mean	37473.	38769.	

*Sample of 36 counties

TABLE 16

COMMERCIAL PARCELS*

	1967	1972	
VAR002	.02634 (15.20)	.02087 (13.63)	VAR003
DAR012	-.04967 (1.33)	.01722 (0.43)	DAR013
C	313.18	340.80	
R^2	.96905	.98563	
R^2(a)	.96814	.98521	
DAR012	.11748 (718.12)	.11351 (1640.24)	DAR013
C	1197.63	1035.94	
R^2	.95479	.97969	
Mean	3019.	3440.	

*Sample of 36 counties

TABLE 17

INDUSTRIAL PARCELS*

	1967	1972	
VAR002	.00408 (3.24)	.00305 (1.11)	VAR003
VAR007	- .01259 (.80)	- .00258 (.02)	VAR015
C	164.60	183.54	
R^2	.73970	.74826	
R^2(a)	.73205	.74086	
VAR007	.01260 (84.93)	.01833 (96.66)	VAR015
C	251.88	189.56	
R^2	.71412	.73979	
Mean	477.	539.	

*Sample of 36 counties

TABLE 18

DELTA RESIDENTIAL PARCELS 1967-72

V002	.22972 (29.69)
VAR002	.01170 (22.01)
C	- 22.08444
R^2	.47444
R^2(a)	.45899
Mean	1295.53

VAR002 $<$ 99000

V002	.12603 (1.42)
VAR002	- .01052 (0.43)
C	1027.917068
R^2	.05795
R^2(a)	.02171
Mean	769.10

TABLE 19

DELTA COMMERCIAL PARCELS 1967-72

DAR012	.03506	(283.86)
C	- 47.10469	
R^2	.89304	
Mean	420.91	

VAR002 < 99000

V012	.07869	(.50)
C	- 124.70376	
R^2	.01898	
Mean	- 18.21	

TABLE 20

DELTA INDUSTRIAL PARCELS 1967-72

V007	- .02060 (20.74)
C	35.72305
R^2	.37891
Mean	62.52

VAR002 $<$ 99000

VAR004	.01635 (5.63)
C	- 94.11369
R^2	.17791
Mean	35.07

TABLE 21

DELTA PUBLIC UTILITIES PARCELS 1967-72

V002	- .08740	(5.42)
V004	- .69876	(3.43)
V009	3.04437	(12.69)
VAR004	- .020829	(17.97)
V007	- .065627	(2.99)
V011	1.00701	(2.59)
C	838.81868	
R^2	.53520	
R^2(a)	.45773	
Mean	- 280.58	

VAR002 $<$ 99000

V007	- 2.01662	(3.70)
V002	- .19752	(6.94)
VAR002	- .05081	(3.73)
V011	- .02032	(0.00)
V005	- 2.24002	(1.95)
V004	.80717	(.82)
C	1602.05829	
R^2	.78343	
R^2(a)	.72155	
Mean	- 313.46	

TABLE 22

DELTA RESIDENTIAL AND COMMERCIAL PARCELS 1967-72

V012	.32012	(33.44)
V002	.20393	(21.77)
C	166.62244	
R^2	.50895	
R^2(a)	.49451	
Mean	1716.44	

VAR002 $<$ 99000

V002	.13494	(1.59)
DAR012	- .19329	(.83)
C	1012.97130	
R^2	.07582	
R^2(a)	.04028	
Mean	750.89	

Explanation of Regression-Model Tables (Tables 15-38)

As indicated earlier, equations for the land conversion models can be defined by selected variables using regression analysis. Using Table 23 as an example; we can explain in more detail how one interprets each of the regression-model tables. Table 23 depicts the explanatory models for the dependent variable," assessed value of all taxable land for 1967 and 1972". The dependent variable is always labelled under the table number for each of the regression models.

The regression-model table contains the results of four statistical regression analyses. The first analysis is shown under the column heading "1967" which indicates the year of the dependent variable. The independent variables for this analysis are shown on the left-hand margin. For Table 23 "1967", the independent variables are VAR002 (1967 population), VAR007 (1967 manufacturing employment) and DAR012 (1967 household employment). The first set of numbers (i.e., 311.87, 616.22, 706.34) represents the weight of each independent variable in the regression equation. The associated number in parentheses for each independent variable is the F-statistic which indicates the statistical significance of each independent variable in the regression equation. The regression constant, $C(10^3)$, is shown under the independent variables. Thus the regression equation for 1967 in Table 23 is:

$$Y_{IND029} = 3910.23 \times 10^3 + 311.87\ (VAR002) + 616.22\ (VAR007) + 706.34\ (DAR012)$$

where:

Y_{IND029} = assessed value all taxable land,
VAR002 = total population 1967,
VAR007 - manufacturing employment 1967,
DAR012 = household employment 1967.

When this equation is applied to the 88 Ohio counties, 99.158% of the statistical variance in the model is explained, as indicated by the R^2 value. This example illustrates a highly predictive model. By adjusting the R^2 for the sample size and the number of independent variables, 99.138% of the statistical variance is explained, as indicated by the $R^2(a)$ value.

The results of this regression analysis (i.e. 1967 for Table 23) implies that if data exists for counties in Ohio in 1967 on total population and the two employment types (manufacturing and household), one can predict greater than 99% of the time the 1967 assessed value for all taxable land in the counties. Thus, the implication of the model is potential prediction of assessed value for all taxable land based on projected population and employment data.

Similarly, the regression equations for the three additional models represented in Table 23 can be constructed. These additional models are (1) a simple 1967 model with total population as the only independent variable, (2) a model for 1972 assessed value of all taxable land with three independent variables, and (3) a simple model for 1972 with total population as the only independent variable.

The interpretative procedure, as described above, may be applied similarly to the other regression-model tables presented in this report.

TABLE 23

ASSESSED VALUE ALL TAXABLE LAND

	1967	1972	
VAR002	311.87 (42.82)	241.18 (4.57)	VAR003
VAR007	616.22 (10.07)	1396.09 (10.44)	VAR015
DAR012	706.34 (7.95)	1818.68 (20.02)	DAR013
$C(10^3)$	3910.23	5926.65	
R^2	.99158	.98487	
R^2 (a)	.99138	.98452	

	1967	1972	
VAR002	514.66 (8238.20)	823.90 (4216.44)	VAR003
$C(10^3)$	- 1544.06	- 9123.26	
R^2	.98967	.98001	

	1967	1972
Mean Value	61322779.	91265538.
Max	954572500.	
Min	4251867.	4162957.

TABLE 24

ASSESSED VALUE RESIDENTIAL LAND

	1967		1972		
VAR002	281.07	(134.62)	155.63	(3.89)	VAR003
VAR007	321.24	(10.59)	1432.29	(22.46)	VAR015
DAR012	- 134.46	(1.11)	794.20	(7.80)	DAR013
$C(10^3)$	- 6615.45		- 8587.46		
R^2	.99396		.98181		
$R^2(a)$	.99382		.98138		

	1967		1972		
VAR002	309.48	(12453.19)	524.62	(3487.89)	VAR003
$C(10^3)$	- 6809.64		- 16554.28		
R^2	.99314		.97594		

	1967	1972
Mean Value	30993644	47368497
Max	534298875	952651250
Min	593000	669640

TABLE 25

ASSESSED VALUE COMMERCIAL LAND

	1967		1972		
DAR012	761.74	(16.16)	963.34	(105.78)	DAR013
VAR002	31.09	(.74)	43.34	(2.78)	VAR003
VAR007	83.76	(.32)	- 155.56	(2.44)	VAR015
$C(10^3)$	- 2769.09		- 3014.81		
R^2	.95306		.98951		
$R^2(a)$	.95196		.98926		

	1967		1972		
DAR012	1042.21	(1693.71)	1063.58	(7808.85)	DAR013
$C(10^3)$	- 1432.76		- 2016.91		
R^2	.95168		.98911		

	1967	1972
Mean Value	12652290.	18238812
Max	327851750	393033937
Min	94400	94400.

TABLE 26

ASSESSED VALUE INDUSTRIAL LAND

	1967	1972	
DAR012	390.66 (50.40)	460.04 (31.37)	DAR013
VAR007	262.71 (37.93)	505.33 (33.52)	VAR015
VAR002	- 56.50 (29.13)	· 97.21 (18.10)	VAR003
$C(10^3)$	599.97	566.59	
R^2	.94917	.92639	
$R^2(a)$	.94797	.92466	
		510.13 (759.30)	VAR015
$C(10^3)$		- 2590.49	
R^2		.89826	
Mean Value	3142700.	5197847.	
Max	91787312.	13082312.	
Min	5130.	34340.	

TABLE 27

DELTA RESIDENTIAL LAND ASSESSED VALUE 1967-72

(10^3)

VAR002	.16464	(492.08)
V002	- .89555	(40.00)
I020	1.28365	(12.00
IND020	- .48910	(5.97)
C	- 3761.07	
R^2	.94862	
R^2(a)	.94363	

Mean	16374851.
Min	
Max	

TABLE 28

DELTA RESIDENTIAL LAND ASSESSED VALUE 1967-72

(10^3)

V004	- 1.66589	(53.50)
VAR002	.25494	(777.06)
I020	.88711	(7.30)
IND020	- .41250	(4.70)
C	- 4934.11	
R^2	.95370	
R^2(a)	.95204	
Mean	16374851.	
Min		
Max		

TABLE 29

DELTA INDUSTRIAL LAND ASSESSED VALUE 1967-72

(10^3)

V007	.46125	(13.39)
VAR007	.05887	(5.58)
IND021	.57523	(35.43)
I020	- .06069	(1.14)
C	- 89.95	
R^2	.89605	
R^2(a)	.89234	

Mean	2055146.
Min	
Max	

TABLE 30

DELTA COMMERCIAL LAND ASSESSED VALUE 1967-72

(10^3)

V012	1.37676	(53.21)
DAR012	.69014	(33.59)
IND0022	- .63634	(110.99)
VAR002	- .01738	(1.04)
C	- 1179.52	
R^2	.92153	
R^2 (a)	.91873	
Mean	5586520	
Min		
Max		

TABLE 31

LTA RESIDENTIAL & COMMERCIAL LAND ASSESSED VALUE 1967-72

(10^3)

DAR012	1.31460	(23.57)
V004	- .60024	(5.41)
I020	.78633	(4.12)
IND020	- .26005	(1.63)
IND022	.12720	(0.60)
IND023	.17469	(3.06)
C	- 161.73	
R^2	.97176	
R^2(a)	.97004	
Mean	21961372	
Min		
Max		

TABLE 32

TOTAL RESIDENTIAL ASSESSED VALUE

	1967	1972	
VAR002	800.91 (47.00)	1045.48 (137.11)	VAR003
DAR012	1796.16 (8.55)	- 319.99 (0.988)	DAR013
VAR007	793.12 (2.77)	2119.45 (38.38)	VAR015
$C(10^3)$	- 10247.39	- 14857.72	
R^2	.99067	.99596	
$R^2(a)$	.99045	.99587	

	1967	1972	
VAR002	1198.32 (7986.63)	1272.21 (14314.98)	VAR003
$C(10^3)$	- 21942.23	- 16219.37	
R^2	.98935	.99395	

	1967	1972
Mean Value	155396375	186115312
Max		
Min	3793700	4432020

TABLE 33

TOTAL COMMERCIAL ASSESSED VALUE

	1967	1972	
VAR007	3650.52 (40.78)	- 140.67 (0.382)	VAR015
VAR002	- 448.47 (10.21)	198.84 (11.21)	VAR003
DAR012	1822.81 (6.11)	1397.15 (42.58)	DAR013
$C(10^3)$	1991.86	7264.12	
R^2	.89306	.98750	
$R^2(a)$	.89054	.98720	
		2222.99 (5743.31)	DAR013
$C(10^3)$		- 911.74	
R^2		.98525	
Mean Value	42365719	59645348	
Max			
Min	638860	648710	

TABLE 34

TOTAL INDUSTRIAL ASSESSED VALUE

	1967	1972	
VAR007	1452.89 (42.16)	1709.25 (72.48)	VAR015
DAR012	1126.43 (15.23)	475.99 (6.34)	DAR013
VAR002	- 165.37 (9.06)	- 107.92 (4.24)	VAR003
C(10^3)	4032.30	2605.32	
R^2	.94837	.96093	
R^2(a)	.94715	.96001	

	1967	1972	
VAR007	1504.07 (1323.89)	1663.31 (1960.11)	VAR015
C(10^3)	1757.08	- 778.20	
R^2	.93900	.95797	

	1967	1972
Mean Value	25230578.	29808551.
Max	507840250.	518877812.
Min	88340.	285720.

TABLE 35

DELTA TOTAL RESIDENTIAL ASSESSED VALUE 1967-72

(10^3)

VAR002	.21989	(256.09)
I060	3.45933	(65.29)
IND060	- .58045	(6.60)
V002	- .62063	(5.68)
C	1541.68	
R^2	.87569	
R^2(a)	.87129	
Mean	30718944.	
Min		
Max		

TABLE 36

DELTA TOTAL COMMERCIAL ASSESSED VALUE 1967-72

(10^3)

V012	12.61351	(77.63)
V002	1.31763	(10.64)
I060	- 1.68601	(34.28)
DAR012	- 1.87392	(12.13)
VAR002	- .19966	(12.18)
IND060	.40007	(7.01)
C	- 2737.17	
R^2	.93974	
R^2(a)	.93607	
Mean	17279623.	
Min		
Max		

TABLE 37

DELTA TOTAL INDUSTRIAL ASSESSED VALUE 1967-72

(10^3)

VAR002	- .02170	(2.63)
V002	.48332	(52.43)
VAR007	.52989	(26.53)
V007	1.12970	(18.17)
IND060	- .08291	(3.00)
I060	.13780	(2.55)
C	918.80	
R^2	.76963	
$R^2(a)$	.75559	

Mean	4577979.
Min	
Max	

TABLE 38

LTA RESIDENTIAL & COMMERCIAL TOTAL ASSESSED VALUE 1967-72

(10^3)

V012	1.72848	(1.75)
V002	3.41777	(72.99)
VAR002	.40056	(24.53)
I060	1.85202	(20.88)
IND060	- .44851	(4.22)
C	8810.51	
R^2	.95629	
R^2(a)	.95419	

Mean	47998566.
Min	
Max	

Model 4 - Establishing the Reliability of LANDSAT Data

The largest contribution which LANDSAT can make to the planning process is in the provision of a repeatable, reliable data base on land use and land use change. Once the reliability of these data have been established, LANDSAT information can be directly incorporated into the modeling process established by Model 3. Thus, LANDSAT will become directly linked, in both a static and dynamic model, with socioeconomic data available from other sources.

The purpose of Model 4 is to establish, in quantitative terms, the errors associated with LANDSAT data. Two types of errors will be quantified. Error 1, the error associated with rescanning and geometric adjustment will be estimated by comparing the land use classification given to a small area (such as one or two counties) for an 18 or 36 day gap in ERTS information. During this short time period, land uses will not change significantly. Thus, any differences in classification for pixels in the area must be due to Error 1.

Error 2, the error caused by misclassification, will be established for Franklin and surrounding counties for 1972, 1975, and the change matrix for these dates. This will be accomplished through the analysis of aerial photographs (used also in Model 3) and with some field checking. In each year, land uses will be tabulated from the aerial photographs and compared with the interpretations given by Bendix interpretation of ERTS, CCT's. This model will thus yield a quantitative error term which might be employed as a correction factor so that ERTS data will be more useful in the State of Ohio.

Summary of Tasks for Phase II

A number of tasks must be performed in Phase II of the project. These are:

1. Continue work on Models 1 & 2 to arrive at a more refined model of tax parcels and assessment changes.
2. Use results of Models 1 & 2 to supervise programming of final predictive models.
3. Assemble, with the help of DECD, land use data from aerial photographs.
4. Utilize the data collected in Task 3 to derive a predictive model of land use change, Model 3.
5. Utilize LANDSAT data from 1972 and 1975, and data for one 18 day time gap, to quantify Errors 1 & 2 associated with LANDSAT data use, Model 4.
6. Use results of Models 3 and 4 to supervise programming of final predictive models.
7. Make an evaluation of the accuracy of DEMOS.
8. Prepare a final written report and make a final presentation.

Method of Analysis for Phase II

Phase II will involve the refinement and programming of each of the equations derived in Models 1 & 2. In order to calibrate a set of equations for Model 3, data will be gathered from aerial photographs on the changes in land use for a sample of 10-20 Ohio counties. The number of counties in the sample will depend largely on the funds available for this task. For each county a set of aerial photographs will be obtained for two different years. Since economic data and population estimates are available for each year, any two years with a three to five year gap will be sufficient to detect land use change. Therefore, the photographs will first be used to select a sample of those areas where land use changes have occurred. This will be accomplished by placing a clear plastic overlay on each frame of the county's photo mosaic for the earlier year and tracing the shapes of all urban land uses. This overlay will then be placed over the photographs from the later year. Any land use changes will appear as a different pattern on the later photo. By using standard aerial photo-interpretation techniques, for each frame where a detected change has occurred a characterization will be made of the initial and final land uses and the area involved in the change.

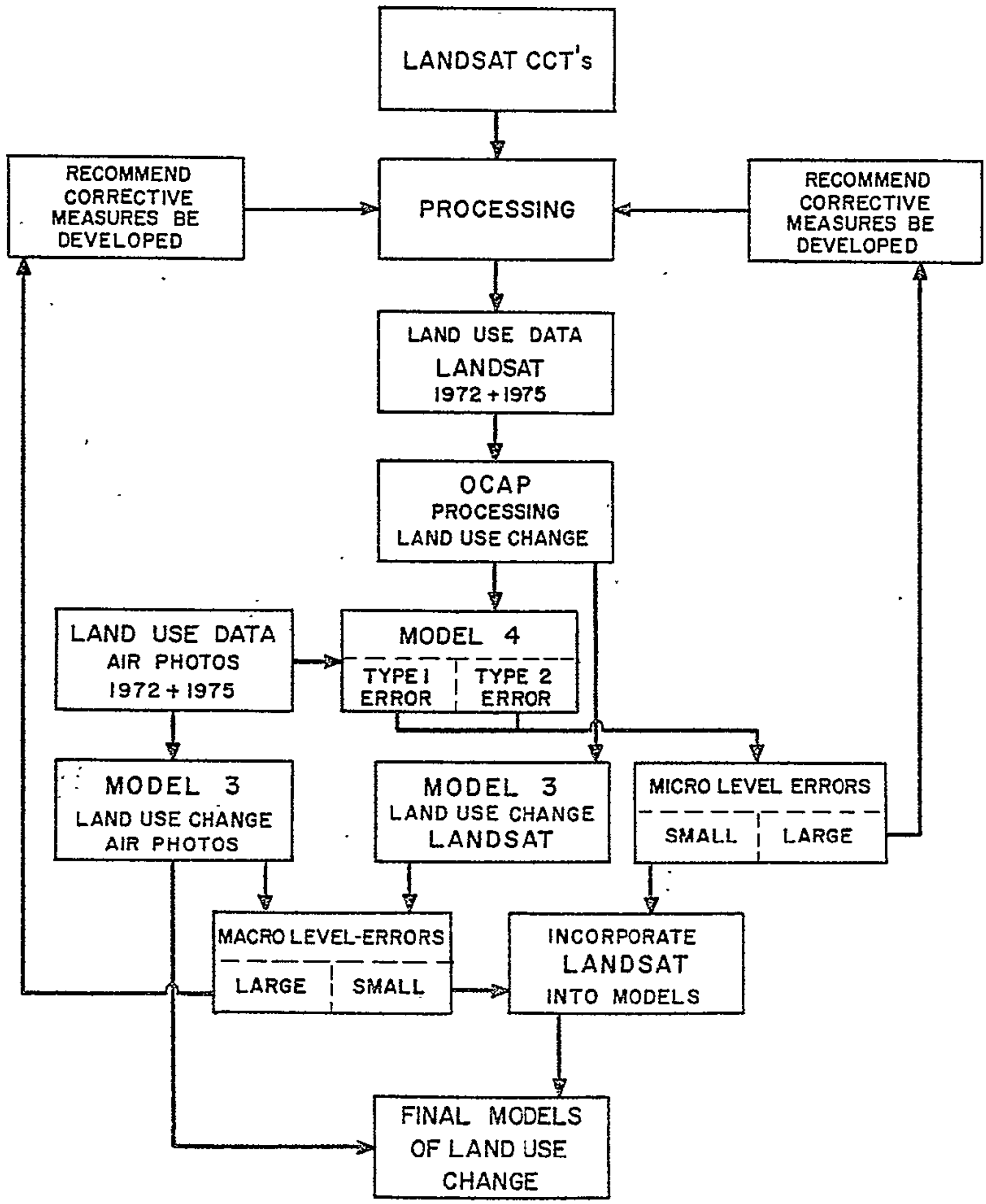
Given a set of data on land use changes in the sample of counties, a model of land use conversion will be generated using regression analysis. The independent variables for this new model (Model 3) will be the same as those used in Models 1 and 2. The dependent variables will be the land use change categories.

In order to generate the data for Model 4, a number of operations will be performed. First, aerial photographs of Franklin County and surrounding counties will be analyzed for changes in land use between 1972 and 1975. In this case, a complete characterization will be made of the land use mix in each of these years. Next, the LANDSAT data interpretations provided by Bendix Corporation will be subjected to the types of analysis described previously under the review of the OCAP system. This will include not only complete coverage of those areas for 1972 and 1975 but also will include an 18 day gap for one selected area. Thus, three sets of land use data will be available - land use information generated by aerial photo-interpretation for 1972 and 1975, LANDSAT coverage for the same area in the same years, and LANDSAT coverage for a smaller area for one 18 day period difference from the 1972 coverage.

Figure 2 illustrates how the LANDSAT will fit into Phase II of the project. As can be seen in this flow chart, LANDSAT will be utilized in two major ways. First, data from the aerial photos and the 18 day gap from LANDSAT will be utilized to identify Error 1. Error 2 will be quantified by comparing LANDSAT data to aerial photo data for both years. These are labelled as micro-level errors since they are related to technical and classification errors at the pixel scale. If these errors are small, LANDSAT may be directly incorporated into the modeling process. If the errors are large, further research on error correction can be recommended.

The second way in which LANDSAT will be incorporated into Phase II is by direct application in the formulation of an alternative set of models to Model 3. In this way, the resulting regression coefficients from LANDSAT data may be compared with those from Model 3 which utilized aerial photos. It may be that Errors 1 & 2 "average out" on the macro-scale and do not significantly effect the models constructed here. By comparing the coefficients generated in each set of models, a determination can be made of the macro-scale errors associated with LANDSAT. A similar decision can be made regarding the incorporation of LANDSAT into the land use modeling process.

FIGURE 2
INCORPORATION OF LANDSAT INTO THE MODELING PROCESS



JC 1-76

The final output from Phase II will thus be a series of more refined tax models and a set of land use change models derived from both aerial photographs and LANDSAT.

Footnotes

1. Land Use Subcommittee of The Advisory Committee to HUD, Urban Growth and Land Development, (Washington, D.C.: National Academy of Sciences, 1972); Jerome P. Pickard, Dimensions of Metropolitanism, (Washington, D.C.: Urban Land Institute Research Monograph 14, 1967); Office of Area Development, U.S. Department of Commerce, Future Development of the San Francisco Bay Area 1960-2020, (Washington, D.C.: U.S. Superintendent of Documents, 1959.)

2. K. Christensen et al. State-Required Impact Evaluation of Land Developments, (Washington, D.C.: The Urban Institute, 1974.)

3. Land Use Subcommittee, Urban Growth and Land Development, (Washington, D.C.: National Academy of Sciences, 1972), p. 2.

4. Ibid., p. 13.

5. Jerome P. Pickard Dimensions of Metropolitanism. (Washington, D.C.: Urban Land Institute Research Monograph 14, 1969.)

6. H. James Brown, J. Royce Ginn, Franklin J. James, John R. Kain, and Mahlon R. Straszheim, Empirical Models of Urban Land Use: Suggestions on Research Objectives and Organization, (New York: Columbia University Press, National Bureau of Economic Research, Exploratory Report 6, 1972.)

7. Gregory K. Ingram, John F. Kain, J. Royce Ginn, The Detroit Prototype of the NBER Urban Simulation Model (New York: Columbia University Press, National Bureau of Economic Research, Urban and Regional Studies 1, 1972.)

8. Center for Real Estate and Urban Economics, Jobs, People, and Land, Bay Area Simulation Study (Berkeley, Calif.: Institute of Urban and Regional Development, 1968.)

9. Landscape Architecture Research Office, The Interaction Between Urbanization and Land: Quality and Quantity in Environmental Planning and Design. (Cambridge, Mass: Harvard University Graduate School of Design, October, 1974).

10. A. H. Voelker, A Cell-Based Land Use Model (preliminary draft) (Oak Ridge, Tennessee: Oak Ridge National Laboratory, Regional Environmental Systems Analysis Program, November, 1975).

11. R. Ellefson, P.H. Swain, and J.R. Wray Urban Land Use Mapping by Machine Processing of ERTS-1 Multispectral Data: A San Francisco Bay Example (West Lafayette, Indiana: The Laboratory for Applications of Remote Sensing, Purdue University) LARS Information Note 101573, p. 2A-9.

12. Armond T. Joyce "Land Use and Mapping," in S.C. Freden et al. (ed.), Third Earth Resources Technology Satellite Symposium. Volume 2, (Springfield, Va.: National Technical Information Service #N75-10560, 1974), p. 138-146.

13. Ibid.

14. James R. Wray "Cartographic Aspects of an Operational System for Detecting Urban Change by Remote Sensing." EROS Reprint #157, (Washington, D.C.: U.S. Geological Survey, Geographic Applications Program).

15. Ellefson, Swain, and Wray. "Urban Land Use Mapping...", p. 2A-9.

16. Paul L. Vegas "Extracting Land Use Information from the Earth Resources Technology Satellite Data by Conventional Interpretation Methods," NASA Technical Note, NASA TN D-7730 (Springfield, Va.: NTIS #N7428896, July, 1974) p. 7.

17. Ibid., p. 8.

18. Ohio-Kentucky-Indiana Regional Council of Governments, Land Use Inventory by Drainage Area, Interim Report III (Cincinnati, Ohio: OKI, August, 1975) p. 8.

19. Joseph W. Wiedel and Richard Kleckner, Using Remote Sensor Data for Land Use Mapping and Inventory: A User Guide, USGS Interagency Report USGS-253 (Springfield, Va.: NTIS #PB-242 813, July, 1974.)

20. Richard Ellefson, Leonard Gaydoes, and James R. Wray "Computer Aided Mapping of Land Use ERTS Multispectral Scanner Data, "First Pan American Congress on Photogrammetry, Photointerpretation, and Geodosy. (Mexico City, Mexico, July 1974); Richard Ellefson, Leonard Gaydoes, Philip Swain, and James R. Wray "New Techniques in Mapping Urban Land Use and Monitoring Change for Selected U.S. Metropolitan Areas: An Experiment Employing Computer-Assisted Analysis of ERTS-1 MSS Data." Presented at International Society of Photogrammetry Symposium, Commission VII, Banff, Alberta, Canada, October, 1974.

21. Ellefson, Gaydoes, Swain, and Wray, "New Techniques...".

22. Ellefson, Swain, and Wray. "Urban Land-Use Mapping...".

23. Bendix Aerospace Systems Division, Computer Mapping of LANDSAT Data for Environmental Applications (Ann Arbor, Michigan: Bendix Corporation, November, 1975) p. 8.

24. James R. Anderson, Ernest E. Hardy, and John T. Roach, A Land-Use Classification System for Use with Remote Sensor Data (Washington, D.C.: U.S. Geological Survey Circular 671, 1972.)