DOCUMENT RESUME

ED 101 421 EA 006 698

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|---|---|
| AUTHOR | Clark, Robert A. |
| TITLE | Selected References on Land Use Inventory Methods. Exchange Bibliography No. 92. |
| INSTITUTION | Council of Planning Librarians, Monticello, Ill. |
| PUB DATE | Jul 69 |
| NOTE | 18p. |
| AVAILABLE FROM | Council of Planning Librarians, P.O. Box 229, Monticello, Illinois 61856 ($1.50) |
| EDRS PRICE | MF-$0.76 HC-$1.58 PLUS POSTAGE |
| DESCRIPTORS | *Bibliographies; Classification; *Data Processing; *Facility Planning; Geographic Location; *Information Systems; *Land Use; Maps; Methods; Transportation; Zoning |
| IDENTIFIERS | Inventory Methods |

ABSTRACT

This bibliography attempts to pull together the land use methodology techniques that have been evolving in major transportation studies and developing in conventional planning agencies. In a commentary preceding the 83 references, the author discusses the state-of-the-art of land use methodology. The major components of a land use inventory are identified as: place, or some form of geographic identification; a measure of quantity or intensity, such as area of the parcel; and classification of the land use or activity through a coding system. (Author/MLF)

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July 1969

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# SELECTED REFERENCES ON LAND USE INVENTORY METHODS

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This bibliography represents completion of a piece of business which was unfinished as a result of the author's leaving the Santa Clara County (California) Planning Department, before completing land use inventory manuals on the County's 1965 and 1967 inventories.

References are referred to by sequence number in the following commentary.

Land use methodology is in a very rapid state of evolution. Although the techniques have been evolving most rapidly in the major transportation studies, a substantial amount of development has been taking place, virtually unnoticed in the literature, in the more conventional planning agencies. This bibliography, then, attempts to pull the two worlds together, and reflects the shelf of documents upon which the compiler drew most heavily while devising methodology for the 1962, 1965, and 1967 land use inventories of Santa Clara County, and trying to lay the groundwork for a property-oriented information system in that County (see Exchange Bibliography No. 59, July, 1968 ).

Very few of the referenced studies are reports on actual experience: most are in the nature of instruction manuals prepared before work started. Therefore, there is little or no data on costs of inventory work. Nor is there much in the way of critical analysis of work procedures or inventory techniques. Without critical analysis based on hindsight, how is the profession to advance?

Because the usual accusation against the land use inventory supervisor or the research planner has been that the inventory takes a disproportionate share of the agency budget and its usefulness is seriously impaired by the length of time needed to complete it, some thought needs to be given by planners as to what data is the bare minimum needed to operate a successful planning operation. It has been suggested in some transportation study literature that population (or housing) and employment data may be sufficient for transportation planning. If the conventional land use survey can be omitted in transportation planning, for what reason, other than tradition, does the city planner need land use information? Each staff should try to answer this question for itself. As the nature of planning practice continues to change, this question needs to be brought up periodically and earlier responses re-evaluated.

In the judgment of the author, there are three major components of a land use inventory. These are: place, or some form of geographic identification; a measure of quantity or intensity, such as area of the parcel;

and classification of the land use or activity through a coding system. All three of these components are appearing in multiple in recent land use surveys. Several kinds of geographic references are being used (e.g., parcels, U. S. Census identifiers grid coordinates). Intensity is being shown by numbers of employees, dwelling units, etc., as well as land area. Finally, land use or activity is being shown by not one but several codes reflecting various attributes or "dimensions" of land use. The studies reported in this bibliography reflect some experiences and proposals in these directions.

## Inventory Method

The choice of land use inventory technique for the prospective inventory supervisor is becoming wider and wider. At the same time, the demand for more and more kinds of data having their origin in a land use inventory has been increasing rapidly. Today, not only is the land inventory a means for obtaining a visual impression of the city through map representation of land use data, but also a means of obtaining extensive statistical tabulations of many kinds of data (17, 18, 50). The growing use of electronic data processing has influenced significantly the means of recording land use data too, and poses a dilemma for those agencies desiring both an annotated map and a hard copy record for use in later data processing steps. The traditional practice in city planning agencies has been to record field observations directly on work maps from which display maps were made later (4, 5, 17, 26, 37, 41, 45, 51, 61, 63, 64, 65, 79). Now, however, increasing use is being made of field notation directly on field listing sheets which are keyed to the related maps (6, 7, 21, 22, 31, 43, 54, 66, 72, 75, 78). This dilemma may be resolved in the future by full use of the capabilities of improved hardware, such as digitizer-keyboard combinations for recording field notes, as well as by making mapped boundaries machine readable and measuring land areas (10, 18, 24, 36, 37, 53, 55, 56, 57, 59, 80). On the output side will be found computer-plotter combinations, capable of reproducing annotated maps at any scale and providing the desired tabulations too (24, 53).

What have been the choices up to now? The traditional method, as mentioned above, has been to record field observations directly on large scale maps. Strangely enough, this traditional method still may be the most economical method of obtaining data in the absence of fully operational property information systems. Field work has usually profited from the availability of current aerial photography, either as a means of checking field work through photo interpretation or by serving as a substitute for base maps (4, 5, 10, 17, 33, 50, 51, 64, 66). It appears likely that planners will eventually be able to obtain composite aerial photo-property line maps at reasonable cost that will be ideal field maps (4).

In a few metropolitan areas, the metropolitan agency has passed on the data collection job to the cities within the region. This has taken the form of either adapting land use studies already performed within the region, or setting up standard specifications for field notes and coordinating the field work (7, 44, 48, 49, 59, 61, 63, 64). The metropolitan agency then performs all necessary data processing.

The possibility of sampling of actual land use rather than taking a one hundred percent field survey has been talked about for many years. A recent study by the Northeastern Illinois Planning Commission is an interesting attempt to update an inventory by sampling (52).

Increasing use is being made of secondary sources to augment the information collected in the field. Although the practices have differed widely between agencies, the emphasis has been on using state unemployment security agency data as a means of linking land use records with the establishment and employment data available from the states (6, 12, 13, 14, 53, 64, 68). However, it has not been uncommon for employment and land use data to be gathered independently (11).

In California, many agencies have made use of the business license permit files from the state sales tax agency to obtain establishment data (11, 58, 63, 64). These files are especially valuable in California because they indicate both situs and mailing addresses as well as owner and fictitious (doing-business-as) names. Such sources are useful also in classification work as type-of-business codes are usually present (SIC codes are used in the unemployment security tapes) (16, 74).

A choice must usually be made between collecting floor area data by establishment or parcel ground area data. A common compromise in the transportation studies has been to collect floor area data in central business districts, and major commercial and industrial concentrations (23, 31, 32, 33, 54, 75). Often, the floor area data has been obtained from measurements made of building outlines from Sanborn fire insurance maps or aerial photos (31, 32, 81). The average planning agency, not affiliated with the well-funded transportation studies, has been able to afford only parcel ground area data.

Other secondary sources used in data collection or verification have included city directories, telephone directories (through use of yellow pages), and reverse telephone directories (11, 18, 58, 63, 64).

The use of public utility records appears to offer great promise. Use of such data has been very spotty, and often not integrated with the land use effort. For example, the Bay Area Transporation Study used electric utility customer data to obtain its O and D sample, but used unemployment security and business license data to obtain employment distribution (11), and a combination of field work and air photo interpretation, with use of digitizers for measurement, to obtain land use information (10).

Although several agencies have been reinventing the wheel with regard to the use of digitizers in land use measurement and grid coordination identification, the duplication of R and D effort can be excused partially on the ground of lack of information dissemination media in planning and the diversity of equipment and goals of the agencies pioneering in applications of this equipment (1, 10, 20, 24, 36, 37, 52, 53, 55, 56, 57, 59, 80, 83). However, this would certainly seem to be an area in which HUD should exercise its authority to prevent wasteful duplication and perhaps perform or have performed the necessary research and development for the planning community. Santa Clara County also has been experimenting with such equipment but the work is unreported.

As many city and county (and metropolitan) agencies are learning, it is not easy to develop an information system based on local property records (usually from the assessors). However, if local assessment officials can be convinced that it is their duty to cut the overall level of government costs by reorganizing their machine readable files in such a way as to provide land use inventory items and either collect for the planning agency or facilitate addition by the planning agency of items not presently available but needed by the planning agency, then we may do away with the land use inventory to a large extent. Perhaps there will be a need for a comprehensive field survey once every ten years to correct the errors that inevitably build up in data files. By then, hopefully, the use of digitizers should have become routine, with each manufacturer having perfected a land use inventory-oriented software package (24, 53). The use of local government property files as the backbone of a property information system (land use inventory) appears to be the lowest cost method for obtaining land use data and keeping it current (1, 3, 6, 7, 18, 20, 21, 22, 34, 39, 42, 43, 47, 48, 55, 56, 58, 68, 69, 71, 72, 73, 77, 78, 82, 83). Virtually none of the inventories performed to date has attempted to maintain land use data on a current basis, and none appears to have succeeded (with the exception, perhaps, of the Lehigh Valley effort (82)). For a fuller discussion of land use-oriented data banks or information systems, see Exchange Bibliography (59), July, 1968.

For a more thorough classification of land use inventory methods used by various transportation studies, see Appendix B in Clawson (18).

## Units of Collection

After some years of experimentation, planners appear to be reaching agreement that there are certain basic units of collection (geographic identifiers) that should be incorporated in land use inventories. Basic to any land use system is the parcel (1, 6, 17, 18, 21, 22, 34, 36, 37, 39, 43, 48, 55, 56, 58, 59, 61, 63, 64, 68, 72, 73, 78, 82, 83). In recent years, a consensus seems to have been reached that land use data also needs to be collected below the parcel level. This is reflected in inventories that record data at the structure (building) and establishment levels, as well as the parcel (6, 32, 34, 54, 64, 68). Particularly in those studies that obtain floor area or employment data is the use of a parcel-structure-establishment scheme of three levels of identification common.

Another consensus has built up around the use (at least by planning agencies, as distinguished from transportation studies) of census tracts and some form of block identification. As the 1970 Census is going to be highly dependent on Address Coding Guides with a block front identification possibility, block front will be increasingly important as a unit of collection. The transportation studies have tended to concentrate on traffic zones as the most important unit of collection, built up from blocks, but often the zone scheme is congruent with census tracting so that tracts can be compiled from zones.

Finally, the transportation studies have emphasized the use of grid coordinate values as a basic unit of collection. Assessors have also shown interest. As the use of digitizing equipment spreads, planning agencies will begin to incorporate grid location as part of their geo-coding scheme (1, 10, 17, 18, 20, 31, 34, 36, 37, 43, 48, 53, 55, 56, 57, 59, 66, 69, 80, 83). The use of coordinate values is closely associated with: (1) the desire for an absolute geographic point, (2) the ability to create a machine-readable map by recording parcel or boundary vertices, and (3) the development of programs to make area measurements from parcel vertices.

Actual street address is also being incorporated into files too. With the large number of cities for which Address Coding Guides will be available for the 1970 Census, street address information is becoming of importance again. Many of the transportation studies had to create equivalents of the Address Coding Guides, either as part of or independently of their land use inventories, in order to assign data by street address to zones, blocks, tracts, etc. For full information on the 1970 Census and Address Coding Guides, see the U. S. Bureau of the Census series GE-40 and the Urban and Regional Information Systems Association 1967 and 1968 proceedings.

## Quantification

Some measure of land use intensity must be made if a land use inventory is to be meaningful. Traditionally, and often because of budget limitations, measurement of land use has been confined to parcel area. However, it is recognized by most professionals that parcel area is only a poor compromise. Floor area by establishment would be of great value, if financially feasible (17, 50).

For residential land uses, the number of dwelling units per parcel by housing type should also be captured as a small beginning on a housing inventory series (63, 64). Similarly, it appears desirable to tie land use records to establishment records (such as unemployment security agency data) in order to obtain employment by location, although many transportation studies have disassociated land use data from employment data series (11, 64). Employment data could also be gathered by field survey at the time of the land use work, or derived from secondary sources other than unemployment security records (such as direct mail questionnaires, telephone calls, chamber of commerce records, etc) with some loss of accuracy. In any event, it seems likely that dwelling unit and employment counts will come to be integrated with land use data in most future efforts, as elementary land use models can be constructed with these items present (11, 20, 23, 26, 31, 33, 36, 37, 38, 45, 54, 55, 56, 57, 60, 61, 63, 64, 65, 66, 72, 78, 80).

Measurement of land area traditionally has been performed by use of the planimeter or counting grid squares on a transparent overlay. In recent years, the areagraph has come into use (63). Eventually, most agencies requiring measurement of area will have the area measured by a digitizer, either through use of equipment owned by the jurisdiction, or through leasing time from an agency or service bureau having such equipment. The General Electric study confirms the results of Santa Clara County pilot tests (in that digitizing apparently consumes as many man hours as comparable hand techniques) (53). However, the Oregon work indicates significant cost savings by digitizing rather than using hand methods (36, 37, 55, 56, 57). Further operational experience will be needed to decide this issue. The advantages of having a completely machine readable file appear to override possible cost disadvantages. A digitizer-generated file can be edited easily by plotting and visual checking of an overlay of the plot on the source documents. Also, the area values generated by the computer should be more accurate than those generated from hand methods. Further, the machine readable file can be plotted to produce maps at a later date and, through polygon matching, additional geographic codes can be added to the file for retrieval and tabulation (36, 37, 57).

Classification and Coding

There has been a conspicuous shift away from actual coding of land use field notes into a classification scheme while the inventory staff is in the field (17). In the uncomfortable situation offered by the usual vehicles used in land use field survey, and with the normal urge to get the notes down as quickly as possible, field coding is obviously undesirable. Who wants to thumb through the usual 100-page classification manual to find the correct multi-digit code in a field situation? It was the high coding error rate noted in such situations that has led to increasing use of staff specialists in an office environment to perform the classification of notes into codes for machine processing. In such an arrangement, coding must follow the field work, preferably alfter quality checks have been run on the field notes.

Although some Federal pressure has been exerted upon planning and transportation studies to use the Bureau of Public Roads Standard Land Use Coding Manual, increasing overt and covert resistance is being encountered (17, 18, 49, 62, 76). The BPR code, although SIC related, is open to much criticism on a wide variety of grounds, such as deviation from a pure activity orientation, unwarranted compression of SIC detail, omission of significant land use classes, and general lack of a "feel" for land use classification the way the planning profession has "seen" it (18, 49). Perhaps there were too many chiefs and too few land use inventory-experienced Indians on the review committee.

Not that a land use study need lack for examples of alternative classification schemes (2, 7, 12, 13, 14, 17, 30, 51, 60, 69, 70, 79). Of these, the Detroit Metropolitan manual has been the best received and widely used as a jumping off point for local adaptations (35, 40, 64).

As the BPR manual hints, many agencies have come to the conclusion that land use classification implies the use of multi-dimensional coding (i.e., there are several ways of looking at land uses, and each way can be reduced to a classification scheme). In part, multi-dimensional coding means the adoption of cross-referencing manuals (such as between SIC, a business license code, and a land use code) (6, 9, 12, 13, 14, 16, 17, 18, 28, 29, 30, 49, 58, 62, 63, 64, 67, 69, 76). However, one major innovation has been the incorporation of a notion of a generalized, functional or structural view of the urban area's major land use components. Some structural ideas are discussed in Murphy's book, The

American City, (see pages 261 and 340), which are similar to classification schemes in use in a few agencies (10, 49, 63, 64). The SLUC Manual calls the codes for added dimensions "auxiliary" codes for auxiliary functions (such as central offices), ownership, farm use, and type of residential structure. Clawson and others have pointed out the need for data on the development characteristics of vacant and non-urban lands, and Chapin has a long list of land use-related studies, many of which could be tied in with a land use inventory and coded at the same time the inventory is coded (17, 18). The BPR Manual has been challenged right in its own back yard by an excellent report from the Washington COG, which suggests a large number of dimensions (49). Guttenberg may be credited with fathering much of the current interest in multi-dimensional classification and suggests many ideas that have yet to be attempted in working agencies (28, 29). Given the high cost of gathering additional data items that is implied by adding additional dimensions, it seems likely that the profession will have to wait for local government information systems oriented to property to get off the ground before much of the "juicy" analytical possibilities suggested by multi-dimensional data becomes testable.

Data Handling

In the shift in emphasis from mapped land use data to tabular and statistical presentation, the major stumbling block has been conversion of field observations to some form suitable for tabulation. Since the mid-50's, the emphasis has been on use of, first, punched card equipment (electronic accounting machines), for tabulation, and, more recently, electronic computers for data processing (1, 3, 6, 7, 10, 17, 18, 19, 20, 21, 22, 25, 26, 31, 34, 36, 37, 38, 39, 42, 43, 44, 45, 46, 47, 48, 49, 54, 55, 56, 58, 60, 61, 63, 64, 65, 66, 68, 70, 72, 73, 75, 77, 78, 80).

The conventional approach (when punch cards have been involved rather than hand tabulation) has been to record field notes on maps or forms taken into the field. Then, the field notes are coded and transferred to a document from which the information is key-punched. This intermediate or transcription step has been a target for bypassing in the interests of efficiency and accuracy (the more the information is handled by humans, the greater the chance of error). However, the major argument in favor of a transcription step has been the need for some interpretation and human manipulation (such as measurement) of the source documents (field notes and maps) before making coded entries. At some point in this process, the quantification or measurement step has to be accomplished so that quantitative data can be punched at the same time identification and classification data is punched.

In several transportation studies, a single source document was used on which data was noted or collected, coding and measurement steps performed, and sheets for forms used in the field submitted directly to key-punching (7, 44, 54, 66, 70, 75). Some clever work has been done in form design. It must be noted, however, that data handling procedures are closely related to data collection decisions, so that one cannot be considered independently of the other.

Although I know of no inventory that has used scanner sheets such as the Census Bureau's FOSDIC or the familiar test sheets often associated with Digitex, scanner sheets appear to offer one method of direct coding of data in the field and office, bypassing both transcription and keypunching (assuming an efficient scanner device that records directly on magnetic tape).

There is one problem that has plagued those agencies which have sought to generate a master file by machine matching and merging several subsidiary files having a common identifier such as parcel number. If there are more than a minimal number of errors in the basic identifiers in the files, the problem of file matching and correction may become overwhelming. At least one major transportation study was substantially delayed through inability to merge the several component files that were to be combined into the master file. Santa Clara County experienced aggravating problems in trying to link together several files representing the 1962, 1965, and 1967 parcel files and a 1966 local census (64). The matching problem included subsidiary establishment and housing files for the 1965 and 1967 inventories. Although there are several ways to overcome such problems, the inventory procedures should be designed with file matching problems in mind.

Some attempts at use of the computer for machine editing for errors has been reported. However, the cost of programming error check routines has been prohibitive in many cases (not so much from the standpoint of salaries paid to programmers but because neither the time nor talent needed to prepare the programs were available within a time period fitting the schedule of the project). With improved programming capabilities, machine editing would be profitable.

While most transportation studies have exercised quality control through sampling, planning agencies have tended to perform 100 percent dit checks (31, 45, 54, 61, 63, 64, 66, 72, 75, 78). It is, perhaps, the drive for perfection by planning types that is responsible for the high costs of many planning agency inventories. However, any planner who has prepared and displaved a land use map knows the impact of having some contentious citizen point out in a public hearing a map error. Similarly, no matter what a quality control program based on sampling may achieve, no study can afford tabulations in which a few records have decimal points moved three or four places in the wrong direction. Even where sampling has been used to control the quality of individual work, the control for area-measurement accuracy usually has taken the form of forcing unit records to close to a block (or similar higher order area) control total within some tolerance limit.

## Tabulation of Data

The comments in this section assume the use of electronic data processing (EDP) equipment in tabulation of land use inventory data. Although the use of EDP to tabulate large amounts of statistics is often mandatory because of the volume and detail of the inventory records, EDP has proven to be a major problem for many inventories (21, 25, 26, 43, 46, 47, 63, 64, 65, 68, 69, 77). This seems to be particularly true for most local planning agencies because they have not had adequeately trained and experienced data processing advisors and assistants. Most local agencies have had to "do it alone" as the data processing personnel within the local government were either not available or equally unable to cope with the EDP requirements posed by a land use inventory.

Although the need for and usefulness of generalized "software" and packaged programs (computer instructions that can be created by relatively untrained planning personnel to perform a wide variety of computer functions, including file creation, correction, updating, retrieval, and tabulation) was recognized by many studies, even those studies which utilized expert consultants foundered on the rocks of: cost of such software packages, change in computer configuration from second to third generation, and incompatibility between machines of the same generation (47, 63, 64, 68, 69, 77, 83). There has been little or no carry-over value even to generalized programs or packages from one agency to the next. The enormous wastage of time and talent in fighting computer problems is perhaps the saddest feature of experience up to this point. Even where an individual agency has achieved success, there exists no machinery within the profession for communication of practical experience in data processing. Neither the conferences of the planning profession, the urban information specialists, the transportation-land use modellers, nor the data processors have served as a medium of communication, and no journal has been established which carries articles of practice. What little communication that has taken place has occurred on a face-to-face basis, limited by public agency budgets for travel, no matter what the possible payoffs.

Mapping

Decisions on classification systems are in part dictated by the need to graphically portray the land use data. For example, the planner has been faced by decisions on classes for residential uses--should we show type of structure or dwelling unit density? Much of the interest in structural or functional classification schemes comes from an interest in showing the urban pattern in terms a layman can grasp--shopping center versus central business district, industrial park versus "heavy" industry. At some point in the inventory, field notes and land use codes have to be translated back into mapped data. If a simple one-digit or two-digit generalized land use classification system is used, a black and white base map can be created, with use areas outlined following parcel boundaries, field lines, etc.; the codes noted on the map; and the map later "colored by the numbers" to create visual impact. This has been the traditional approach (17, 40, 45, 51, 63, 79).

However, just as modern technology has created the digitizer-computer combination to assist us in measuring and deriving locational data, so we also have the computer-plotter combination which would allow us to machine draft land use maps (36, 37, 57). Using a plotter, maps at various levels of classification detail or scale, with perhaps a selection of two or more data items, could be machine generated. However, although such machinery is available and has been used in major metropolitan transportation studies, it does not appear to be readily usable to local planning agencies (53). Again, the manufacturers have not catered sufficiently to the planners' needs to develop a market. Perhaps this will come.

There is a rapidly growing variety of software for graphic display that makes use of the printer of a computer system for map generation. The Horwood and SYMAP packages are the best known. As this kind of display is not particularly useful for land use mapping associated with inventory work (although it is in the analysis stage), no references are listed here.

However, several articles on this topic appear in the proceedings in which the General Electric article appears (see reference 53).

Administration

Knowing from experience that the number of manuals and reports that get written is only the point of the iceberg with respect to the total number of land use inventory activities that must be going on in planning, we can raise the question of where do all the people go who have acted as supervisors of land use inventory activities? Obviously, we are not learning too well from experience. One angle to this is the communication gap caused by the failure of land use specialists to continue in this role after the first experience. Although some of these supervisors must have moved up to higher level jobs in the profession, have they moved to other agencies that need their land use inventory expertise? This would make an interesting study but it would undoubtedly be handicapped by the proclivity of planning agencies for omitting credit to the staff that actually performed the work, and in the case of land use inventories, the inventory supervisor. The land use inventory operation in planning appears to be demonstrating the old adage that those who fail to learn from history are doomed to repeat it. This bibliography is eloquent testimony to the truth of the adage, while it is also a small attempt to overcome it.

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