AN ABSTRACT OF THE THESIS OF

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Title: Geographic Information Systems: Suitability to a Land Use Planning Problem

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Geographic Information Systems (GIS) is a burgeoning field with its roots in geography. It is increasingly being used by a large variety of disciplines, including land use planning, as a decision support tool to help solve complex spatial problems. At Oregon State University, researchers have developed an analog model which will assist planners in designating 'secondary' or marginal resource lands.

The OSU Secondary Lands Model is translated into a series of digital algorithms and applied to a study area in north-central Lane County, Oregon with pcARC/INFO, a popular personal computer (PC) GIS program. Translation of the analog model to digital is analyzed and summarized in the conclusion. Lessons learned from this research are drawn upon to make recommendations to others who wish to use GIS in land use planning or any other multi-disciplinary environment. These include careful data preparation, avoiding the pitfalls of 'digital determinism,' keeping data broken

down into their smallest components, and using appropiate data structures.

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Geographic Information Systems:

Suitability to a Land Use Planning Problem

by

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CHAPTER I

INTRODUCTION

The method by which data concerning spatial phenomena have been collected, stored, and analyzed has been a concern to geography since its inception. In fact, it is considered by many to be a primary focus of the discipline. This is reflected in Peuquet's (1988, 375) quote:

> 'The manner in which geographic information is represented, both conceptually and physically as stored data observations, is a central issue in the field of geography and in any field that studies phenomena on, over or under the surface of the Earth.'

Research into the handling of spatial data has manifested itself over the last three decades into the mushrooming field of geographic information systems (GIS).

GIS, in its broadest sense, is interpreted as an 'information technology' capable of storing, displaying, and analyzing data (Parker 1987, 73). The traditional definition portrays it as a 'collection of computer programs' that operate on spatial data in a method 'analogous to a series of map overlays' (Robinove 1986, 1; Figure 1-1). As an information technology, the definition of GIS is refined further by others to encompass 'decision support systems' for integrating spatial data in a 'problem solving environ-

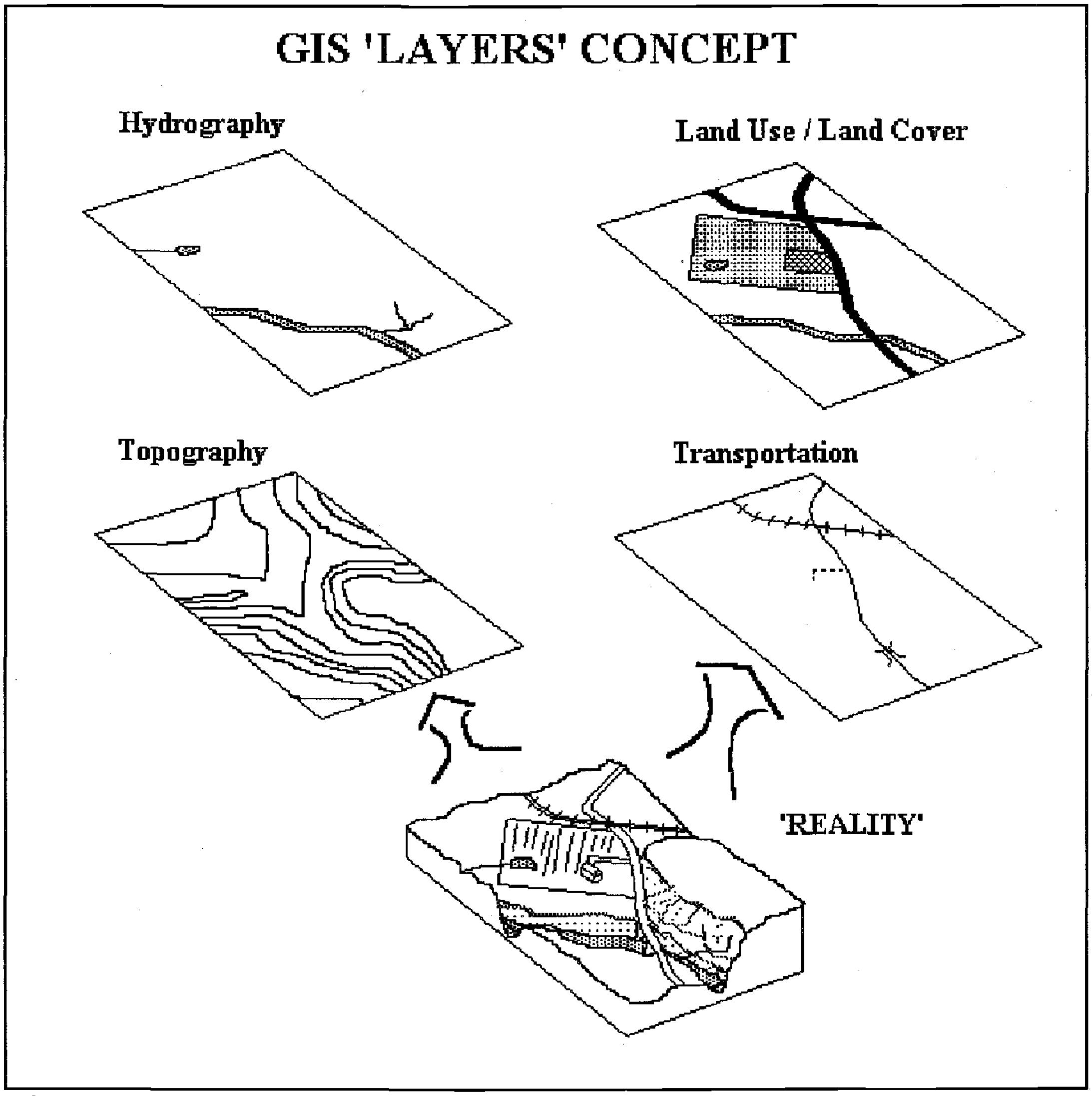

Figure 1-1. GIS 'layer' definition.

ment' (Cowen 1987, 54).

Land use planning is an apparent 'problem solving environment' where a revolutionary tool such as GIS can help synthesize seemingly disparate data about the milieu to assist the planner in the decision making process (Dueker 1985, 172; Kimerling 1988, 1/11; Lang 1988, 78; Muller 1985, 41; Parker 1988, 1548). Planning is also a continually evolving process facing new problems every day. GIS can help planners meet these challenges and prepare for new ones; <u>and</u> the cost and capabilities of current GIS software and hardware are within the budgets of most state and local land use planning programs. Accordingly, GIS is being incorporated into the planning process to a greater extent.

Oregon, over the last twenty years, has developed a comprehensive land use planning program that has withstood many challenges despite limited staffing and funding at the county level, where the plans are implemented. Of acute interest to the planning program has been the matter of 'secondary' resource lands. They are lands that are of low resource value or cannot support intensive resource use, such as forestry and agriculture, because of natural properties or neighboring development pressures. Many people believe that Oregon's land use laws don't adequately account for these lands. In an attempt to remedy the situation, various methodologies have been tested over the last decade with limited success. All of the evaluations have used a manual approach requiring spatial data from several sources in the counties, recompiling them to a common scale on transparent overlays, and taking measurements from the hand-colored coded maps to get results. The process, to say the least, has been intensive, especially when changes were made to the models and the tests reapplied using the new criteria.

RESEARCH PROBLEM

Goal of research

This thesis focuses on testing a new approach to applying the secondary lands methodology. Specifically, a popular, 'off-the-shelf' personal computer (PC) GIS software package, pcARC/INFO, will be used to implement the Pease-Huddleston (OSU) Primary/Secondary Lands planning methodology on an agricultural area in north central Lane County, Oregon. Strengths and weaknesses in the software will be scrutinized as to their potential effects on Model analyses and what this may mean for others, especially land use planners, in their work.

Area of study

The area of study is the Coburg Hills Area (the designation given to it during previous secondary lands criteria tests) of north central Lane County, Oregon. It includes prime agricultural lands in the heart of the southern Willamette Valley. It is located approximately 7 miles north of Eugene with Oregon Route 99 as its border to the west and the Willamette River to the east (Figure 1-2). The Public Land Survey (PLS) sections included are as follows: Township 16 South, Range 4 West, Sections 8, 9, 16 and 17.

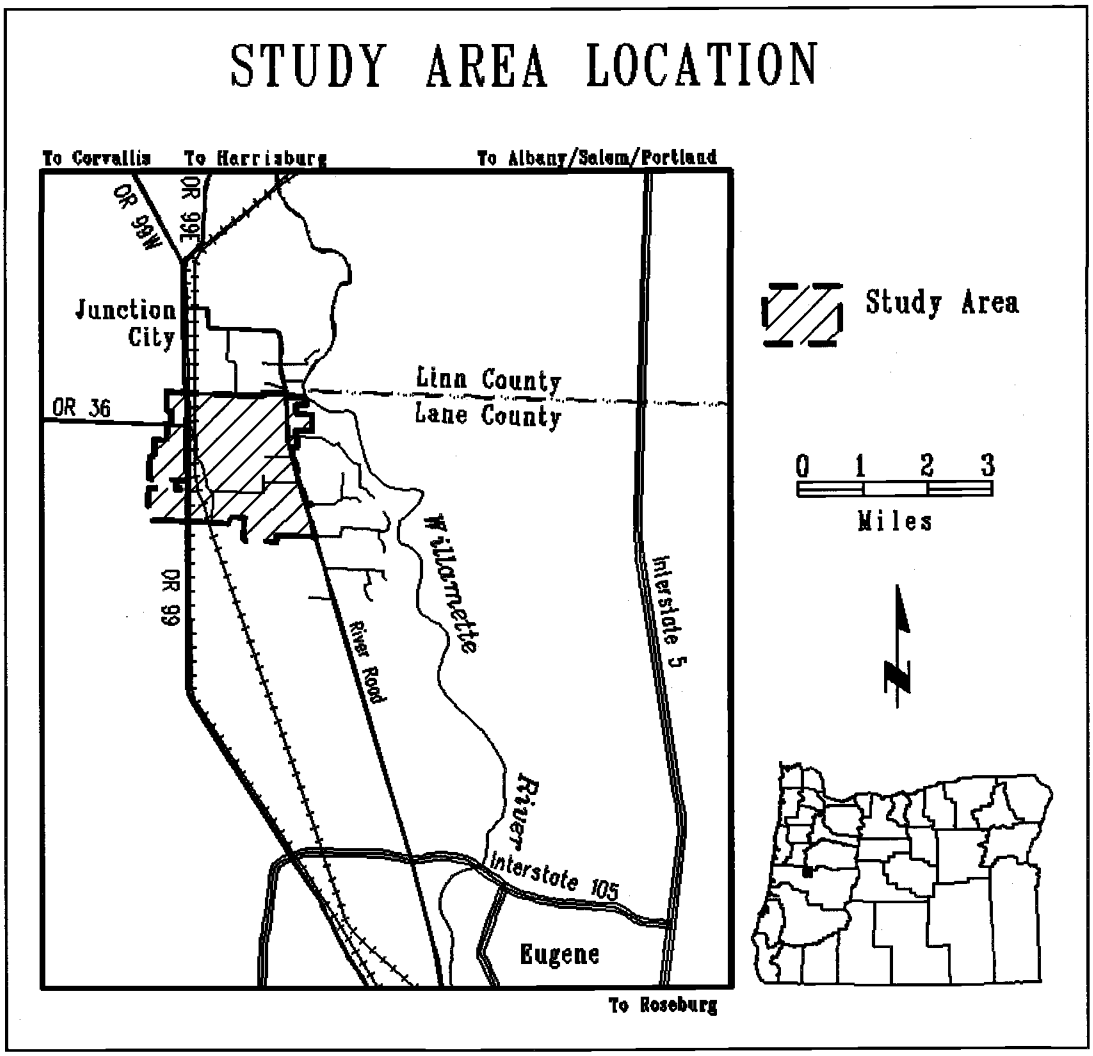

Figure 1-2. Study area locater map.

Overview of thesis

The paper is divided into seven chapters. The second chapter, 'Literature Review,' covers the topic of GIS in some depth, highlighting significant research in the field as well as the application of GIS to land use planning. Chapter III, 'Oregon Primary/Secondary Lands,' examines the Oregon secondary lands issue and the OSU Secondary Lands Model, the methodology used subsequently in the analyses.

Chapter IV, 'Methods,' summarizes the pcARC/INFO software and microcomputer hardware that will be used in the analyses, and outlines the methodology that will be used in the GIS. The GIS analyses used in applying the OSU Secondary Lands Model to the study area are explained in-depth in Chapter V with accompanying results in Chapter VI. Finally, Chapter VII, 'Conclusions,' wraps up the paper with a critique of the OSU Model and, specifically, its adoption to a digital format and what implications this research might hold for similar efforts.

CHAPTER II

LITERATURE REVIEW

AN OVERVIEW OF GEOGRAPHIC INFORMATION SYSTEMS

The core of any geographic information system is the structure in which the data are held, since this governs the manner in which they are manipulated. To some extent, this also determines the types of analyses that can be carried out within the system.

The definition and use of current GIS data structures are a result of the development of automated spatial analysis from the human perception of space. After reviewing the history of GIS, the vector data structure will be introduced since it closely suits discrete parcel boundaries which are the focus of any land use planning effort using GIS, the thrust of this thesis.

Perception of space

Space can be broken down into a series of 'levels' of abstraction that make it more discernable to the human mind and translatable to a form which may serve as the basis for analysis of a particular phenomenon. Peuquet (1984, 67-69) defines these 'levels,' (by successive abstraction) from the real world to an objective model, as reality, the data model, and the data structure. Reality is the phenomenon as it actually exists, including all aspects perceived and not perceived by humans. From that, the data model is derived, which only describes the measured properties of reality relevant to the researcher, and the data structure builds upon this, detailing the arrangement of the data elements.

Digital spatial structures are derived inherently from how humans perceive their environment and by practical limitations imposed on them by existing computer architecture. The earliest representation of space and a tool used by people for millennia is the map (Peuquet 1984, 75). It is the 'most universal and well known representation for geographic phenomena' (Peuquet 1988, 377) and still serves in this function. With the Quantitative Revolution in geography in the 1950s and 1960s, the role of the map as a primary data storage element was transformed into a primary means of computer data input (Tobler 1959, 526).

Peuquet (1988, 378) defines the map at the conceptual level as 1) a graphic image and 2) as a geometric structure in graphic form (1988, 377). The map as an image depends on subjective human interpretation to convey meaning and thus is represented historically by the raster data model and later, as computer graphics evolved, as vector drawing software without topology--notably, CADD (Computer Assisted Drafting/Design). On the other hand, the map interpreted as a geometric form uses mathematics, i.e. topology, graph and lattice theory, and analytic and projective geometry, and evolved into the vector data model (Peuquet 1988, 377-378).

As a third, and much less adapted, representation of reality, the structure of the phenomenon itself has been put forth as a source of information which serves as its own data structure. This proposition was developed by Francois Bouille and it consists of coming up with a model of the phenomenon of concern--the properties and relationships between objects involved--and converting this into a data structure (Mark 1982, 82). It thwarts consistency among current GIS software and analytic techniques, and creates an inability to transfer data between systems. This phenomenological approach may be possible in the near future for individual applications with the development of expert systems in GIS and object-oriented programming (OOP).

Development of GIS

Technological advances in computer science and cartography laid the foundations for the development of GIS in the 1960s. The conceptual framework for GIS was formed by individuals from geography and related disciplines who realized the need for computers in integrating data from a variety of sources, manipulating and analyzing the data, and providing output for use in the decision making process. Richard Kao (1963) anticipated the need for computer processing by geographers as a convenient and necessary way to handle their data (1963, 533). Subsequently, Ian McHarg (1969) in his influential book, Design With Nature, contributed greatly to this area of early, manual GIS research and was important in introducing further work in the use of overlays of spatially-indexed data in resource planning and management decision making (Smith, et. al. 1987, 14). This helped set the stage for revolutionary concepts in map structure, content, and use, and provided a digital methodology for the quantitative modeling of spatial relationships (Berry 1987, 1403).

During the 1960s and 1970s, two main trends in the application of computer methods developed from the spatial perceptions of the map discussed previously: 1) spatial analysis at the expense of graphics and; 2) automation of the existing tasks with an emphasis on cartographic accuracy and visual quality (Burrough 1986, 6). The raster data structure first emerged at this time as the predominant standard because it was a format easily stored and manipulated by early computers (Burrough 1986, 20; Maffini 1987, 1397; Peuquet 1984, 85). Analyses involving relatively small sets of digital spatial data were carried out in batch mode on large mainframe computers using the high-level programming languages of the day, chiefly FORTRAN, which were designed to handle simple matrix operations on single-dimension linear arrays, and produce output on line printers (Chrisman 1987b, 33; Croswell and Clark 1988, 1571; Douglas 1982, 92; Peuquet 1979, 132). A gridded format was the only method by which this could be done. This gained wider acceptance and usage in the 1970s with the advent of the U.S. Landsat series of remote sensing satellites and the subsequent 'explosion' in raster image data (Maffini 1987, 1397).

The logical dual of the raster format, the vector data method for representing spatial phenomena, has been the most common analog data structure. This is due to the development of cartography and its use of lines, or vectors, to represent linear features and define the edges between diverse spatial entities (Maffini 1987, 1397). The vector structure gained popularity following further research and development in computer processing, storage, and display devices (vector mode CRTs and plotters) in the 1970s (Croswell and Clark 1988, 1571). Peucker and Chrisman (1975) conducted some of the earliest research into the vector format at the Harvard Laboratory for Computer Graphics and Spatial Analysis where they produced the Odyssey GIS, one of the first 'topologically complete' GIS. A popular vector format of the period, the DIME (Dual Independent Map Encoding) system, was developed by the U.S. Bureau of the Census to describe street network, blocks and tracts, and addressing schemes of larger urban areas in a computer database (Monmonier 1982, 21).

In the 1980s, the progress of the 1970s in digital hardware and structures has been incorporated in operational GIS software (Croswell and Clark 1988, 1571). Related advances in processor performance and microtechnology have enabled a substantial decrease in microprocessor size without compromising speed. Based on these important enhancements, there has been a trend toward smaller, low maintenance, easy-to-operate systems, i.e. micro-computers and graphic workstations. Likewise, full GIS functionality involving complex analysis and mapping procedures--large database operations, polygon overlay analysis, and sophisticated geographical queries--has allowed software to operate on microcomputers, though with some limitations on the 16-bit (PC AT-style) models (Croswell and Clark 1988, 1572-1573).

The two trends in computer-assisted cartography/GIS, outlined by Burrough (1986, 6) previously, are coming together as the ability to handle the vector and raster data structures is no longer hardware, or software, dependent. It appears that the user's application dictates the data structure(s) involved. Therefore, it is imperative that both structures--vector and raster--are fully understood.

Vector data structure

The vector data model represents, as exactly as possible, the most basic and implicit structure of a map (Burrough 1986, 19, 25). It is merely a tracing of a map's lines as defined by polygonal arcs which are delimited by endpoints (depicted by coordinates) and form some type of connectivity (Burrough 1986, 19; Corbett 1979, 1; Peuquet 1982, 75).

The simplest type of connectivity is the spaghetti model, a direct line-for-line translation of a paper map defined by a string of x-y coordinates (Peucker and Chrisman 1975, 57; Peuquet 1984, 76). This model retains no spatial relationships among any of its entities--it is non-topological (Rhind and Green 1988, 178). This makes it very inefficient for most types of spatial analysis (Peuquet 1984, 77) because an exhaustive element-by-element search must be made through the entire database for each spatial query. A more common and complex type of vector structure is the topological model, wherein connectivity and adjacency information is explicitly recorded for each entity, consequently retaining spatial relationships and allowing for more efficient analyses (Peuquet 1984, 77-78).

Topology--the general study of continuity (Frank and Kuhn 1986, 415)--addresses a vector data structure in terms of points (nodes), lines (arcs), and areas (polygons) (Burrough 1986, 26-27; Corbett 1979, 1; Deuker 1987, 384), or, alternatively, as 0-, 1-, and 2-dimensional objects (Frank and Kuhn 1986, 416; NCDCDS 1988, 25-26; White, M.S. 1984, 16). The topology for a particular data model is 'complete' when the model explicitly and independently represents the object and incidence (when cells touch one another) relations of all of the complex objects (White, M.S. 1978, 3). This is accomplished by maintaining a list of all of the 0-, 1-, and 2-dimensional objects, and coding the boundary and coboundary relationships. For example, a polygon (2-D object) is made up of 'n' arcs (1-D objects) which are, in turn, comprised of 'n' points (0-D objects). Since arcs (and points) may form the basis of adjacent polygons, 'adjacency' the knowledge of neighboring elements, can be established. If topology has not been accomplished, then the power to fully access and manipulate the model has been lost (Peuquet 1982, 75; White, M.S. 1978, 6). The comprehensive listing has been criticized by Peuquet (1982, 77; 1984, 98) for demanding large storage requirements and being unable to anticipate <u>all</u> of the relationships among the entities that may be required for a specific application. Notwithstanding, the object listing facilitates an automated topological check for consistency among the structure's objects. It entails 1) linking chains into a boundary network, 2) checking polygons for closure, 3) linking the lines into polygons, 4) computing polygon areas, and 5) associating non-graphic attributes to the polygons (Burrough 1986, 29-31; Corbett 1979, 1; Frank and Kuhn 1986, 417; White, M.S. 1984, 19).

Apart from the topological network, a metrical class of properties also exists for a vector data structure. They center around the x-y coordinates that make up the objects and involve such questions as the position of points, length of lines, area of polygons, distance between two points or a point and a line, and angles between intersecting lines (Frank and Kuhn 1986, 416; White, M.S. 1984, 19). M.S. White (1978, 11) emphasizes that the x-y coordinates, however, serve a descriptive rather than a definitive function in keeping with topology's invariance. Properties of coincidence (points and points), incidence (points with lines), and inclusion (points in areas) remain unchanged under all operations, e.g. scale and or projection transformations (Frank and Kuhn 1986, 417). Metric methods are subordinated to topological for both description and analysis (Reichenbach 1958, 244; from Kao 1963, 534); though, as Kao (1963, 534) states, 'the real work is carried out in terms of the x-y coordinates because they are found to be particularly suitable for rapid arithmetic manipulation.'

After topological consistency has been confirmed, the nongraphic attribute data are added to the vector data model, as mentioned previously. The spatial relationship for a nongraphic datum is defined by a coordinate attribute, or as an area attribute by the NCDCDS (1988, 25) (Aranoff, et. al. 1987, 221). Each topological object--point, line, and polygon--may carry a non-graphic attribute (Nagy and Wagle 1979b, 152; Peucker and Chrisman 1975, 56-57) and for each object there is a separate nongraphic attribute database with pointers, such as the area attribute for the polygons, back to the object file (the geographic 'half' of the listing). The advantage of this scheme is that each object may have nongraphic data attached to it, giving it full representation in the database if required, and it is readily retrievable for analysis (Corbett 1979, 1). A 'true' GIS package will automatically update the pointers after each edit of the graphic listing. A relational database management system (RDBMS) routinely handles the object attribute files for a vector GIS. A RDBMS consists of a set of relationships explicitly represented as tables and a set of data integrity rules. The rules preserve the integrity of the pointers that form the relationships between the attribute tables and topological objects. An example would be that a point entity should not possess a record indicating its area (Burrough 1986, 34). The rules also permit new spatial and nonspatial relationships to be defined and can accommodate new types of queries as well (Peuquet 1986, 463).

Overlaying, or analysis incorporating data from two or more layers, is a complex geometric procedure for a GIS based on a vector data structure. It is, in the words of Denis White (1978, 1), 'the spatial synthetic process of grouping back together information which has been previously isolated and classified from experience.' There are two main approaches to the overlay problem: 1) the exact method, whereby all intersections of the boundary lines from the two layers are found precisely and all of the polygons are identified on the new map; and 2) the heuristic process, in which each map is converted to a grid structure and the grids are overlaid in a simple and rapid step, and the composite grid is revectorized (Goodchild 1978, 2). The actual overlay process includes the following steps: 1) finding the polygons of a given data layer that overlap with those of the remaining layer; 2) finding the points of actual overlap; 3) recognizing when a new polygon has been created; 4) identifying the 'parentage' of the new polygons; and 5) testing the new polygons for topological consistency (White, D. 1978, 2). Interestingly, Goodchild (1978, 5) finds that the number of polygons created in an overlay depends not on the number of polygons being overlaid, but on the complexity of each parent layer as defined by the vertices in the arcs that comprise the polygons. Serious problems arise when arcs show a tendency to coincide, this occurring most often when a prominent linear feature, e.g. a river or road, appears in more than one layer for a particular area. The two versions of the line will not coincide and an overlay will produce a number of spurious polygons--small slices of an arc delimited by two versions of the feature. Severity increases with the accuracy of digitizing and overlay coincidence (Goodchild 1978, 5). The presence of spurious polygons can present major complications as well. They increase the complexity of a data layer and, therefore, multiply the volume of a data set describing polygon attributes (Goodchild 1978, 11).

Data manipulation

Geographic information systems have developed to the degree that there are certain basic analytic techniques with each software package, even for the microcomputer. Data input, usually through manual digitization (Tomlinson and Boyle 1981, 67), is the first step in getting data entered into the system. Keyboard entry is another method, but, with increasing amounts of data already in a digital format, it is important for a GIS to have file transfer capabilities. The NCDCDS (1988) is currently putting together a set of digital cartographic data standards for consistent data file transfer among all GIS users. A GIS should also have data retrieval techniques common to most CAD systems such as browsing, windowing, adjacency analysis, and point and polygon retrieval (Dangermond 1984, 1-38). Automated cartographic techniques are required for map generalization and map sheet manipulation, and include line thinning, droplining (between polygons containing the same attribute), edgematching (Tomlinson and Boyle 1981, 67), polygon reclassification, scale change, and projection changes (Dangermond 1984, 1-41 - 1-42). The actual data analysis, the nucleus of a GIS, requires buffer generation, polygon overlay, and various measurement techniques. For three-dimensional surfaces, a digital terrain module, which includes display, contouring, slope/aspect/sun intensity, and water- and view-shed determination (Dangermond 1984, 1-42 - 1-52) is also necessary. Basic editing/updating tools are always needed for maintaining the database (Tomlinson and Boyle 1981, 67). Finally, output techniques allow the data to be viewed on hard copy maps and CRT displays, and for statistical tabulations (Dangermond 1984, 1-52).

The 'other half' of a GIS, the RDBMS mentioned previously, supports the nongraphical attribute data. It requires 1) a friendly, flexible user interface; 2) a system that can manipulate geographical entities according to their geometry--point, line, and polygon--and handle their attributes and relationships; 3) a system that can define the structure of complex objects, and cluster highly interrelated data; and 4) a system that can work in a single user workspace (Lorie and Meier 1984, 244-245).

Data quality

'The highest accuracy of GIS output is only as accurate as the least accurate data plane,' therefore, 'the final product will be less accurate than any of the data layers used.' That is the canon of GIS data quality as asserted by Newcomer and Szajgen (1984, 62; from Walsh, et. al. 1987, 1423) and it can't be stated enough, as there is a tendency for many users to take their output from a GIS as gospel without question of its origin(s). Hence, data quality and its suitability for particular application(s) comes into question and one comes up against the unspoken law of GIS analysis--'garbage in, gospel out.' Goodchild (1982, 89) also expressed it well when he said that, 'geoprocessing tends to expose inadequacies in the raw data in a way that manual cartography doesn't and this forces us to deal with them,' especially when errors are generally cumulative in GIS operations (Otawa 1987, 296). Walsh, and others (1987, 1423), neatly subdivide data errors in GIS into inherent and operational errors. An inherent error is an error present in the source documents and an operational error is produced through data capture and manipulation functions.

Errors in data that are used in a GIS can theoretically be traced back to the first entry of information into a computer. However, it is only important for the user to realize that there are errors inherent in their source documentation and to use that information constructively to decide how best, or if at all, to handle the data and minimize the effects of the errors. More notable and invariable errors occur during map construction, such as the map projection used and its scale, symbolization, and content accuracy of the map subject (Burrough 1986, 104-107; Smith and Honeycutt 1987, 302; Walsh, et. al. 1987, 1424). Map projections introduce geometric distortion into the data through the act of portraying the 'almost' spherical earth, or a portion thereof, on a flat map. Rendering that same piece of the earth on a map also requires a transformation in scale, or some degree of generalization of reality. Finally, did the cartographer get his/her map right--are the objects on the ground portrayed accurately?

Of additional importance is the age of the source material (Burrough 1986, 104) and its lineage, or, just how convoluted is it. Chrisman (1984, 83) proposes the use of a reliability diagram in a GIS (or automated mapping system), as seen on most U.S. Geological Survey (USGS) 1:250,000-scale maps, which shows the sources of the data used in compilation. It could be used in a digital format as an overlay in a GIS database. Dahlberg (1986, 144) has proposed a similar 'data source quality statement' at a more rigorous level which would include: the documentation of data sources, mapping specifications, decision rules for including and/or excluding gestures and feature classifications, spatial resolution of data capture, and criteria employed for cartographic selection and generalization.

Operational errors can occur at several steps in the process of creation, manipulation, graphical output, and maintenance of data in a GIS (Smith and Honeycutt 1987, 301-302). Data entry is an obvious starting place as this is largely a manual process--hand digitizing--and one fraught with subjective errors. Errors are due principally to the digital representation of boundaries, many of which shouldn't be regarded as absolute in the first place, and how to best replicate their curved shapes (Burrough 1986, 116; Chrisman 1982, 161; Goodchild 1982, 87). Otawa (1987, 297) explored the issue and discovered that the area of the majority of polygons that he had his students digitize fell within ±7% range of the mean, and that the error increased proportionally with polygon size. His observations on the digitizing experiment were 'that there are personal differences in terms of style, habit, and attitudes,' and 'most GIS users tend to overlook these human factors and their influence on the quality of digitizing,' and, by association, data quality. Automated scanning of source documents is a technology that is rapidly developing to replace manual digitizing (Otawa 1987, 299). Work is still required to develop the ability to distinguish between map features and enable a foundation from which a user can create the topology for a vector-based GIS or attach attributes to grid cells for a raster-based GIS.

In addition to the possible degradation of data through mistakes in data entry is the related fact that the user is adding a second level of generalization to the data by the very act of transferring it from a map to the digital database, regardless of the type of data structure employed (Goodchild 1982, 87; Smith and Honeycutt 1987, 301; Walsh, et. al. 1987, 1424). Vector generalization occurs when a real world entity is digitally represented as a series of straight lines (Goodchild 1982, 87). Accuracy only worsens as the spatial resolution of the grid becomes more coarse and when the data are sampled from the grid cell midpoint (Goodchild 1982, 88; Walsh, et. al. 1987, 1424-1425).

Once in the system, classification of the data introduces a new set of potential errors (Hixson 1981, 84). Misclassification of information in a GIS is a relatively common mistake due largely to misinterpretation (Smith and Honeycutt 1987, 301), misinformation, or, simply, mislabeling (Walsh, et. al. 1987, 1427).

The technical difficulties involved with overlay analysis have been discussed at length earlier in this chapter. However, there are implications regarding data quality and error that are less obvious to most GIS users. The data quality issues that have been examined become pertinent to the user when an overlay manipulation is carried out, since large errors may be in the final composite (Newcomer and Szajgin 1984, 62). Foremost is the necessity for accurate source maps, or, at the very least, knowledge and/or documentation of their credibility. Assemblage of the data layers, likewise, should be handled with care. The complexity of the algorithms and the number of layers used should be kept to a minimum and/or carefully mapped out, by flowchart, in order to assure the user of an orderly approach to solving the question and to minimize uncertainty concerning the outcome. Also, careful planning and a firm theoretical base should underlie the use of weighing individual data layers according to their contribution to the algorithm (MacDougall 1975, 23; McHarg 1969). It is also important to remember that impurities in the data tend to worsen as the scale is enlarged, and it is a conscious choice on the user's part as to what degree to take this enlargement; hopefully, not too far (Chrisman 1987a, 436). This does not mean that errors make the data or overlay process, as a whole, meaningless (MacDougall 1975, 23; from Chrisman 1987a, 436). 'The point to be made,' Newcomer and Szajgin (1984, 62) conclude, is 'that users of overlay techniques must assess accuracies of the map layers used in a given application and knowledge of these accuracy values allows upper and lower bounds to be determined on the accuracy of the composite map.'

Finally, data quality is ultimately affected by system constraints in the hardware and software. On the hardware side, computers use finite precision for storage and calculations, producing round-off effects which, in turn, introduce a uniform distribution around the stored coordinates (Chrisman 1982, 163). This limitation becomes less significant with the development of new computer processors that have large data handling capabilities (Croswell and Clarke 1988, 1573). Likewise, software not only limits but defines the functionality of GIS. In theory, GIS have already been defined in terms of the desired data manipulations that an ideal system should have, but it is difficult, if not impossible, to test the integrity of these against a known constant or 'benchmark' system. Attempts have been made (Marble and Sen 1986; Goodchild and Rizzo 1986), but an 'ideal' still very much depends on the user's application.

APPLICATION OF GIS TO LAND USE PLANNING

'Because the management of land involves a balance between diverse factors of the natural environment and competing human interests,' Chrisman (1987a, 427) states, 'landscape planning must integrate information from diverse sources.' A GIS is the ideal, 'integrating' tool that can serve the needs of a variety of users, reduce duplication of effort, and reside at the local government level where data are maintained and users have 'hands-on' access to the system (American Farmland Trust 1985, 8; Somers 1987, 1379). The need for these types of data handling capabilities is especially strong in rural counties where conflicts over resource allocation are acute. These counties may be struggling to protect the agricultural land base in the face of population sprawl from adjoining urban counties, resource degradation, and increased economic pressures (America Farmland Trust 1985, 1).

A GIS at the local level, i.e. city/town or county government, uses a model based on tax parcels as its central entity. They are, in turn, tied to a large-scale spatial reference framework such as the State Plane Coordinate (SPC) or Universal Transverse Mercator (UTM) systems, ownership information, and land-related data, e.g. soils, hydrology, and transportation (Somers 1987, 1379). There has been extensive research on, and a proposal for, such a model for adoption by U.S. counties--the Multipurpose Cadastre. Simply, a modern multipurpose cadastre is defined as a record of property rights in land, encompassing both the nature and extent of these rights (NRC 1983, 13). There is also the requirement that large-scale spatial data (greater than 1:24,000) used for planning purposes be drawn from sources of quality that are prepared according to well-defined specifications and standards (Dahlberg 1986, 141). This is due to the fact there is presently a gap between the fine taxonomic and spatial resolution of most parcel databases, and coarsely defined natural resource data (Dahlberg 1986, 143) such as the frequently used U.S. Soil Survey data (example: USDA 1987) which doesn't account very well for small soil groupings at scales larger that 1:20,000, the standard soil sheet scale. Soil survey maps are still a valuable part of a natural resource data layer of any GIS, but care should be exhibited in the use of this information at the parcel level. A sample field check should be carried out, if possible. This holds true with any data that may be suspect because of use at scales larger than is assured by the accuracy at which they are sampled and mapped. Discretion should be employed when deciding whether to use flawed information or whether there is insufficient information to support the user's needs (Chrisman 1987a, 437). Moreover, a soil data layer used in a raster GIS should not be gridded so coarsely as to inhibit its use for detailed planning, even though it will still be useful for a broader level of planning (Nichols 1975, 927). As always, the grid resolution depends on the application. Parcel data in the U.S. still lack ties to a national coordinate system (SPC or UTM) and conversion to a digital format will be an exacting task absorbing extensive resources over many years (Dahlberg 1986, 143). This matter is only worsened by the fact that legal and tax parcels, i.e., the location of boundaries and ownership information, rarely coincide in property deeds on the ground and, therefore, can't be readily checked for accuracy (Chrisman 1987a, 435).

In contrast to the Multipurpose Cadastre which is intended as an all-purpose foundation for a planning model, the LESA (Land Evaluation and Site Assessment) model is designed for site-by-site assessment of 1) the viability of agricultural lands and farms, and 2) the importance of associated natural resources (American Farmland Trust 1985, 9) in the development of farmland protection policies at the state and local government level. It is also the basis for the Oregon Primary/Secondary Lands Model, examined subsequently. The integration of the many, varied data sources for a particular site is a tedious and inefficient manual process, and presents a practical example of applied GIS technology (Williams 1985, 1923-1924).

Such a study was carried out by Williams (1985) when he tested the implementation of LESA on a GIS for Douglas County, Kansas (in the northeast part of state) where development pressures are threatening agricultural land. A raster GIS, M.A.P. (Map Analysis Package), was chosen because of the ease of use of a raster overlay, with a grid cell dimensions of 100 by 100 meters on the ground (2.5-acres; minimum acreage for residential parcels). Grid cells were registered to the UTM coordinate system (Williams 1985, 1924-1926). The location, acquisition, and transferral of the source data was a time and personnel intensive process, but the final LESA map corresponded well to the study area map. Though the LESA map was derived from a cell-by-cell analysis, the LESA rating for a site (parcel) could be computed as an average of individual cell values up to a site size of 100-acres. It was concluded that a 'typical' county database would require a microcomputer GIS with 1 megabyte of RAM (random access memory) to hold the program and two map themes, and a minimum of 10 megabytes of hard disk storage for 39 map themes (Williams 1985, 1930-1931).

GIS at the local government level is slowly becoming a reality. A typical example is in Marin County, California (immediately north of San Francisco), where the planning department implemented a GIS in 1986 using the Landtrak micro-based GIS and Dbase III+ for maintenance of the parcel attribute data (Fitzgerald 1987). Mill Valley, California (also in Marin County) was faced with developing a PC AM (automated mapping)/FM (facilities management) GIS under tight budget constraints (Klien 1987). It is important to note that this AM/FM GIS is <u>not</u> a topological database. Instead, it is only a CAD model (AutoCAD) combined with a nongraphic database management system, RBase, which emulates some functionality of a true topological model. A major disadvantage of this setup (discussed previously), versus a <u>true</u> GIS, is that any changes made to the graphic component are not automatically reflected in the nongraphic database (Klein 1987, 736).

State level GIS have and are being developed to manage, model, and map information for statewide planning and resource management. An early example, the State of Maryland GIS (MAGI), was begun in 1974 by the Maryland Department of State Planning and has been developed to assist in the preparation of the State Development Plan (Maryland 1984, 2-26 - 2-52). The system is used to evaluate the location and potential of the State's prime natural resources, the pattern and extent of existing urban development, and planned facility service areas. Specifically, the Department uses MAGI to compile and assess available data on current trends and future directions of agricultural land use in Maryland. Maps are generated by the GIS for each county and serve as the basis for analyzing farmland and its location, quantity, and vulnerability to urban development (Maryland 1984, 2-52 - 2-53).

The State of Vermont, in conjunction with the University of Vermont, is currently developing a GIS for its recently enacted statewide planning program. Initially, its database will include the following data layers: 1) land cover, soils, elevation, watershed boundaries, streams and rivers, political boundaries, and transportation (Smith and Hendrix 1985, 579).

State and local GIS that are either in the planning or development stages, or are already in operation, in addition to rapid developments occurring in GIS software and microcomputer technology, will enable other planning programs to take advantage of these systems for their own use and enable them to better manage and use their information and resource base. The state of Oregon finds itself in a similar situation as it looks for ways to administer its 20-year old comprehensive planning program into the twenty-first century. The program, a challenge it faces, and how some researchers are attempting to approach it are introduced in the next chapter.

CHAPTER III

OREGON PRIMARY/SECONDARY LANDS

Oregon's agricultural and forestry lands are protected under Goals 3 and 4, respectively, of the nineteen state-wide land use planning goals (LCDC 1985). These lands comprise nearly all of the area outside of the urban growth boundaries (UGBs) which are legal limits of growth established for each incorporated city (Pease 1990, 524).

Since the inception of the Oregon comprehensive land use planning program in 1973, development in rural lands has been severely limited through the local planning process (under the supervision of the Land Conservation and Development Commission--LCDC) unless an 'exceptions' process has been carried out. This has led to mounting criticism that 'marginal, or secondary, resource lands are overprotected, while primary lands are underprotected' (Pease 1990, 524). The LCDC and Oregon Legislature's first response to the criticism was the 1983 Marginal Lands Act, Senate Bill 237. Its provisions are optional for county planning agencies, but if adopted, tests for gross farm income, parcelization, and a soil capability rating and/or related timber production potential rating are required (Holoch 1984, 2). Several counties have looked into incorporating the Act's provisions into their comprehensive plans, but only two, Lane and Washington, have done so and with limited success (McCallister 1987, 3). An accompanying bill, House Bill 2965, directed the LCDC to consider the LESA Model as an alternative to SB 237 (Holoch 1984, 3).

1985 & 1987 Legislative directives
to the LCDC and research

Due to the ineffectiveness of the Marginal Lands Act, the 1985 Legislature directed the LCDC to:

> 'Consider adoption of rules, amendment of goals and recommendations for legislation that will provide a practical means of identifying secondary resource lands.' (Section 11, Chapter 811, Oregon Laws 1985; from DLCD 1987)

The LCDC, complying with the 1985 directive, formed the Rural Lands Advisory Committee in October 1985 (Oregon Planning News 1986, 1) and it met 15 times between November 1985 and April 1987. The initial test draft of the LCDC Model was prepared in December 1986 and was the result of considerable time and effort by the LCDC staff, the Oregon County Planning Directors Association (OCPDA), and a number of related specialists, including soil scientist Herbert Huddleston of Oregon State University (OSU) (DLCD 1987; McCallister 1987, 3). Professor Huddleston and Jerry Latshaw, of the Soil Conservation Service, developed soil suitability ratings--high, medium, or low--for models of soil groups, by county, based on soil properties that influence commercial agriculture and forestry (DLCD 1987). The first model was an areal test with study boundaries defined by contiguous soil groupings, described previously, and used criteria based on average parcel size, current land use, and a minimum secondary block size (McCallister 1987, 4). It was tested by seven counties, and later by three students of Professor James Pease, Extension Land Resource Management Specialist at OSU, and found inadequate for objectively distinguishing between Primary and Secondary lands (Gallagher 1987, 1-2; McCallister 1987; Morrow 1988, 1).

Following the work of the Rural Lands Advisory Committee, the 1987 Legislature directed the LCDC to:

> 'adopt and submit a definition of secondary resource lands and uses permitted on secondary resource lands to the committee [Joint Legislative Committee on Land Use] by July 31, 1988.' (DLCD 1987)

Examination of the matter resumed late in 1987 when the Department of Land Conservation and Development (DLCD) formed a LCDC subcommittee to work with DLCD staff, county planning directors, and other interested parties (DLCD 1987). It was also recommended that a more quantifiable model be tested as well. This model came out of work done by Pease, Huddleston, and their students mentioned previously, and was agreed to by the county planning directors at their monthly meeting of January 8, 1988. Subsequently, funding was made available to Pease by the LCDC, through June 1988, to test his model (the OSU Secondary Lands Model; Appendix A; Pease 1988a) on rural lands in Linn, Lane, and Union Counties in consultation with a subcommittee of the county planning directors from Benton, Linn, and Lane Counties.

The OSU Secondary Lands Model

The OSU Secondary Lands Model, hereafter referred to as 'the Model' (Figure 3-1), begins with a preliminary screening process designed to focus on those areas outside of the UGBs or existing exception areas--rural residential, commercial, industrial, etc.--that would likely yield secondary lands because of poor soil quality or high density patterns, and would block out at or over 640-acres (Pater 1988; Pease 1990, 525-526). The original process was an analog approach. A database for the areas under study was put together from tax maps, with contiguous ownerships from the tax rolls denoted and photo-reduced to the 1:20,000 soils map scale. The contigous ownership layers were overlaid on soils maps, and generalized to the Huddleston-Latshaw soil suitability rating scheme, on translucent paper. As the Model was applied to individual parcels to determine whether they had passed the criteria, various color-pencils were used to denote which criterion/criteria the parcel(s) had passed, and summary data were calculated for each county.

The first section, Model Section A, applies soil suitability and parcelization criteria to each parcel in a

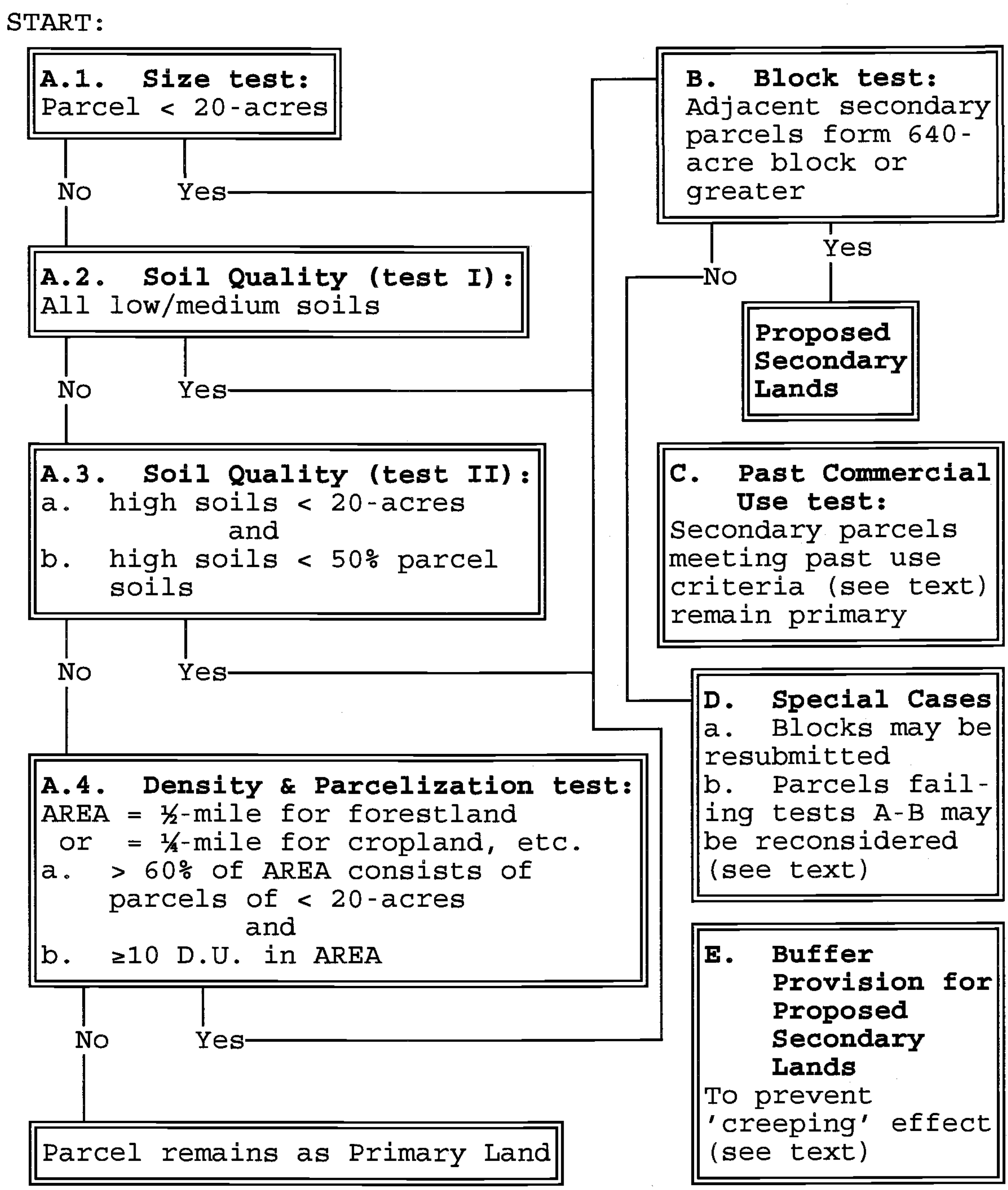

Figure 3-1. Flowchart of OSU Secondary Lands Model.

sifting manner whereby parcels failing any of the criteria drop out from the test altogether and remain designated as 'primary lands.' The Section begins with a simple size test (#1) whereby any parcel under 20-acres is considered secondary.

For parcels that are over 20-acres, tests #2 and #3 seek to determine their soil quality. Under test #2, if a parcel consists entirely of medium or low quality soils, it passes. If the parcel in question contains any quantity of high soils then it can still pass test #3 if its quantity of contiguous high soils is less than 20-acres and all of the high soils make up less than 50% of the parcel area.

The fourth test ascertains the degree of housing density and parcelization surrounding each parcel in question. Firstly, the area examined around a parcel varies according to its use. The 'buffer' is one-half mile around forested parcels, and one-quarter mile around cropland, pasture, rangeland, and mixed farm/forest uses. A buffer may also include those parcels zoned as exception areas, but not within UGBs. A parcel is defined as secondary under criterion #4 if more than 60% of the area around it consists of parcels less than 20-acres and contains 10 or more dwelling units.

Section B, the 'block test,' determines whether adjacent parcels that pass the criteria in Section A form blocks equal to or greater than 640-acres. If they don't, then a significant number of contiguous 'secondary' parcels may not exist in order to form an area designated as secondary. This is done in an attempt to prevent small pockets of secondary lands from sprouting up amongst primary lands and potentially creating more secondary blocks, which could put additional stress on housing density and parcelization.

Other blocking sizes are being proposed as well under an 'alternative block test' to determine what constitutes an acceptable secondary unit. Counties can start with a 480-acre block size if all secondary lands within the county are less than 5% of all privately held forest and agricultural lands (Pease 1988a, 2; Appendix A). Once they have identified all of the potential secondary blocks of 480-acres and greater, they can create smaller blocks down to 320-acres. The process of making smaller blocks can continue in this manner down, in 80-acre decrements, to 160-acre blocks as long as the counties don't exceed the 5% limit. The alternative blocking factor affords the counties the opportunity to create smaller blocks of secondary lands that don't meet the original 640-block minimum size but exist *de facto* as pockets in primary resource lands.

The next criterion for creating secondary lands examines the past use of potential secondary parcels to see if they are part of an existing commercial agriculture or forestry enterprise (Section C). As proposed in the Model by Pease (1988a, 2; Appendix A), the past commercial use test is an additional screen for trapping those blocks of parcels passing the previous tests that are still part of active or potentially commercial agricultural, ranching, or forestry operations. Specifically, any secondary parcel having 'a history of use between 1980 and 1988 as a part of a ranch, farm, or forestry operation or that is capable of grossing more than $40,000 per year shall be designated as primary' (Pease 1988a 3; Appendix A). To apply the past use test, a local review team made up of Extension agents, and farmers, ranchers, or foresters, reviews the proposed secondary blocks and indicates those parcels that, because of past use, should be retained as primary. Forested secondary parcels revert back to a primary designation if they 1) are greater than 80-acres, or are less than 80-acres without a dwelling unit, <u>and</u> 2) are part of a forestry block greater than 500-acres, <u>and</u> 3) are currently stocked to qualify for forest tax deferral.

The 'special case' section, Section D, provides a final mechanism by which a county may submit evidence for consideration of a block of parcels as secondary lands to the LCDC. The evidence must include documentation and findings that show why the block of parcels should be designated as secondary because of soil quality, density, and parcelization. Particular parcels may also be considered for the following reasons: 1) the parcel(s) form(s) an island (less than 160-acres of farmland or less than 500-acres of forest/mixed land) in a secondary block or exception area, <u>or</u> 2) the parcel(s) is/are a peninsula (less than 160-acres of farmland or less than 500-acres of forest/mixed land) bordered on three sides or 75% of its boundary by secondary lands or exception areas, and 3) certain parcels, because of accessibility, or lack thereof, to existing services, terrain, or other factors may be designated secondary.

Finally, Section E requires a buffer for proposed blocks of secondary lands in order to prevent a spreading effect of secondary characteristics onto adjacent primary parcels. An established buffer will <u>not</u>: 1) exceed ten dwelling units on parcels within one-quarter mile of a parcel within the adjacent primary zone, and 2) let 50% of the perimeter of a parcel within the adjacent primary zone be bordered by parcels smaller than 20-acres with a dwelling unit on it or which is eligible for a dwelling. The county can undertake many techniques including density transfer, lot size, or purchase of development rights to achieve buffer standards. Man-made or natural features such as roads, canals, ridges, or rivers 100-feet wide or wider may also be used (Pease 1988a, 3; Appendix A).

Postscript

The LCDC has reviewed the work by Pease and testimony by other interested groups, and has carried out a substantial rewrite of the testing procedures. The LCDC presented its methodology to the public in a series of public hearings, as required by state law, from November 1988 through January 1989. The reaction was, at best, poor (Kight 1988a-f, 1989a&b; Monje 1988; The Oregonian 1988a&b; Westlund 1988a&b). In spite of the response, the LCDC decided at its February 1989 meeting to adopt the primary/secondary lands package. However, the legislature asked the LCDC to postpone adoption and conduct more pilot studies in several counties, which were wrapped up in August 1990 (Pease 1990, 528).

The process of adopting new rules has been slow. The LCDC in December 1992, approved a set of administrative rules for identifying primary and secondary resource lands that included 'designation criteria, land uses, and minimum parcel sizes for six new zones' (Pease 1993, 16). The 1993 legislature is currently reviewing the rules.

Regardless of the criteria chosen, the means by which to undertake the actual analysis are best carried out by a GIS as advocated by Professor Pease in his Final Project Report on the criteria testing to the LCDC (Pease 1988b, 8). The next chapter outlines an approach to the 1988 OSU

Model using a GIS as well as the computer software and hardware best suited to the task.

CHAPTER IV

METHODS

In order to transfer the theory and analog structure of the OSU Secondary Lands Model (Chapter III) to practice in a GIS, software, hardware, and a methodological framework for carrying out the digital analysis must be assembled. The components are described in this chapter.

SOFTWARE AND HARDWARE

pcARC/INFO GIS software

pcARC/INFO is a vector-based GIS produced and sold by Environmental Systems Research Institute (ESRI) of Redlands, California (ESRI 1989). It is a fully functional and complex PC package descended from 'host' ARC/INFO which operates on numerous mini and mainframe computer systems. pcARC/INFO requires at least a PC AT CPU (the Intel 80286, 80386, and 80486), a matching math coprocessor (the Intel 80287 and 80387), 640K RAM, and a 30 Mbyte hard disk. The software is command-line 'driven,' although efforts are being made by ESRI to develop a pull-down menu shell to aid the user's ability to remember the 570 available commands and their many permutations.

The package is made up of one required 'starter' module and five optional modules (ESRI 1989). The optional modules provide more involved GIS editing, overlay, plotting, network, and data conversion procedures. The full package can cost as much as $3,500. Substantial discounts are available to educational institutions.

The Starter Kit, required to run ARC/INFO, sets up the ARC/INFO shell, or working environment, PC-to-host communications, and supports rudimentary map and attribute table creation, and error check plotting. The pcARCEDIT module is responsible for interactive graphics editing, coverage (an ARC/INFO map theme detailed subsequently) creation and update, and attribute query and update through the coverage's graphic elements. The substance of GIS analysis, thematic data overlay, is carried out by operations in pcOVERLAY. Its functions include polygon overlay, line- and point-in-polygon overlay, and buffer generation. In pcARCPLOT, interactive map creation and display occur as well as graphic query and generation of hardcopy maps. The pcNETWORK module has optimal routing, allocation, districting, and address matching/geocoding procedures. For the many data that must be loaded into ARC/INFO from other software and graphic formats, pcDATA CONVERSION covers translation not only between these formats, but also between the vector and raster data types. Finally, pcARC/INFO has a Simple Macro Language (SML) for creation of a wide gamut of programs from simple batch programs that execute a handful of operations without user intervention to ones that use its high-level programming features for interactive editing sessions.

Map themes or GIS layers are referred to as 'coverages' in ARC/INFO and contain the following elements (Figure 4-1): tics, arcs, nodes, label points, polygons, and annotation. Primary coverage features include arcs, nodes, label points, and polygons. Arcs are defined by ESRI as representing line features, the borders of polygons, or both (ESRI 1989, 3-3). Descriptive data about arcs can be stored in an arc attribute table (AAT). Nodes are arc endpoints and intersections of line features. They may be topologically linked to the set of arcs which connect to each other at the node. Label points represent either point features or positions to which attribute data are assigned to polygons, but not as both within a coverage. When representing either feature, a label point has a 'user-id' assigned to it from which descriptive data about the feature may be attached in a point or polygon feature attribute table (PAT). Polygons are area features in ARC/INFO; a polygon is defined topologically by the series of arcs that compose its border and by a label point positioned within its border.

Secondary coverage features include tics, coverage extent, and annotation. Tics, of which at least four must be maintained per coverage, are registration or geographic control points for a coverage. Coverage extent (the BND)

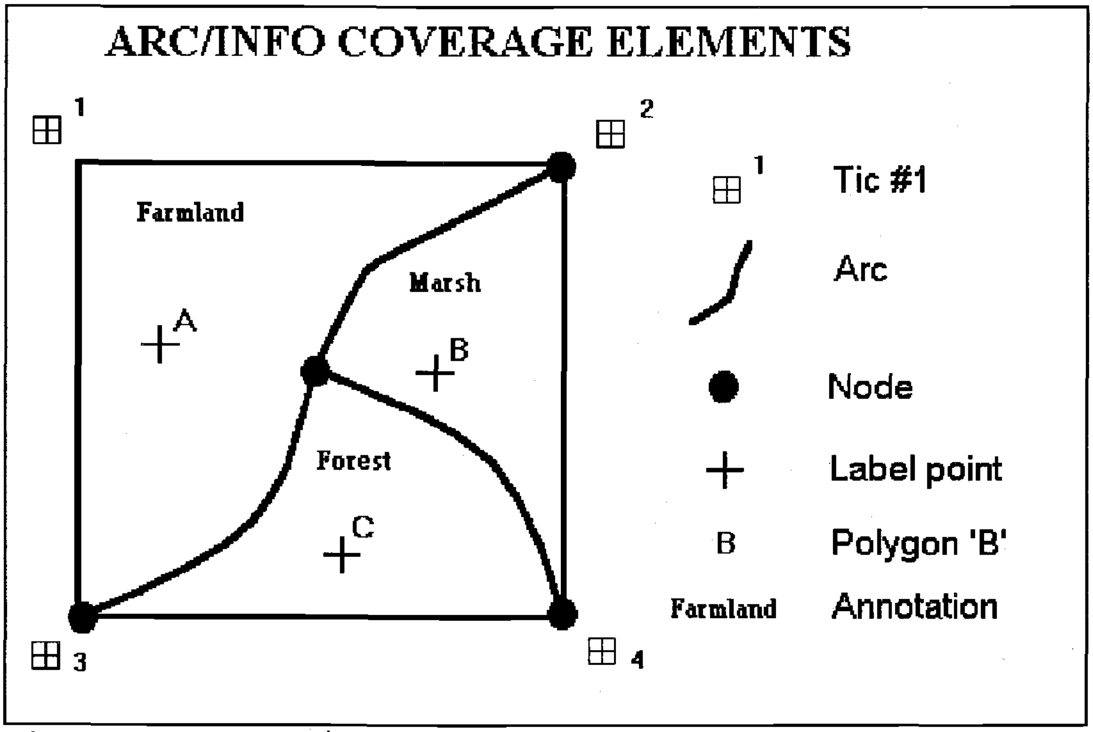

Figure 4-1. ARC/INFO coverage elements.

represents the map extent, a rectangle defining the coordinate limit of coverage arcs and label points. Annotation is text used for display purposes to label coverage features and is not topologically linked with any other features.

The feature attribute files are accessible through pcARC/INFO's database management segment, INFO, which takes two forms, pcINFO and TABLES (ESRI 1989, 3-3). pcINFO is a fully functional relational database management system developed by Henco, Inc. under license to ESRI for use with ARC and must be purchased separately from pcARC/INFO. TABLES is supplied with pcARC/INFO and contains a subset of pcINFO's commands which allows the user to create, manipulate, list, and manage attribute tables. The next version of pcARC/INFO, 3.4D, will use the more popular PC database management software, dBase III+/IV, in addition to TABLES.

Each of the previously mentioned coverage elements and topological pointers are stored as individual files in a coverage under a user's 'workspace.' This means that a coverage exists physically as a subdirectory on a PC hard disk. ARC/INFO's file management is unique in this manner and can prove frustrating, and time consuming, when moving coverages to other platforms or organizing a hard disk. pcARC/INFO provides numerous file handling utilities that are used instead of DOS commands.

Hardware

The following equipment, part of the Geographic Technology Laboratory, Department of Geosciences, Oregon State University, was used in this research:

1) Iconix PC AT-Compatible w/ 40Mbyte hard disk,
2) GTCO 36"x48" Digitizing Tablet, and
3) Hewlett-Packard 7475A pen plotter;

as well as equipment located in the Resource Information Section of the Idaho Department of Water Resources:

1) Delta 386 PC-Compatible w/ 300Mbyte hard disk,
2) Everex 486/33 PC-Compatible w/ 330Mbyte hard disk,
3) Hitachi HI2436S 30"X42" Digitizing Tablet,
4) Bruning Zeta 836S pen plotter, and
5) Hewlett-Packard 7600/355 color electrostatic plotter.

METHODOLOGY

The Model methodology can be broken down into two major parts: 1) data preparation (Figure 4-2) and 2) analyses (Figure 4-3). These split out further into the steps required to accomplish each section. The explanation of the Model will be in terms of breaking the Model down in preparation for digital analysis. The actual Model tests are not discussed here, having been presented in some detail in Chapter III (see also Figure 3-1).

DATA PREPARATION

Soils Data

- Import data into pcARC/INFO from Terrasoft GIS format
- GENERATE coverage and BUILD topolgy
- Add attribute information to associated database

Parcels Data

- Import data into pcARC format
- GENERATE coverage and BUILD topology
- APPEND pieces that comprise study area
- Add attribute information

Figure 4-2. Model framework: Data Preparation.

Data preparation

Data preparation (Figure 4-2) merits its own major section within the overall description of methodology since it naturally consumes a significant portion of any analysis using GIS. A vector GIS requires 'clean' data with a topological structure, hence, a good deal of time is spent entering and checking data carefully before <u>any</u> analysis can begin.

The bulk of data input and preparation in pcARC/INFO involves creating topology in the ARC/INFO format. Most exchange files do not convey topological information that pcARC can use directly since ARC's format is proprietary. Various formats exist that pcARC can 'import' such as: DXF, the AutoCAD software Drawing eXchange Format; or, DLG, the U.S. Geological Survey (USGS) Digital Line Graph format. If data coming into ARC/INFO isn't in any of the formats supported by the software then they have to be formatted into an ASCII file that pcARC will read and create the topology for.

The latter circumstance was the case in this study since soils and tax parcel data were being obtained from a vector GIS package called Terrasoft, which is produced by Digital Resource Systems Ltd. of Nanaimo, British Columbia, Canada. The output format from the software could not be directly 'imported' by pcARC. So, a program was written to reformat the ASCII data into the ARC/INFO 'UNGEN' form (short for the UNGENERATE format) and translated into an ARC coverage with the GENERATE module. In the case of the parcels data which arrived 'in pieces' (by Public Land Survey Section), each piece was converted into an ARC coverage and the coverages were put together with the APPEND command. APPEND does not automatically reBUILD the topological structure of the output coverage.

The coverages for the study must have topology BUILt for them with pcARC's BUILD or CLEAN commands, checked for any remaining topological errors with the LABELERRORS command for instance, edited if necessary in pcARCEDIT, and re-BUILt or CLEANed. Items are added to the coverages' PATs (polygon attribute tables), with the ADDITEM command, to accommodate information associated with the soils and/or parcel polygons required during Model analyses.

Analyses

Model analyses cannot begin immediately since the GIS cannot automatically distinguish among parcels to test and those that don't qualify for testing. The coverages must be coded as such.

Part A of the Model defines an eligible tax parcel as 'contiguous ownership tax lots with the same name on assessor records' (Pease 1988a, 1) that cannot constitute an existing 'exception area' or UGB. An exception area is where tax parcels are zoned, in the case of the study area, as RR2 or RR5 (Rural-Residential with a minimum lot size of 2 or 5-acres, respectively), M2 (Manufacturing, minimum lot size 2-acres), and CR (Commercial-Residential). A UGB is the Urban Growth Boundary around a town or city up to where growth may occur under a county's comprehensive plan. Non-exception areas in the study area include E30 and E40 zones (Exclusive farm use with minimum lot size of 30 and 40-acres, respectively), and PR (Public Recreation, e.g., a golf course).

The lot identification codes, owners' names, parcel zoning designations, and number of dwellings have already been transferred to the parcel coverage's PAT in the 'data preparation' stage. Using this information, accurate tax lots can be aggregated from the name item in the PAT database using the DISSOLVE command. DISSOLVE removes arcs shared by adjacent polygons containing the same value for a selected item in the PAT database. Eligible tracts are then literally 'pulled' out of the original tax lot coverage with the RESELECT command on the basis of the zoning designation. RESELECT extracts polygons from a coverage into a new coverage on the basis of user-defined database selections and automatically re-BUILDs the topology of the output coverage.

Eligible tax parcels under 20-acres qualify as secondary lands under Model criterion #1 (Chapter III; Appendix A). They are relatively easy to ascertain and isolate with

MODEL ANALYSES

Determination of eligible tracts

- DISSOLVE on owner's name
- RESELECT eligible tract based on zoning criteria

A.1 - Size test

- RESELECT parcels passing test

A.2 and A.3 - Soil quality tests

- Overlay soils and parcels coverages with IDENTITY command
- Summarize soil quality information by tax parcel with the FREQUENCY command into a new database and RELATE back to parcel database in pcINFO
- RESELECT parcels passing the test

A.4 - Density and parcelization test

- Recombine parcels from farm and exclusive-use zones with UNION command and reestablish attributes in pcINFO using RELATE

For each candidate parcel:

- RESELECT the candidate parcel from the parcels coverage
- BUFFER the parcel to 1/4-mile
- UNION the buffered parcel with the study area parcels coverage
- summarize dwelling and parcel size information for adjacent parcels within the buffer with the FREQUENCY command
- RELATE summary information back to the parcels coverage database and REPORT on results of test through pcINFO

B. - Block test

- interactive SELECTion and flagging of blocks through pc-ARCEDIT
- summarize block areas with FREQUENCY

Figure 4-3. Model framework: Analysis.

the RESELECT command.

The soil quality section comprises two criteria, #2 and #3. A parcel passes test #2 if all of its soils are determined to be entirely of low or medium quality. If it has any high quality soils, and they account for less than 20 contiguous acres and make up less than 50% of the total soils in the parcel, the parcel passes test #3. Since it must be known what soils lie within a parcel, then the parcels and soils coverages must be digitally overlayed with any one of a number of commands found in pcOVERLAY. The IDENTITY command is appropriate in this case because it not only combines two coverages but also crops one of the coverages to the extents or limits of the other, the identity coverage. The parcels coverage should be the identity coverage because it covers a smaller area than the soils data and is the focus of attention during Model analyses.

Determining the soil composition of each parcel then becomes a series of database procedures of summing up soil quality types--low, medium, and high--by parcel identifier. The FREQUENCY command will sum values on selected items in a coverage's database by attribute changes in other items in the same database. This information is put into a newly created database. In order to find those parcels that pass either criteria #2 or #3, data from the summary database have to be passed back to the parcels coverage PAT in pcINFO with the RELATE command which sets up a temporary link between the databases. After the necessary details have been summarized and transferred back to the parcels PAT, the RESELECT command is used to obtain the qualifying tax lots.

Model criterion #4 ascertains whether a parcel is secondary on the basis of predetermined levels of housing density and parcelization in the immediate area. Since this research focuses on an agricultural area, a buffer of ¼-mile is used around each candidate parcel. For farmland, if 60% of the area around a parcel consists of tracts of less than 20-acres and there are more than 10 dwellings, then the parcel is secondary. A candidate parcel is any tax lot that hasn't passed any of the previous Model tests, is not zoned in an exception area, and is not within ¼-mile of the study area border. Examining the area around <u>each</u> candidate parcel requires first isolating the parcel with the RESELECT command and putting it through the Model analyses before the next parcel is tested. The BUFFER command will be used to delimit the area of concern for the parcel being tested. To find the affected parcels in the surrounding area, the BUFFERed parcel's coverage is reintegrated with the parcels coverage using the pcOVERLAY UNION command. A UNION simply digitally overlays two ARC/INFO coverages, preserving all features from both coverages in the output coverage. A helpful by-product of the BUFFER command is the inclusion of the INSIDE database item in the output coverage which codes the area around the BUFFERed polygon as being inside or outside the buffer. This flag will assist in determining which parcels adjacent to the candidate parcel fall in the effective area of the density and parcelization test.

Adding up the necessary information to carry out the test, how many dwellings there are and how much land area is in parcels under 20-acres, is carried out through database operations from this point on. The FREQUENCY command and database RELATEs and REPORTs in pcINFO will assist in the determination of which parcels will pass criterion #4.

The final test carried out with the GIS is the 'block test,' Model Section B. Adjacent parcels passing previous Secondary Lands Model tests have to form blocks of 640-acres or more. Pease (1988a) also proposed alternative blocking factors from 480 to 160-acres, decrementing by 80-acres, that will also be considered in this research.

The most straightforward method for conducting the test is to examine the parcels coverage in pcARCEDIT, the interactive graphical editor. Parcels passing any of the previous tests can be SELECTed through the PAT database, highlighted on the screen which will show whether they are adjacent, and flagged through a database item. The acreage of the flagged, potential blocks of secondary lands are summed with the FREQUENCY command to see if they meet the minimum acreage requirements for creating a block.

The methodology described here is applied with the GIS in the following chapter. Each step, including the commands used in pcARC/INFO, will be presented and explained in detail.

CHAPTER V

GIS ANALYSES

The OSU Secondary Lands Model is first presented in its original analog format in Chapter III and a digital approach to applying the Model is discussed in Chapter IV. In this chapter, the digital strategy is actually put to the test using a GIS. The preparation of analog information and ancillary digital data, and Model analyses are examined. The results of the analyses are studied in Chapter VI.

DATA PREPARATION

The Model requires soils and tax parcel data for an area of land to which it will be applied. In this case, the area in question was comprised of four sections (4 square miles) of the Public Land Survey System (PLSS) of the Coburg 'Hills' area of north central Lane County. Therefore, the data were obtained primarily in analog format (paper) from the Lane County Planner's Office in Eugene, Oregon (the county seat).

Soils data are available in map form for most counties in the United States, including Lane County (USDA 1987). The maps include labelled soil polygons on a screened aerial photograph background at 1:20,000-scale and are accompanied by detailed soil unit descriptions in a soft bound manual (Figure 5-1).

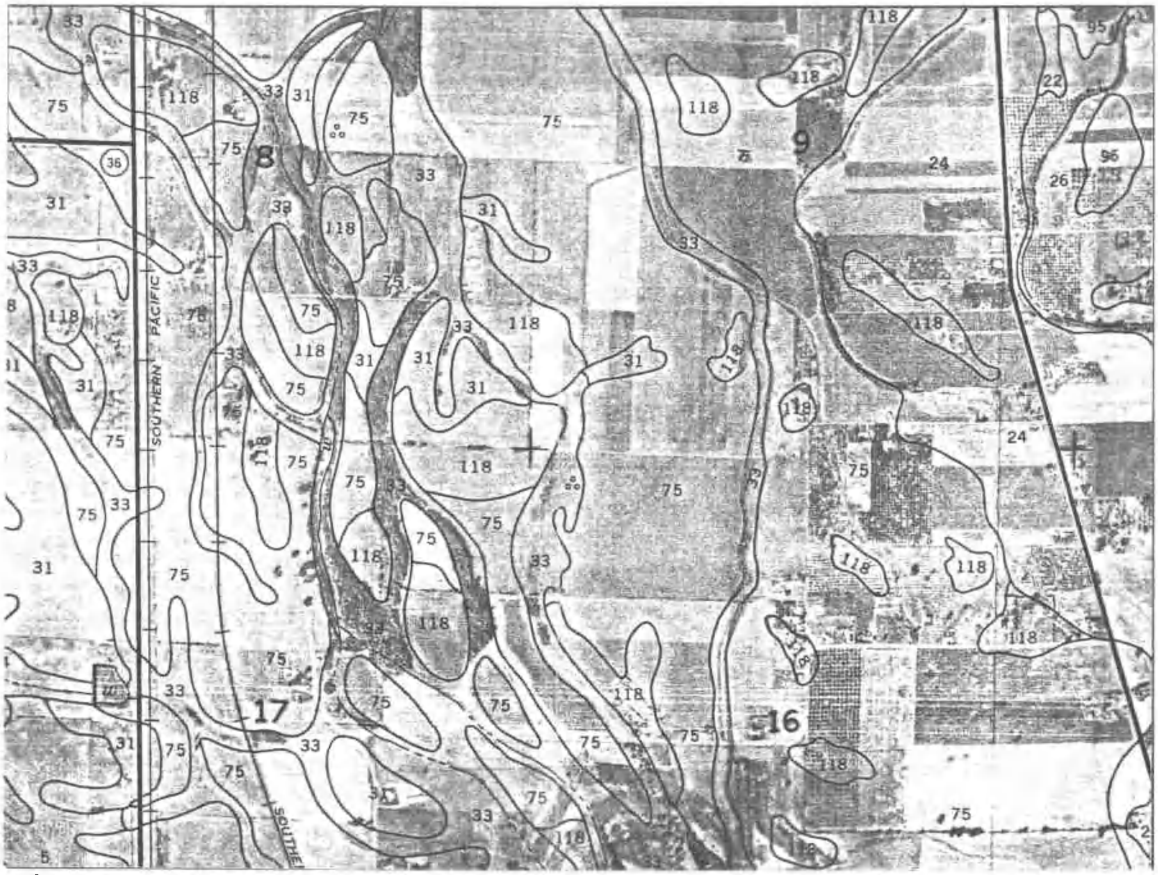

Figure 5-1. Example of a soil survey map.

Parcel data required for the Model are comprised of tax parcel maps, zoning maps, and 'flysheets.' Tax parcel maps, commonly at 1 inch to 400 feet (1:4800-scale), show land lot information for a section such as lot acreage and dimensions, dwelling types, access points, and easements (Figure 5-2). Zoning maps show zoning boundaries, with county zoning codes and lot lines from parcel maps, for two adjacent sections and at a smaller scale (roughly 1:12,000). Flysheets are computer listings with lot num-

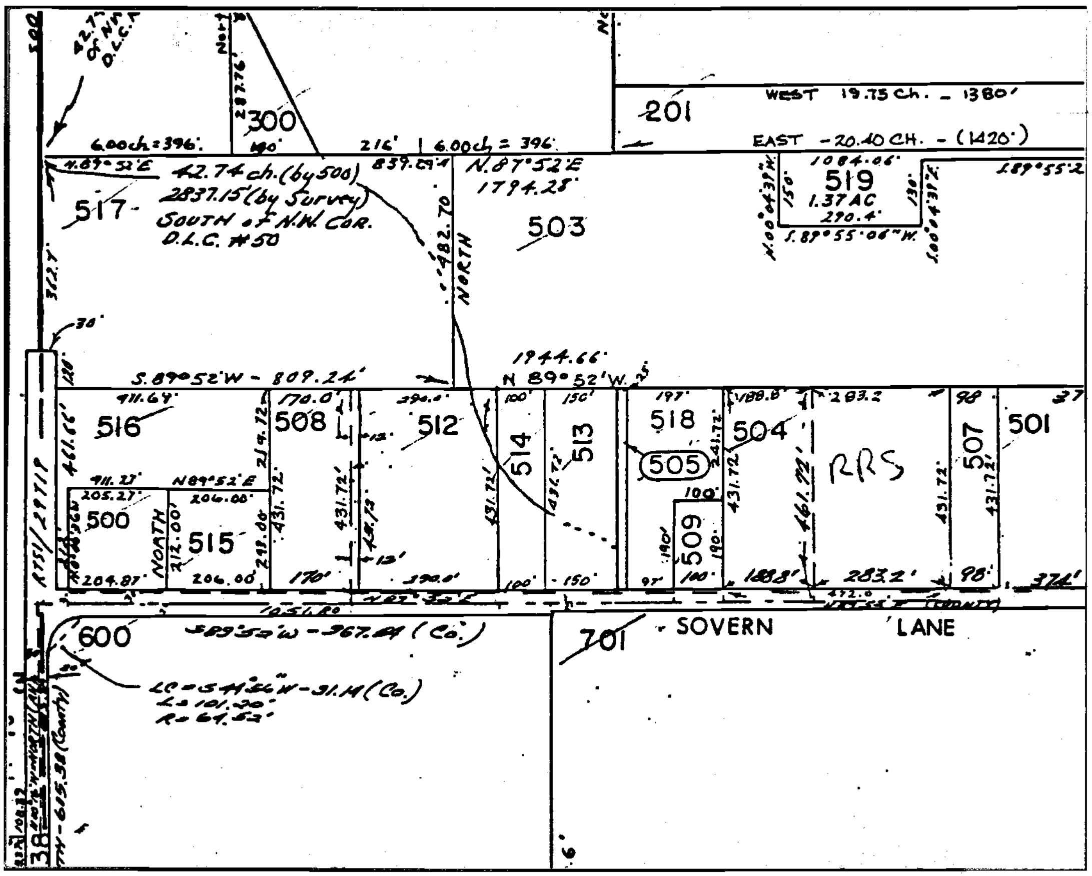

Figure 5-2. Example of a tax parcel map.

bers, owners' names, acreage, zoning designations, and values for tax parcels for selected areas of the user's choosing.

Initial data preparation involves conversion from analog to digital format, or from paper to computer to put it simply. For Model analyses, soils and parcel map data are digitized by students of Professor Herbert Huddleston (Chapter III) in the Terrasoft PC GIS.

DATA PREPARATION

Soils Data

- Translate data from Terrasoft GIS into pcARC/INFO format with TERRARC.PAS program and TABLES
- Build topology with CLEAN
- Transfer annotation information to a database field with ADDITEM and pcARCEDIT
- Fill PAT with H-M-L soil quality rating using the HML.FIL program in pcINFO
- Derive final coverage used in remaining analyses by DISSOLVing on H-M-L rating

Figure 5-3. Model framework: Soils Data Preparation.

Soils data

A few, fairly involved steps (Figure 5-3) are required to convert the digital data from the Terrasoft format to pcARC/INFO format. To begin, arc and label point data from the Terrasoft soil and tax parcel coverages are 'exported' into ASCII text files on floppy diskettes. A Turbo Pascal (Version 4.0) program, called TERRARC.PAS (Appendix B), is executed to extract and reformat the data into the ARC/INFO 'UNGENERATEd' file format. This will allow for importation of the data into pcARC/INFO coverages through ARC's GENERATE command. The following is an example of GENERATing the soils coverage for the test area from Lane County Soil Survey sheet #27 (USDA 1987):

(NOTE: Hereafter, all documented computer input will include only commands typed in at the PC, not software responses or banners, or full directory prompts.)

```
> GENERATE SOIL27

Generate> INPUT LNSLS027.LIN  (line coordinate data
                               for the soil polygons
                               output from TERRARC.PAS)

Generate> LINES     (instructs ARC to accept coordi-
                    nate data for lines from the a-
                    forementioned ASCII file)

Generate> INPUT LNSLS027.PTS  (point coordinate data
                               from TERRARC.PAS)

Generate> POINTS    (works like LINES)

Generate> INPUT LNSLS027.ANN  (annotation data)

Generate> ANNOTATION 1,10     (creates annotation from
                               the text file at 'level
                               1' with textsymbol #10)

Generate> INPUT LNSLS027.ANS  (more annotation)

Generate> ANNOTATION 2,6 (creates annotation at 'level
                          2' with textsymbol #6)

Generate> QUIT (ends the ARC GENERATE session and pro-
               cesses the data from the text files
               into an ARC coverage)
```

When a coverage is GENERATed in ARC/INFO, two companion database files are automatically created: the <cover>.TIC file to maintain tic registration identification number (ids) and coordinates, and the <cover>.BND file to keep coordinates of the coverage's maximum graphic extents. Registration tic id and coordinate data are loaded into ARC coverages from the TERRARC.PAS formatted files with TABLES, pcARC/INFO's 'mini-database' (Chapter

IV). For example, in the case of ARC coverage LNSLS027, GENERATEd previously, the TABLES ADD command imports the soils coverage tics from the text files as follows:

```
> TABLES

Enter Command: SELECT LNSLS027.TIC (SELECT the ARC
                                    coverage LNSLS027
                                    TIC attribute file)

Enter Command: ADD FROM LNSLS027.TIC     (import data
                                          from text
                                          file)

Enter Command: Q STOP    (end the current TABLES ses-
                          sion)
```

The pcARC/INFO soils coverage LNSLS027 is now fully converted from Terrasoft. Polygon topology must be built in ARC, and polygon errors located and cleaned up. Soils data for the study area are first extracted from LNSLS027, which covers an entire Soil Survey map sheet, with the ARC command CLIP. The output coverage, SOIL27, is smaller than LNSLS027 and should be easier to process.

The ARC command CLEAN is used to intersect overlapping arcs, 'snap' arc endpoints within a specified 'fuzzy' distance, and clip 'dangling' arcs, also within a specified tolerance. It then performs functions particular to the ARC BUILD command to create polygon and/or arc topology and enable errors such as unlabelled polygons or those with more than one label, and dangling arcs that perhaps should be attached to other arcs to complete a polygon to be high-

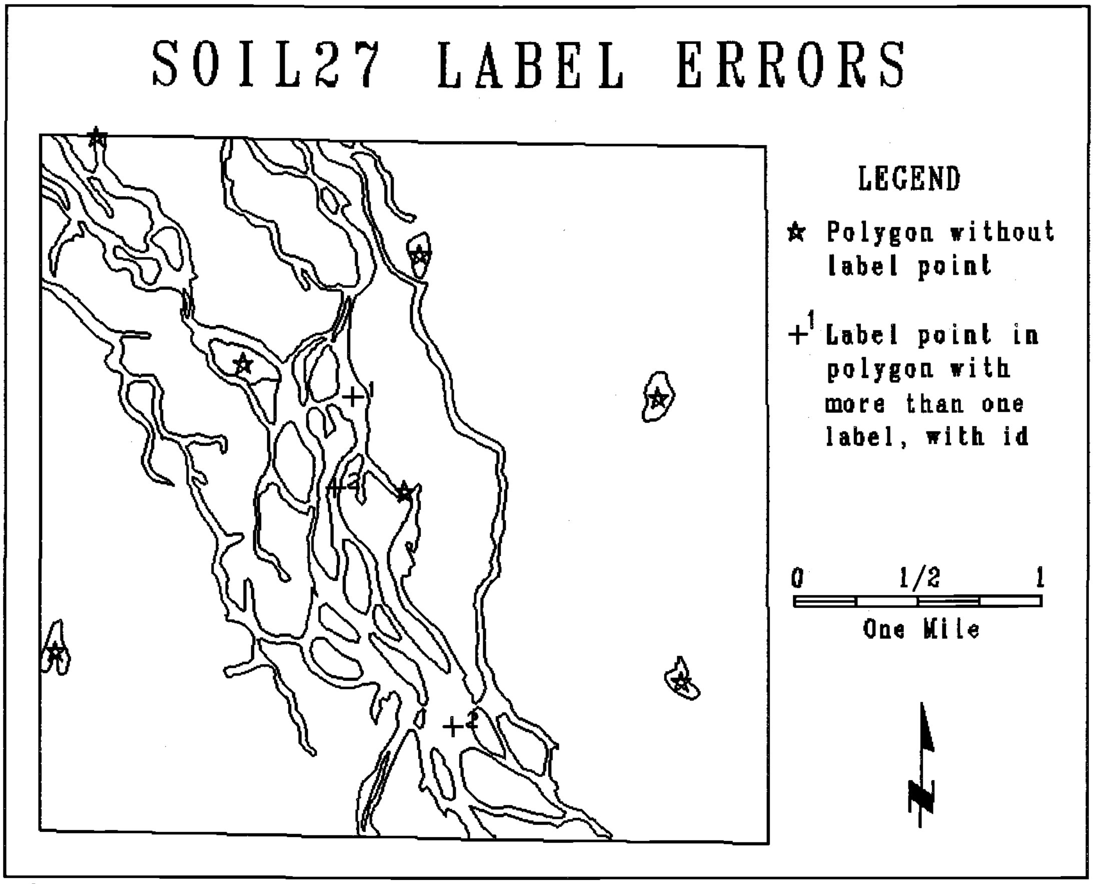

Figure 5-4. Soils coverage label-errors plot.

lighted. The pcARC/INFO command EDITPLOT is used to display graphically on the PC screen or output to a plotter or printer the polygon errors for the SOIL27 coverage (Figure 5-4). Likewise, tabular output of the label errors for the coverage are derived with the ARC LABELERRORS command (Table 5-1). The graphic and tabular output are used to assist with the interactive editing of the errors in pcARCEDIT. The process of cleaning up polygon errors is iterative, often requiring going through the aforementioned steps several times in order to find and correct <u>all</u> of the errors. The best approach is to fix polygon errors first

Table 5-1. Soils coverage label-errors listing.

Polygon	1	has	0	label points.
Polygon	3	has	3	label points.
Label User-ID:			2	
Label User-ID:			1	
Label User-ID:			2	
Polygon	5	has	0	label points.
Polygon	39	has	0	label points.
Polygon	66	has	0	label points.
Polygon	75	has	0	label points.
Polygon	129	has	0	label points.
Polygon	139	has	0	label points.

and then label errors because labels cannot be associated with polygons until polygon boundaries close.

CLEAN/BUILD also creates a polygon attribute table (PAT) for the coverage, in the pcINFO/TABLES database format, with records associated with each polygon. The default items, referred to as 'fields' in other databases, are as follows for the SOIL27 coverage:

ITEM	TYPE	WIDTH (output)
AREA	F(loating point)	12
PERIMETER	F(loating point)	12
SOIL27#	B(inary)	5
SOIL27-ID	B(inary)	5

The item SOIL27-ID, referred to hereafter as the user-id, is the unique identification code for the polygon's label point, accessible graphically through pcARCEDIT. The label points and their ids for SOIL27 are loaded into the coverage with GENERATE, discussed previously. The default items shown above should not be altered by the user in any way as

ARC/INFO uses this template to maintain pointers between the graphical component of the coverage and its database and, thusly, the coverage topology. Any number of items (attributes) may be added, as will be shown, to the default structure.

The item, MU_SYMBOL, is added to SOIL27's PAT to hold each polygon's soil series number. The command is as follows:

ADDITEM SOIL27.PAT SOIL27.PAT MU_SYMBOL 4 4 C

It roughly translates to, 'add the item MU_SYMBOL to SOIL27.PAT to create SOIL27.PAT and define it as a character item with 4 bytes of internal and output width.' The MU_SYMBOL numbers are carried over from the Terrasoft files as annotation in ARC/INFO. The process of transferring the numbers from annotation to the database file is interactive and carried out in pcARCEDIT. To begin, SOIL27 is made the EDITCOVERAGE, the DRAWENVIRONMENT is set to draw coverage arcs, label points, and annotation, and the EDITFEATURE is set to labels. A soil polygon is 'zoomed' into--enlarged on the screen--to clearly see the annotation that is over it, and its label point is 'SELECTed' with crosshairs on the screen from the keyboard or a mouse. The command, 'MOVEITEM {MU_SYMBOL value from the annotation} TO MU_SYMBOL,' is used to put the annotation value into the item MU_SYMBOL in SOIL27.PAT.

The study area soils coverage SOIL27 must have additional attributes based on soil types which will make it useful to the Model. The most important of these attributes is a 'soil resource classification' number for cropland devised by Huddleston and Latshaw (Chapter III). They have put the ratings for each Oregon county in 'lists.' Lane County's list (Appendix C) includes each soil's map unit symbol (item MU_SYMBOL in coverage SOIL27's PAT), the series, texture, slope letter code, minimum and maximum slopes, resource ratings for agriculture and forestry, and drainage class. The listing was entered into pcINFO by students in Professor Kimerling's GIS class, Winter term, 1988. An additional item, referred to as 'HML_CLASS' since the ratings are qualified as 'high, medium, or low,' will be affixed to SOIL27.PAT to retain each soil's overall resource rating.

At this point, the power of relational database functionality is first demonstrated. In pcINFO, a database linkage, or simple 'relate,' is set up between SOIL27.PAT and SOIL.DATA, the Lane County soil data list (Appendix C), on the item MU_SYMBOL, as follows:

```
> INFO

ENTER USER NAME: ARC

ENTER COMMAND: SELECT SOIL27B.PAT  {SELECT database
SOIL27B.PAT}
```

ENTER COMMAND: RELATE SOIL.DATA 1 BY MU_SYMBOL {RE-LATE database SOIL.DATA (RELATEd file #1) by item MU_SYMBOL}

ENTER COMMAND: RUN HML.FIL {execute INFO program, HML.FIL}

As is just shown, an INFO program, HML.FIL (Appendix D), is then executed to search SOIL.DATA on each soil type in SOIL27.PAT for the crop and woodland resource ratings. The program takes the higher of the two ratings and puts an 'H' (high), 'M' (medium), or 'L' (low) in the item 'HML_CLASS' of SOIL27.PAT. For example, map unit '033,' 'Conser silty clay loam,' has a resource rating of medium for crops and '3' (equivalent to a low rating for atypical use of the resource based on little or no yield data) for woodlands. The higher rating, medium or 'M,' would thus be used as the overall resource rating, HML_CLASS, for the soil.

Final preparation of the soils coverage, SOIL27, for use in the Model is facilitated by isolation of the overall resource rating, HML_CLASS. The ARC command DISSOLVE is used to remove arcs between polygons based on a common coverage attribute selected by the user. For example, the command syntax for DISSOLVing SOIL27 into SOILHML using HML_CLASS as the 'dissolve' item is:

DISSOLVE SOIL27 SOILHML HML_CLASS

SOIL27 remains available as a more complete soils layer for the study area, however, SOILHML retains only essential information necessary for further Model analysis. An item ACRES is added to SOILHML's PAT to complete the information needed within SOILHML. In TABLES, ACRES is calculated from the default item AREA using the following expression:

CALCULATE ACRES = AREA / 43560

Since the coverages were built in ARC/INFO from data digitized from maps projected on the Oregon State Plane grid, which is in feet, then AREA represents square feet and an acre is equal to 43,560 square-feet.

DATA PREPARATION

Tax Parcel Data

- Translate data from Terrasoft GIS into pcARC/INFO format with TERRARC.PAS program and TABLES
- APPEND four section coverages together and build topology with CLEAN
- Transfer annotation information and data from flysheets to database field with ADDITEM and pcARCEDIT

Figure 5-5. Model framework: Tax parcel data preparation.

Tax parcel data

The tax parcel coverage is compiled much the same way as the soils data (Figure 5-5). The fundamental difference between the two layers is that the parcel data, maintained primarily by single public land survey sections by the county, must be assembled from four Terrasoft data files because the study area covers four sections. The four files are TX160408, TX160409, TX160416, and TX160417. They are converted into pcARC/INFO coverages with the TERRARC.PAS-ARC GENERATE procedure discussed at length previously. After they are CLEANed, the ARC APPEND command is used to join them together into a single coverage called TAX1604. The procedure goes as follows:

> APPEND TAX1604

Enter the 1st coverage: TAX160408

Enter the 2nd coverage: TAX160409

Enter the 3rd coverage: TAX160416

Enter the 4th coverage: TAX160417

Enter the 5th coverage: {press <Enter> to finish input}

APPEND 'joins' the coverages together but does not rebuild topology. TAX1604 is CLEANed before continuing further. This also enables polygon label errors to be located with EDITPLOT, as they were with SOILS27, and corrected in pcARCEDIT along with edgematching errors between adjacent sections.

Tax parcel data are acquired primarily from paper maps and 'flysheets' obtained by Professor Huddleston from the Lane County Assessor's office. The primary lot numbers are captured, similar to those for the soils polygons, from coverage annotation added by Huddleston's students and transferred manually during an ARCEDIT session. These numbers are entered into an item called MAPLOT and confirmed from paper tax maps (Figure 5-2). The entire list of items affixed to TAX1604.PAT for Model analysis are as follows:

ITEM	TYPE	WIDTH (output)
MAPLOT	C(haracter)	14
NAME	C	45
ZONE	C	5
DWELL	I(nteger)	2

The information for the items NAME and ZONE are found on assessor's flysheets mentioned before. Zoning categories for lots are also checked from parcel zoning maps. The number of dwellings for each lot is found on tax parcel maps (Figure 5-2) and can be verified from the assessed value listed on the flysheet.

Tax lots are coded with a 13-digit code devised by Lane County and stored under MAPCODE. The taxonomy of the code is as follows for code '1604083400500':

```
     1 6 0 4 0 8 3 4 0 0 5 0 0
       |   |   | | |         |
 Township  |   | | |         |
           |   | | |         |
       Range   | | |         |
               | | |         |
        Section  | |         |
                 | |         |  (1/4 and 1/4-1/4
       1/4 Section |         |   sections numbered
                   |         |   counterclockwise
     1/4-1/4 Section         |   from the upper
                             |   right corner)
                        Lot id
```

In addition, some parcels are split up by roads or rivers even though they are considered by the lot number to be a single lot. According to the methodology used by Huddleston's students when the lots are digitized, a character suffix is added to the map lot id for each piece of the subdivided lot. For example, the first piece will have a suffix of 'A,' the second piece will be 'B,' and so on. For purposes of Model analysis, and because they are largely ignored, the lots that contain roads and railroads will be considered as one transportation polygon in the GIS database.

MODEL ANALYSES

Determination of eligible tracts

Model analysis begins with the determination of eligible ownership tracts as defined in Part A of the Model (Figure 5-6) and discussed in Chapter IV. The process for finding eligible lots involves combining tax parcels or, in this case, polygons together with the same names (from the NAME item in TAX1604.PAT) outside and inside exception areas, but not across zoning boundaries between exception and non-exception areas. The RESELECT command is used to separate exception areas and non-exception areas from coverage TAX1604 into coverage TX-EXCPT (Figure 5-7):

```
> RESELECT TAX1604 TX-EXCPT POLY  {SELECT POLYgon fea-
tures from coverage TAX1604 into coverage TX-EXCPT}
```

MODEL ANALYSES

Determination of Eligible Tracts

- Separate tax lots in non-exception zones from exception areas with the RESELECT command
- DISSOLVE on name item and re-join 'lost' database information with JOINITEM command
- re-CALCULATE parcel acreages in TABLES and dwelling totals in pcARCEDIT
- Summarize acreage and dwelling values by parcel with the FREQUENCY command and restore to the PAT database in pcINFO with the RELATE command

Figure 5-6. Mode framework: Determination of eligible tracts.

: RES ZONE <> 'E30' AND ZONE <> 'E40' AND ZONE <> 'PR'
{RESELECT polygons/parcels that don't have non-exclusive use zoning designations}

: {press <Enter> to finish}

RESELECT, which is packaged with the pcOVERLAY module of pcARC/INFO, is used to select coverage features (polygons, arcs, or points) from coverages based on user-defined attributes associated with a coverage. These selections, since they are made from a database using Boolean logic, can be made a variety of ways. In this case, tax parcels that constitute exception areas could be used as well with item ZONE set equal to each of the values in the above selection criterion. The non-exception zoning types are used because there are fewer types to deal with. Non-exception parcels are RESELECTed in a similar manner from TAX1604 into TX-FARM (Figure 5-7):

> RESELECT TAX1604 TX-FARM {the POLY option is not used here since it is the default option}

: RES ZONE = 'E30' OR ZONE = 'E40' OR ZONE = 'PR'

To achieve the Model definition of an ownership tract, the DISSOLVE command is used on coverage TX-EXCPT to derive T-EXCPTD and on TX-FARM to get T-FARMD, both using item NAME. A unique problem develops, however, in that <u>all</u> of the attributes other than the default coverage items (AREA, PERIMETER, COVER#, and COVER-ID) and the item DISSOLVEd on (NAME) are dropped. For example, in the case of cover TX-EXCPT, items MAPLOT, ZONE, and DWELL are dropped when the coverage is DISSOLVEd into T-EXCPTD on item NAME. The predicament is that all of the items are necessary to subsequent analyses and the missing data must be re-secured. Also, tax lots with the same name and maplot number that are separated by a transportation polygon are not DISSOLVEd together. The latter case will be discussed subsequently.

For adjacent maplots that have been DISSOLVEd together by the same name, 'lost' data can be reattached with the JOINITEM command. The following JOINITEM command is executed at the ARC prompt on coverage T-FARMD's PAT:

> JOINITEM T-FARMD.PAT TX-FARM.PAT T-FARMD.PAT NAME NAME

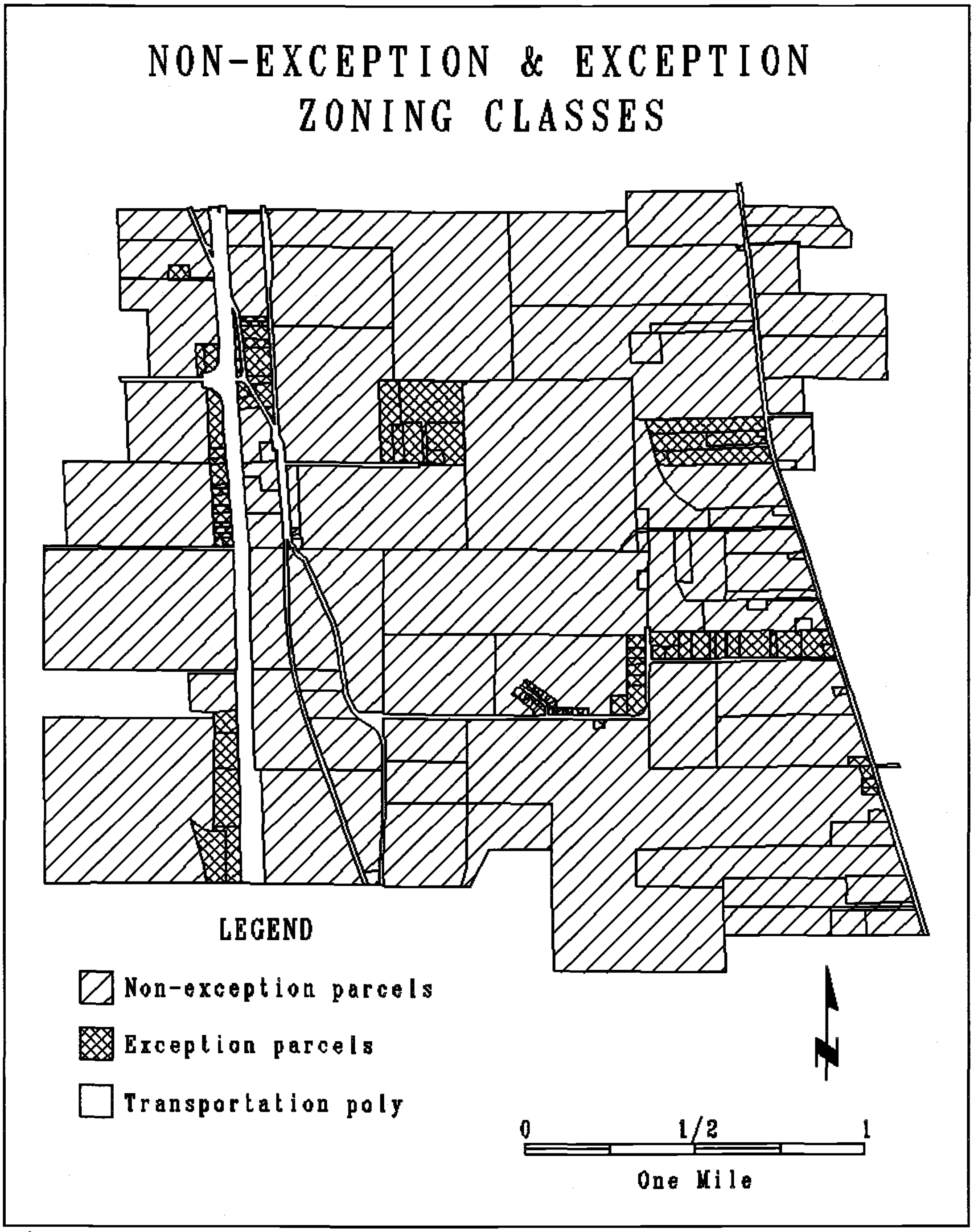

Figure 5-7. Model zoning classes.

In this case, JOINITEM is used to permanently (versus a temporary pcINFO 'RELATE' previously used) 'join' the PAT of TX-FARM to that of T-FARMD through the contents of the

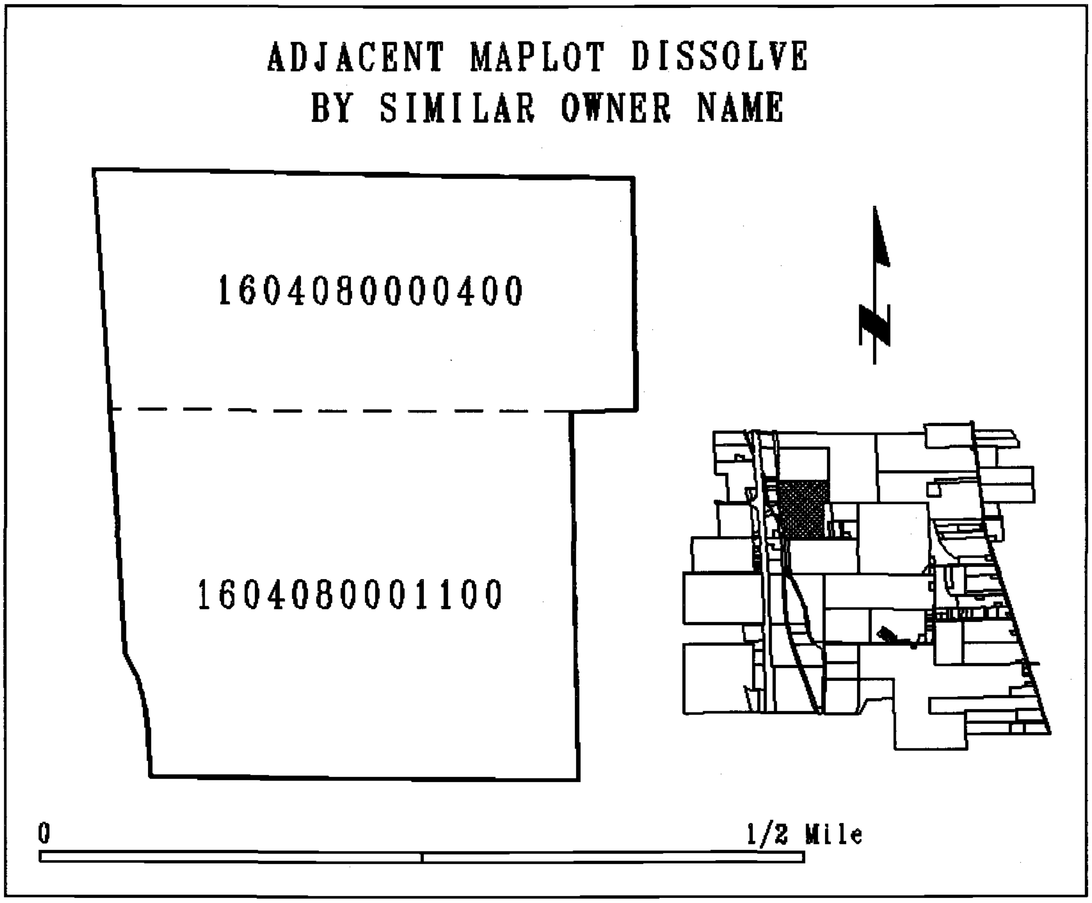

Figure 5-8. Dissolving adjacent maplots by the owner's name.

NAME item. It is also used on T-EXCPTD.PAT in the same manner. Maplots '1604080000400' and '1604080001100,' from TX-FARM, serve as a good example (Figure 5-8). The name entered into the data base from the tax records for both of the lots is 'FISHER DONALD W & FISHER MARY M,' hence they DISSOLVEd together. Only one of the original maplot item values, '1604080000400,' will be 'joined' to this field in coverage T-FARMD from the unDISSOLVEd TX-FARM.PAT. It is an example of a 'one-to-many' relate of database items whereby the <u>first</u> record encountered by JOINITEM in TX-

FARM.PAT that matches a record in T-FARMD.PAT will have its contents JOINed to TX-FARM.PAT. This does not matter for future analyses, but the MAPLOT field may be useful as another unique identifier of the resultant lot besides the name. The numeric item ACRES is also erroneous after the DISSOLVE and can be easily reCALCULATEd in TABLES from the item AREA since it is an ARC default item which is readjusted when ARC topology is rebuilt. The number of dwellings in each tax lot is not so easily corrected since it is independent of the default items. For a small area, such as the study area, the total number of dwellings in the DISSOLVEd lots is adjusted rather quickly in ARCEDIT. In an interactive ARCEDIT session, for example, the coverage T-FARMD is the active EDITCOVERAGE and TX-FARM is displayed behind it in another color. This has the effect of 'highlighting' those tax lots which have been DISSOLVEd because their un-DISSOLVEd boundaries are made visible, as symbolized by the dashed line in Figure 5-8. The areas of interest are zoomed into, the BACKCOVERAGE TX-FARM is swapped into the position of EDITCOVERAGE for querying, and the number of dwellings for the constituent lots ascertained. Coverage T-FARMD is swapped back, the DISSOLVEd lot SELECTed in EDITFEATURE LABEL, and item DWELL reCALCULATEd to the correct summary value.

The user is still left with the unresolved matter of those tax lots that are adjacent and possess the same name

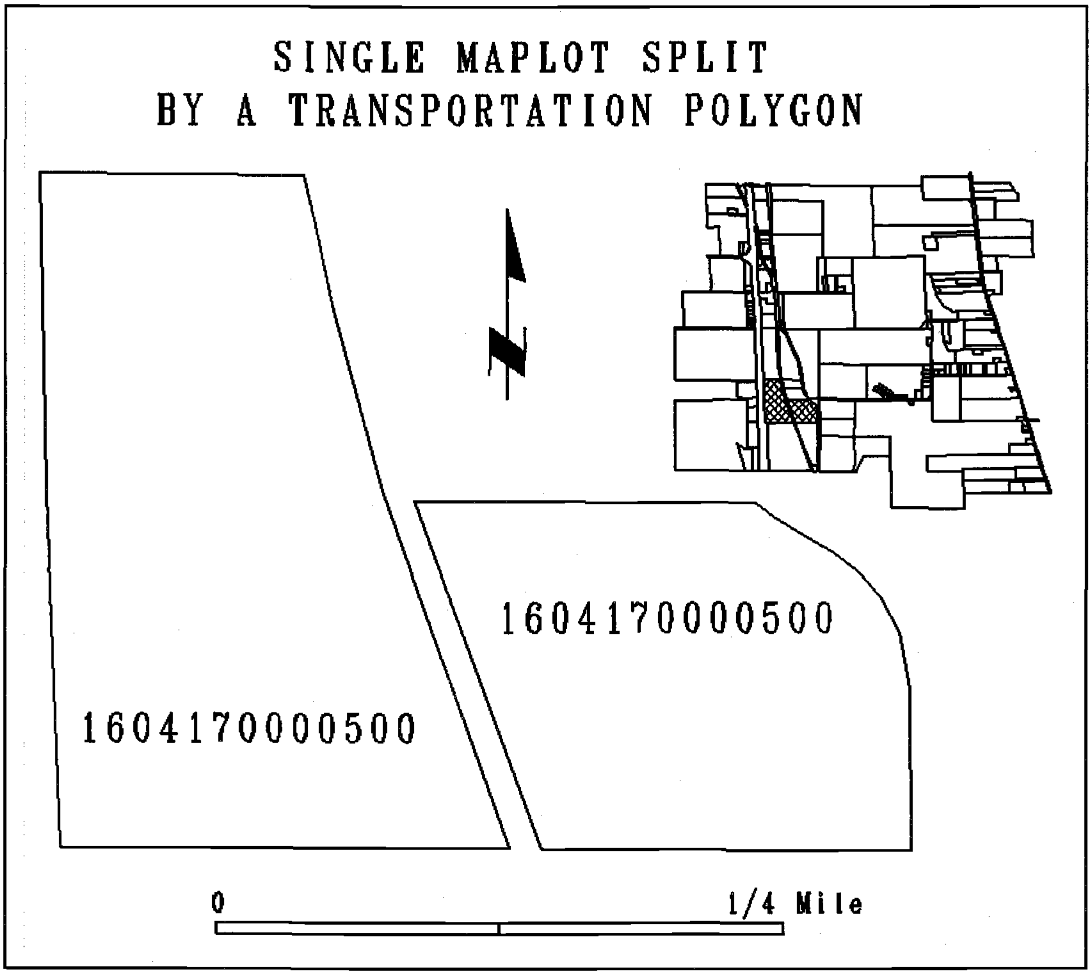

Figure 5-9. Maplot split by a transportation polygon.

on the tax lots, <u>but</u> are split by a transportation polygon. Lot '1604170000500,' which is comprised of lots '500A' and '500C' (letters from Huddleston digital data), will be used to illustrate an approach to correcting it (Figure 5-9). They can't be DISSOLVEd together because the intervening transportation polygon doesn't share a common item on which to DISSOLVE. It is also impractical to DISSOLVE an entire transportation polygon that extends beyond a split tax parcel. The polygons' database fields, however, can be 'tied' together by a common attribute. The logical item to use in this case, and as will be shown, is the maplot number because a tax lot split by a road--transportation polygon--will carry the same number. The tax lot's NAME item, in the database, is not totally reliable either because it may show up as the name on the tax fly sheet for other polygons that are not adjacent and the user does not want them to be tied together in the database. Employing the maplot number as the unifying attribute requires that the character suffixes be dropped. This procedure is easily carried out in TABLES or pcINFO on T-FARMD's PAT.

Further processing to reattach data to lots split by the transport poly needs only to be done to the 'farm' lots coverage T-FARMD since they are the only lots that can be affected by the Secondary Lands analysis. 'Exception' lots are by their very definition already secondary.

Since the map lot number is the key field for 'connecting' split tax lots, it can be used to summarize other numeric fields. In this case, the user needs summary data for each lot's acreage and dwelling counts. ARC's FREQUENCY command is used for this purpose in the following manner:

```
> FREQUENCY T-FARMD.PAT TF-FREQ.ACDW
frequency item name 1: MAPLOT
frequency item name 2: END  {finish input of frequency items}
```

summary item name 1: ACRES

summary item name 2: DWELL

summary item name 3: END {finish input}

FREQUENCY creates a new INFO database file from T-FARMD's polygon attribute table, TF-FREQ.ACDW, which summarizes the items ACRES and DWELL for each unique map lot number. This same map lot number will be used to link the summary data back to T-FARMD.

Two new items, TOTL-AC and TOTL-DWL, or total acreage and dwellings, respectively, are added with ADDITEM to T-FARMD's PAT to hold the summary data in TF-FREQ.ACDW. A relate is set up in pcINFO between T-FARMD.PAT and TF-FREQ.ACDW to facilitate a transfer of the summary data from the latter to the former database with the following commands:

ENTER COMMAND: SELECT T-FARMD.PAT

ENTER COMMAND: RELATE TF-FREQ.ACDW 1 BY MAPLOT

ENTER COMMAND: MOVE $1ACRES TO TOTL-AC {MOVE data from summary item ACRES in TF-FREQ.ACDW into item TOTL-AC}

ENTER COMMAND: MOVE $1DWELL TO TOTL-DWL {repeat for dwellings}

It is important to reiterate that 'relates' can only be done in pcINFO and not in TABLES.

Size test

The first test of the Model, and perhaps the easiest to apply, determines whether a parcel is 'secondary' based

MODEL ANALYSES

A.1 - Size Test

- RESELECT for parcels < 20 acres

Figure 5-10. Model framework: Size test.

on a parcel's size (Figure 5-10). Basically, if the parcel is smaller than 20-acres it is secondary. The pcOVERLAY RESELECT module is used to select parcel polygons from the T-FARMD coverage, using the <u>total</u> parcel acreage located in item TOTL-AC, to create two new coverages. They are TXF-LT20, a coverage of those lots <u>less</u> than 20-acres, and TXF-GE20, a coverage of lots <u>greater</u> than 20-acres which will be used in subsequent analyses. The specific commands are as follows:

> > RESELECT T-FARMD TXF-LT20 POLY
>
> : RES TOTL-AC ≤ 20 {RESELECT for a parcel's total acreage *less than or equal* to 20}

> > RESELECT T-FARMD TXF-GT20 POLY
>
> : RES TOTL-AC > 20 {RESELECT for a parcel's total acreage *greater* than 20}

Soil quality test

The soil quality test actually encompasses two Model criteria, numbers two and three (Figure 5-11). If a parcel

MODEL ANALYSES

A.2 and A.3 - Soil Quality Tests

- Combine soils and parcel coverages with IDENTITY command
- Determine soils composition of each parcel with FREQUENCY command, RELATE to parcel coverage database, and CALCULATE percentages of soil quality ratings
- For test #2, RESELECT out those parcels with all medium or low soils
- For test #3, RESELECT out those parcels where contiguous high soils are < 20 acres in size and < 50% of a parcel's total area

Figure 5-11. Model framework: Soil quality tests.

is composed <u>entirely</u> of medium or low quality soils (test #2), or consists of contiguous high quality soils less than 20-acres and all high soils make up less than 50% of the total soils (test #3), than it is secondary. At this point, the coverage TXF-GT20, farm parcels greater than 20-acres, will be the focus of further study and TXF-LT20, those less than 20-acres, can be put aside since its parcels are already secondary under criterion one, discussed previously.

To begin the process of determining soil quality according to the criteria, the tax parcels and soils coverages must be 'overlayed' digitally. The ARC/INFO command sequence is as follows:

```
> IDENTITY TXF-GE20 SOILHML TX-SOIL
```

The IDENTITY function combines the coverages TXF-GE20 and SOILHML to produce TX-SOIL. TXF-GE20 is also referred to as the 'identity' coverage because it defines the extent of the resultant coverage, TX-SOIL.

<u>Before</u> the coverages are combined, the item ACRES in TXF-GE20.PAT is renamed to TAX-AC in order to retain the total acreage of each tax parcel for subsequent analysis. This should be done when coverages are overlayed because one of the similarly named items is dropped by ARC/INFO. After the IDENTITY, the items TXF-GE20#, TXF-GE20-ID, SOILHML#, and SOILHML-ID are dropped from TXF-SOIL.PAT with the following command:

```
> DROPITEM TXF-SOIL.PAT TXF-SOIL.PAT TXF-GE20#, TXF-
GE20-ID, SOILHML#
```

This will clear up the PAT of extraneous items.

The actual process of determining the percentage of soil HML classes within each of the parcels can start. First, the FREQUENCY command is used to sum the item HML_CLASS by MAPLOTs in ACRES in the following manner:

```
> FREQUENCY TX-SOIL.PAT TX-SOIL.FREQ
frequency item name 1: MAPLOT
frequency item name 2: HML-CLASS
summary item name: ACRES
```

Then, the item 'PERC-H,' percentage-high soils, is added to TXF-GE20.PAT as a floating point number with a width of eight characters and two places reserved after the decimal point. In pcINFO, TXF-GE20.PAT is SELECTed and TX-SOIL.FREQ is RELATEd by the item MAPLOT. The percentage of high quality soils is then determined in the following manner:

ENTER COMMAND: RESELECT $1HML_CLASS = 'H'

ENTER COMMAND: CALCULATE PERC-H = ($1ACRES / TOTL-AC) * 100

The parcels in TXF-GE20, RELATEd on the MAPLOT item to the summary database TX-SOIL.FREQ, are RESELECTed down to those parcels with high soils only ($1HML-CLASS = 'H'). The percentage of high soils within the parcel is CALCULATEd by dividing the total acreage of the high soils from the summary database, $1ACRES, by the total acreage within the parcel, TOTL-AC, and multiplied by one hundred.

The first part of the soil quality test, discussed previously under Model criterion #2, can be applied. The RESELECT module is carried out on coverage TXF-GE20 to create a new coverage with parcels that pass the criteria--simply, those parcels without any high quality soils. The commands are as follows:

RESELECT TXF-GE20 TX-NOHI

: RES PERC-H = 0

To find those parcels that are secondary under Model criterion #3 a few more steps in the Model analysis by GIS are required. To restate, this criterion covers parcels that consist of contiguous high soils less than 20-acres and all high soils make up less than 50% of the total soils (Model, #3). Item 'H-GE-20AC' is added to TXF-GE20's PAT to keep a Boolean record, Y(es) or N(o), of whether each parcel has contiguous high soils greater or equal to 20-acres. This is determined by RELATing TXF-GE20.PAT, where there is a record (attribute data) for each parcel over 20-acres, to TX-SOIL.PAT, where there is a record for each soil polygon within a parcel. The procedure is as follows in pcINFO:

```
ENTER COMMAND: SELECT TX-SOIL.PAT
ENTER COMMAND: RELATE TXF-GE20.PAT 1 BY MAPLOT
ENTER COMMAND: RESELECT HML_CLASS = 'H' AND ACRES GE
20
ENTER COMMAND: MOVE 'Y' TO $1H-GE-20AC
ENTER COMMAND: SELECT TXF-GE20.PAT
ENTER COMMAND: RESELECT H-GE-20AC NE 'Y'
ENTER COMMAND: MOVE 'N' TO H-GE-20AC
```

TX-SOIL.PAT is SELECTed and RELATEd to TXF-GE20.PAT through the item MAPLOT. Those polygons comprised of high soils with acreage greater than or equal to 20-acres are selected out. A 'Y(es)-flag' is moved into the associated TXF-GE20 polygon records. TXF-GE20.PAT is then SELECTed, also closing the RELATE with TX-SOIL, and a 'N(o)-flag' is moved into the remaining polygons by RESELECTing out for records that don't have a 'Y(es)' in item H-GE-20AC. Finally, the parcels that pass the test are derived with the RESELECT module as follows:

```
RESELECT TXF-GE20 TXLT50HI
: RES H-GE-F20AC = 'N' AND PERC-H LT 50
```

Density and parcelization test

The focus of this test, Model criterion #4 (Figure 5-12), is to determine whether parcels are secondary on the basis of surrounding housing density and lot parcelization. The test states that a parcel is secondary if '60% of the area consists of tracts of less than 20-acres <u>and</u> there are 10 dwelling units in the area' (Pease 1988a, 1; Appendix A). Pease (1988a, 1) defines 'area' as '½-mile for forest-land and ¼-mile for cropland, pasture, rangeland, and mixed farm/forest uses.' Therefore, the area around candidate parcels in the study area will be ¼-mile since it is made up entirely of farmland. The area around a parcel may also contain land zoned as exception classes, defined earlier under the 'Determination of eligible tracts' section, but not within a UGB (Urban Growth Boundary).

Since parcels from farm use and exclusive use zones must be considered together for this test, their respective coverages, T-FARMD and T-EXCPTD, need to be combined. Initially though, the status of each parcel in the Secondary Lands test--whether it passed or failed Model tests #1 through #3--has to be captured. Those parcels passing

MODEL ANALYSES

A.4 - Density and Parcellization Test

- Flag and combine parcels passing previous model tests with UNION and pcINFO
- Pass information back to farmland parcels coverage and recombine with the parcels from the exception zones using UNION and pcINFO
- Determine eligible parcels for test by BUFFERing study area boundary and IDENTIFYing candidates for test in pcARC-PLOT

For each candidate parcel:

- Isolate the candidate parcel from the tax parcels coverage with RESELECT
- BUFFER the parcel by 1/4-mile (1320 feet)
- UNION the buffered parcel coverage with the study area parcels coverage
- Identify the parcels within the buffer area with FREQUENCY and pass this information back to the study area database with RELATE in pcINFO
- RESELECT the parcels within the buffer and summarize their dwelling and area attributes
- Determine the percentage of the buffer area around the candidate parcel that is composed of parcels < 20 acres and how many dwellings there are using REPORTs in pcINFO and hand calculations

Figure 5-12. Model framework: Density and parcellization test.

Model test #1 (size), TXF-LT20, and #3 (soil quality; none passed #2), TXLT50HI, are combined into coverage TXS-123 with the UNION command as follows:

```
UNION TXF-LT20 TXLT50HI TXS-123
```

An unfortunate by-product of the UNION command, as well as most of the other pcOVERLAY functions, is that items common to the UNIONed coverages are dropped from the PAT of the second coverage. In this case, TXS-123 will lose data for polygons from TXLT50HI in the NAME, TAX-AC, TOTL-AC, MAP-LOT, ZONE, DWELL, and TOTL-DWELL items because TXF-LT20.PAT contains the same items and they will supersede TXLT50HI's when the coverages are UNIONed. The process for reestablishing the data to TXS-123's PAT is as follows in pcINFO:

ENTER COMMAND: SELECT TX2-123.PAT

ENTER COMMAND: RESELECT TXLT50HI-ID NE 0 {this pulls out only those records for polygons coming from the TXLT50HI coverage}

ENTER COMMAND: RELATE TXLT50HI.PAT 1 BY TXLT50HI-ID {RELATE the TXLT50HI.PAT database by item TXLT50HI-ID}

ENTER COMMAND: MOVE $1NAME INTO NAME {transfer data from the RELATEd database, TXLT50HI.PAT; repeat in similar manner for items TAX-AC, TOTL-AC, MAPLOT, ZONE, DWELL, and TOTL-DWELL}

Now, the Model status information for each parcel can be summarized. The item, SECOND, will hold these data and is added to TXS-123's and T-FARMD's PATs with the ADDITEM command. It is a two-byte character field. In pcINFO, the data are summarized in SECOND:

ENTER COMMAND: SELECT TXS-123B.PAT

ENTER COMMAND: RES TOTL-AC < 20 {retrieve records for polygons passing the size test, Model #1}

ENTER COMMAND: MOVE '1' TO SECOND

ENTER COMMAND: ASEL

ENTER COMMAND: RESELECT H-GE-20AC = 'N' AND PERC-H < 50 {retrieve records for polygons passing soil quality test #3}

ENTER COMMAND: MOVE '3' TO SECOND

ENTER COMMAND: SELECT T-FARMD.PAT {SELECT T-FARMD's PAT move the summary data into it from TXS123B.PAT}

ENTER COMMAND: RELATE TXS-123B.PAT 1 BY MAPLOT

ENTER COMMAND: MOVE $1SECOND TO SECOND

ENTER COMMAND: RES SECOND = '1' OR SECOND = '3'

ENTER COMMAND: MOVE '0' TO SECOND {'mark' records for those polygons not passing any Model tests thus far}

Coverages T-FARMD and T-EXCPTD may now be joined to create output coverage TXS-4B:

UNION T-FARMD T-EXCPTD TXS-4B

The data in the NAME, ACRES, MAPLOT, ZONE, and DWELL attributes are re-affixed to T-EXCPT's PAT database through pcINFO, similar to the process described earlier, because T-FARMD's PAT possesses them as well.

Since no data theoretically exist beyond the study area boundary for this test, it is also theoretically impossible to collect information for parcels whose ¼-mile buffer extends beyond the study area. Therefore, eligible tracts for the density and parcelization test <u>within</u> the study area must be determined up to ¼-mile from the study area boundary. This fairly straightforward task begins by producing a short report of the remaining eligible tracts--those parcels that haven't passed the previous Model tests and are zoned as an exclusive farm use or public recreation. Executed in pcINFO, the procedure is as follows:

ENTER COMMAND: SEL T-FARMD.PAT

ENTER COMMAND: RES SECOND = '0'

ENTER COMMAND: PRINT MAPLOT,ZONE

The 'long' list of potential test lots has to be whittled down to a 'short' list which doesn't include parcels within ¼-mile of the study area. To determine what the ¼-mile limit looks like, the study area boundary must first be RESELECTed into its own coverage and BUFFERed by ¼-mile with the LINE option to get an internal buffer as well as the standard external buffer, as follows:

> RESELECT TXS-4B TXS-BND POLY

: RESELECT TXS-4B# = 1 {reselect for the 'universal' or bounding polygon)}

> BUILD TXS-BND LINE {build topology for arcs so that it can subsequently be BUFFERed for the LINE option}

> BUFFER TXS-BND TXBNDBUF # # 1320 5 LINE {BUFFER TXS-BND LINE features into TXBNDBUF by 1320-feet (¼-mile) with a fuzzy tolerance of 5-feet (snap tolerance)}

In pcARCPLOT, the BUFFERed study area boundary, TXBNDBUF, is displayed with parcel coverage TXS-4B (with different symbology) and the 'long' list of candidate parcels are shaded. Parcels in the study area, and not within ¼-mile of the study area boundary, are easily picked out by a screen cursor and their MAPLOTs displayed with the IDENTIFY command to derive the 'short' list of eligible tracts for

Table 5-2. Density and parcelization test parcel list.

1604080000400
1604080000900
1604090001002
1604090001900
1604160000600
1604162002800
1604170000100
1604170000200
1604170000500
1604170000601

the density and parcelization test (Table 5-2 and Figure 5-13).

Each eligible parcel must undergo the density and parcelization test separately since buffer analysis can only be summarized by individual parcels. Examples of the test analyses implementing GIS will focus on maplot '1604162002800' (Figure 5-13). First, the MAPLOT in question is RESELECTed from the complete tax lot coverage, TX-4B, into TXS-4B1 as follows:

```
> RESELECT TX-4B TXS-4B1
: RESELECT MAPLOT = '1604162002800'
```

Now that the parcel has been isolated, it is BUFFERed by ¼-mile (1320 feet) into coverage TXS-4B2:

```
> BUFFER TXS-4B1 TXS-4B2 # # 1320 5
```

The BUFFERed parcel coverage TXS-4B2 is re-integrated with study area coverage TXS-4B in order to determine what surrounding parcels within maplot '1604162002800's buffer are required for further analysis. This is done with the UNION command:

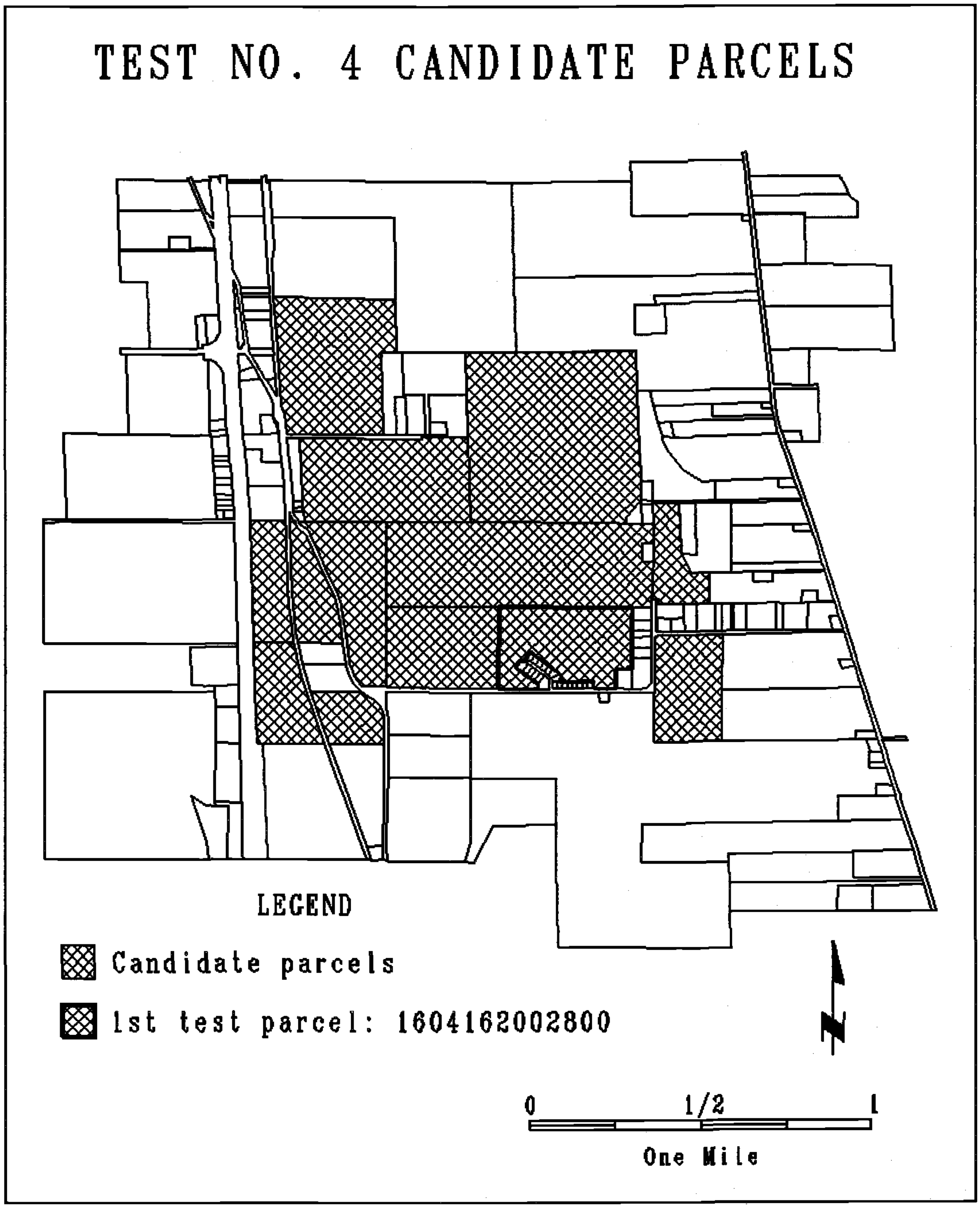

Figure 5-13. Density and parcellization test candidate parcels.

> UNION TXS-4B2 TXS-4B TXS-4B3

The position of tax parcels with respect to the buffer around '1604162002800' is maintained in the item 'INSIDE' which is created by the BUFFER command during execution--a value of '100' if a polygon is inside the buffer and '0' for outside. Since the lots may be fragmented by location and/or the BUFFER boundary, their maplot number and location status must be initially summarized from the BUFFERed coverage's PAT, TXS-4B3.PAT, and this information transferred to the study area coverage PAT, TXS-4B.PAT. First, the information is summarized with the FREQUENCY command from TXS-4B3.PAT into TXS-4B3.FREQ on the items 'MAPLOT' and 'INSIDE.' Then, an item, 'INBUF' (2-byte character), is added to the PATs of TXS-4B and TXS-4B3 to hold the appropriate status flag. The position data are transferred to the database TXS-4B3 in pcINFO as follows:

ENTER COMMAND: SEL TXS-4B3.PAT {SELECT the PAT of the BUFFERed candidate parcel in the study area}

ENTER COMMAND: MOVE 'N' to INBUF {initialize the in-buffer flag with a 'no' value}

ENTER COMMAND: SEL TXS-4B3.FREQ {SELECT the MAPLOT summary data base}

ENTER COMMAND: RES INSIDE = 100 {RESELECT records for those parcels inside the buffer}

ENTER COMMAND: RELATE TXS-4B3.PAT 1 BY MAPLOT {RELATE the summary data base to the study area PAT by the MAPLOT number for those parcels within the buffer}

ENTER COMMAND: MOVE 'Y' TO $1INBUF {flag the PAT parcels with a 'yes' value}

ENTER COMMAND: SEL TXS-4B.PAT {SELECT the study area PAT}

ENTER COMMAND: MOVE 'N' TO INBUF {initialize the in-buffer flag with a 'no' value}

```
ENTER COMMAND: RELATE TXS-4B3.PAT 1 BY MAPLOT  {RELATE
to the BUFFERed candidate PAT}

ENTER COMMAND: MOVE $1INBUF TO INBUF  {transfer parcel
buffer position information into the study area PAT}

ENTER COMMAND: Q STOP
```

Now that the buffer position information has been assembled for tax lot '1604162002800,' the dwelling density and parcelization data for the parcels within the buffer around it can be summarized to ascertain whether it will qualify as secondary lands under Model criterion #4 (Appendix A). The initial data base summary is accomplished by RESELECTing those parcels within the buffer and summarizing on their zoning designation, dwellings, and lot acreage:

```
> RESELECT TXS-4B TXS-4B4

: RES INBUF = 'Y'

> FREQUENCY TXS-4B4.PAT TXS-4B4.FREQ

frequency item 1:  MAPLOT

frequency item 2:  ZONE

summary item 1:  DWELL

summary item 2:  TOTL-DWL

summary item 3:  ACRES

summary item 4:  TOTL-AC
```

The final summary for the candidate lot is done in pcINFO where its database reporting capabilities are required. The database session begins by SELECTing the FREQUENCY database just created and RESELECTing out those parcels zoned as Rural-Residential and <u>without</u> a dwelling, and CALCULATing their dwelling summary item, DWELL, to one. This accounts for the allowance of at least one dwelling on lands that are zoned in this manner. The commands are as follows:

ENTER COMMAND: SEL TXS-4B4.FREQ

ENTER COMMAND: RES ZONE = 'RR2' OR ZONE = 'RR5' AND DWELL = 0

ENTER COMMAND: CALC DWELL = 1

Next, all of the MAPLOTs in the BUFFERed area of the candidate parcel are ASELECTed back together. The universal polygon (MAPLOT = ' '), the transportation polygon (1604-TRANSPORT), and the candidate parcel (1604162002800) are taken out of the select-set since the criterion is concerned with effects from the BUFFERed parcels only:

ENTER COMMAND: ASEL

ENTER COMMAND: RES MAPLOT = ' '

ENTER COMMAND: ASEL MAPLOT = '1604162002800' AND MAPLOT = '1604-TRANSPORT'

ENTER COMMAND: NSEL

Finally, the summary can be produced. The database is first sorted on the MAPLOT and ZONE fields to enable pcINFO to group and total the data by parcel (MAPLOT):

ENTER COMMAND: SORT ZONE, MAPLOT

The first of two reports is executed reporting on total dwellings and acreage by MAPLOT in the BUFFERed area (Table 5-3; pcINFO report form in Appendix E):

ENTER COMMAND: REPORT TXS-4B4.RPT

Table 5-3. Output from first INFO report on test #4.

1604162002800 QUARTER-MILE BUFFER

Maplot	Zone	Dwellings	Acres
1604090001000	E30	0	1.20
1604090001001	E30	1	1.25
1604090001002	E30	0	160.15
1604090001900	E30	2	20.60
1604090002000	E30	1	4.40
1604090002100	E30	1	14.65
1604160000503	E30	0	18.37
1604160000600	E30	0	39.97
1604160001000	E30	1	303.65
1604162000101	E30	0	1.17
1604170000100	E30	2	123.30
1604170000601	E30	0	50.85
1604170002000	E30	1	18.95
1604170002001	E30	1	19.68
1604160001200	RR2	1	0.49
1604162000400	RR2	1	0.23
1604162000500	RR2	1	0.21
1604162000600	RR2	1	0.21
1604162000700	RR2	1	0.20
1604162000800	RR2	1	0.18
1604162000900	RR2	1	0.18
1604162001000	RR2	1	0.19
1604162001100	RR2	1	0.20
1604162001300	RR2	1	0.59
1604162001400	RR2	1	0.29
1604162001500	RR2	1	0.26
1604162001600	RR2	1	0.28
1604162001700	RR2	1	0.29
1604162001800	RR2	1	0.44
1604162001900	RR2	1	0.27
1604162002000	RR2	1	0.23
1604162002100	RR2	1	0.22
1604162002200	RR2	1	0.24
1604162002300	RR2	1	0.24
1604162002400	RR2	1	0.27
1604162002500	RR2	1	0.30
1604160000500	RR5	1	0.96
1604160000508	RR5	1	1.83
1604160000512	RR5	1	2.80
1604160000514	RR5	1	0.97
1604160000515	RR5	1	1.00
1604160000516	RR5	1	2.30
1604162000200	RR5	2	1.30
1604162000201	RR5	1	1.14
1604162000202	RR5	1	1.13
1604162000203	RR5	1	0.70
1604162000205	RR5	2	1.10
1604162000300	RR5	1	1.78
1604162002700	RR5	1	3.08
Totals for buffered area:		47	804.28

Parcels under 20-acres are selected from the database since

Table 5-4. Results from second INFO report for test #4.

1604162002800 QUARTER-MILE BUFFER WITH PARCELS < 20 ACRES

Maplot Acres	Zone	
1604090001000	E30	1.20
1604090001001	E30	1.25
1604090002000	E30	4.40
1604090002100	E30	14.65
1604160000503	E30	18.37
1604162000101	E30	1.17
1604170002000	E30	18.95
1604170002001	E30	19.68
1604160001200	RR2	0.49
1604162000400	RR2	0.23
1604162000500	RR2	0.21
1604162000600	RR2	0.21
1604162000700	RR2	0.20
1604162000800	RR2	0.18
1604162000900	RR2	0.18
1604162001000	RR2	0.19
1604162001100	RR2	0.20
1604162001300	RR2	0.59
1604162001400	RR2	0.29
1604162001500	RR2	0.26
1604162001600	RR2	0.28
1604162001700	RR2	0.29
1604162001800	RR2	0.44
1604162001900	RR2	0.27
1604162002000	RR2	0.23
1604162002100	RR2	0.22
1604162002200	RR2	0.24
1604162002300	RR2	0.24
1604162002400	RR2	0.27
1604162002500	RR2	0.30
1604160000500	RR5	0.96
1604160000508	RR5	1.83
1604160000512	RR5	2.80
1604160000514	RR5	0.97
1604160000515	RR5	1.00
1604160000516	RR5	2.30
1604162000200	RR5	1.30
1604162000201	RR5	1.14
1604162000202	RR5	1.13
1604162000203	RR5	0.70
1604162000205	RR5	1.10
1604162000300	RR5	1.78
1604162002700	RR5	3.08
		105.75

criterion #4 singles out their effects on the candidate parcel (Table 5-4; report form in Appendix E):

```
ENTER COMMAND: RES ACRES < 20
```

ENTER COMMAND: REPORT TXS-4B4.RPT2

To obtain the percentage of land in the buffer around the candidate parcel that is comprised of parcels less than 20-acres, the total acreage of parcels less than 20-acres in the buffer is divided by the total acreage of all parcels in the buffer.

MODEL ANALYSES

B - Block Test

- In pcARCEDIT, SELECT parcels passing previous model tests and flag adjacent parcels with a block code
- Summarize potential secondary blocks with the FREQUENCY command

Figure 5-14. Model framework: Block test.

Block test

The 'block test,' Section B., is the last of the Model criteria analyzed with GIS tools (Figure 5-14). According to the criterion, 'tracts which qualify for secondary lands designation must compose a contiguous block of 640-acres or more' (Pease 1988a, 2). An alternative block test has also been proposed for inclusion in the Model by Pease (1988a, 2) that would allow for blocks of secondary land down to 160-acres in size if the total secondary blocks in a county comprise less than five percent of all of the privately owned forest and agricultural lands.

The test is fairly straightforward to apply in a GIS once the candidate secondary parcels have been identified by the previous tests. First, the item, BLOCK, is added to TXS123B's polygon attribute table (PAT) as a 4-byte integer field with the ADDITEM command. Then, the potential blocks of secondary land are identified and flagged in the BLOCK field in pcARCEDIT as follows:

```
> ARCEDIT

: EDITCOVERAGE TXS123B  {edit coverage TXS123B}

: DISPLAY 4  {set the screen to graphics mode}

: DRAWENVIRONMENT ARC LABEL  {set the draw-environment
to draw arcs and label points}

: DRAW  {draw the previously determined set of fea-
tures}

: EDITFEATURE LABEL  {edit the coverage's polygon
features}

: SEL SECOND <> 0  {select the polygons (parcels) that
passed the previous Model tests}

: SETDRAWSYMBOL 2  {make the draw-select symbol red}

: DRAWSELECT  {draw the selected set of polygons}

: SEL MAN  {flag each potential block of secondary
parcels by selecting their polygons' label points with
the screen cursor}

: CALC BLOCK = 1  {enter the block flag, 1 for the
first block, for the selected block; repeat the selec-
tion and calculation (flagging) for each identified
block on the screen}

: SAVE  {save the results and quit from pcARCEDIT}
: QUIT
```

Fifteen blocks of land are identified and their total acreage summarized by the FREQUENCY module from TXS-123B.PAT

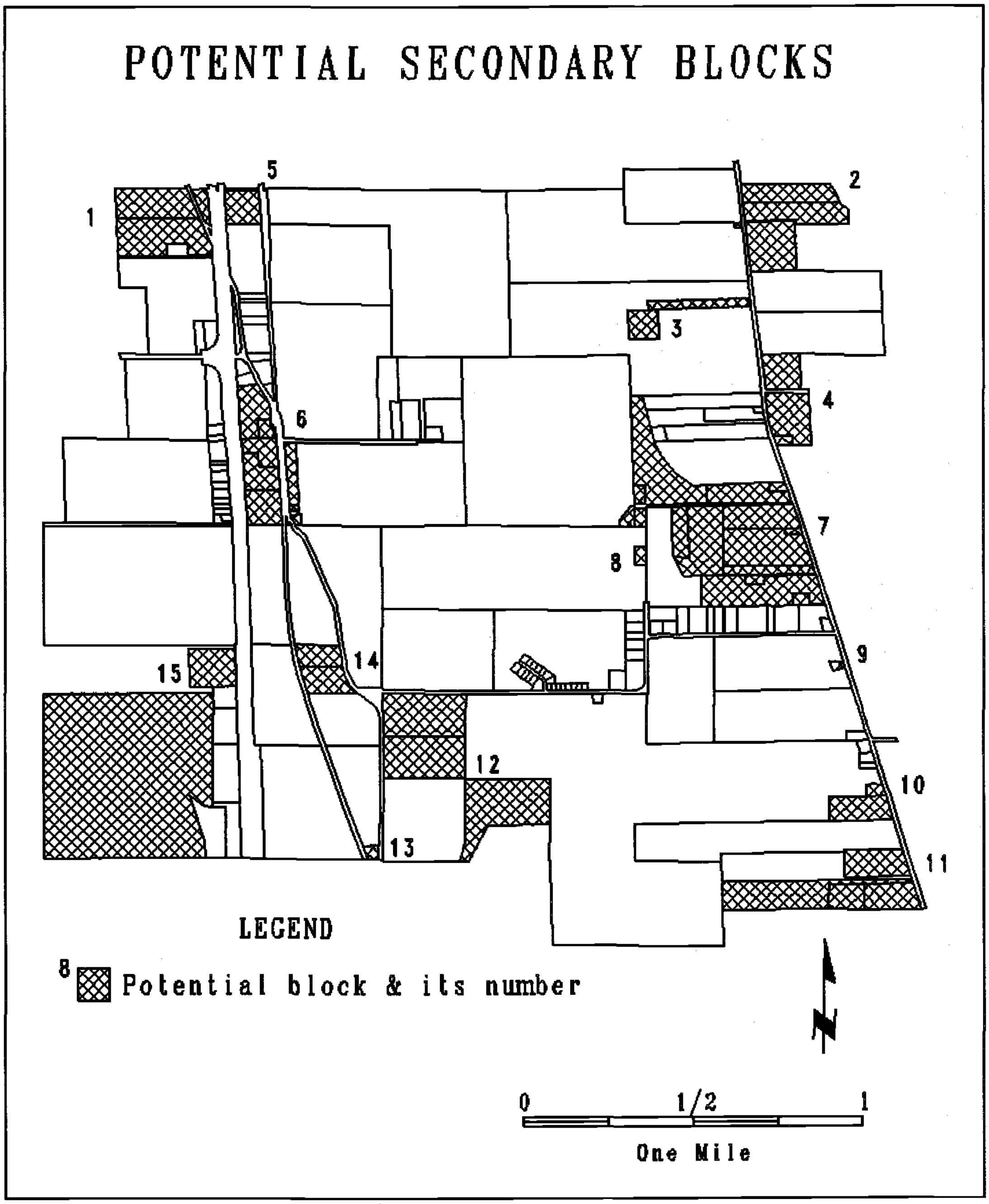

Figure 5-15. Location of potential secondary blocks.

into BLOCK.FREQ (Figure 5-15).

Results from the GIS analyses examined in this chapter are presented and discussed in the next chapter.

CHAPTER VI

RESULTS

The results presented in this chapter from the Model analyses performed, using GIS in Chapter V, will help one to understand how the digital approach to this basically analog methodology works. What kind of results are the analyses generating and what do they mean?

Size test

The first Model test (Chapter III; Appendix A) seeks to determine whether a parcel is 'secondary' based on the parcel's size. If the parcel is smaller than 20-acres it falls into the secondary category. The RESELECT module has been used in the analyses to select parcel polygons from the T-FARMD coverage (farmland parcels), based on total parcel acreage (from item TOTL-AC). There are 53 parcels meeting this criterion and they are shown in Figure 6-1 and a tabular breakdown is presented in Table 6-1.

As can be seen in the figure, the eligible parcels under 20-acres are distributed in widely scattered clumps. This isn't surprising for the area since it is primarily under agriculture and all the other parcels under 20-acres are ineligible for consideration as secondary lands since they're in exception areas, which, in this case, are zoned primarily as rural-residential.

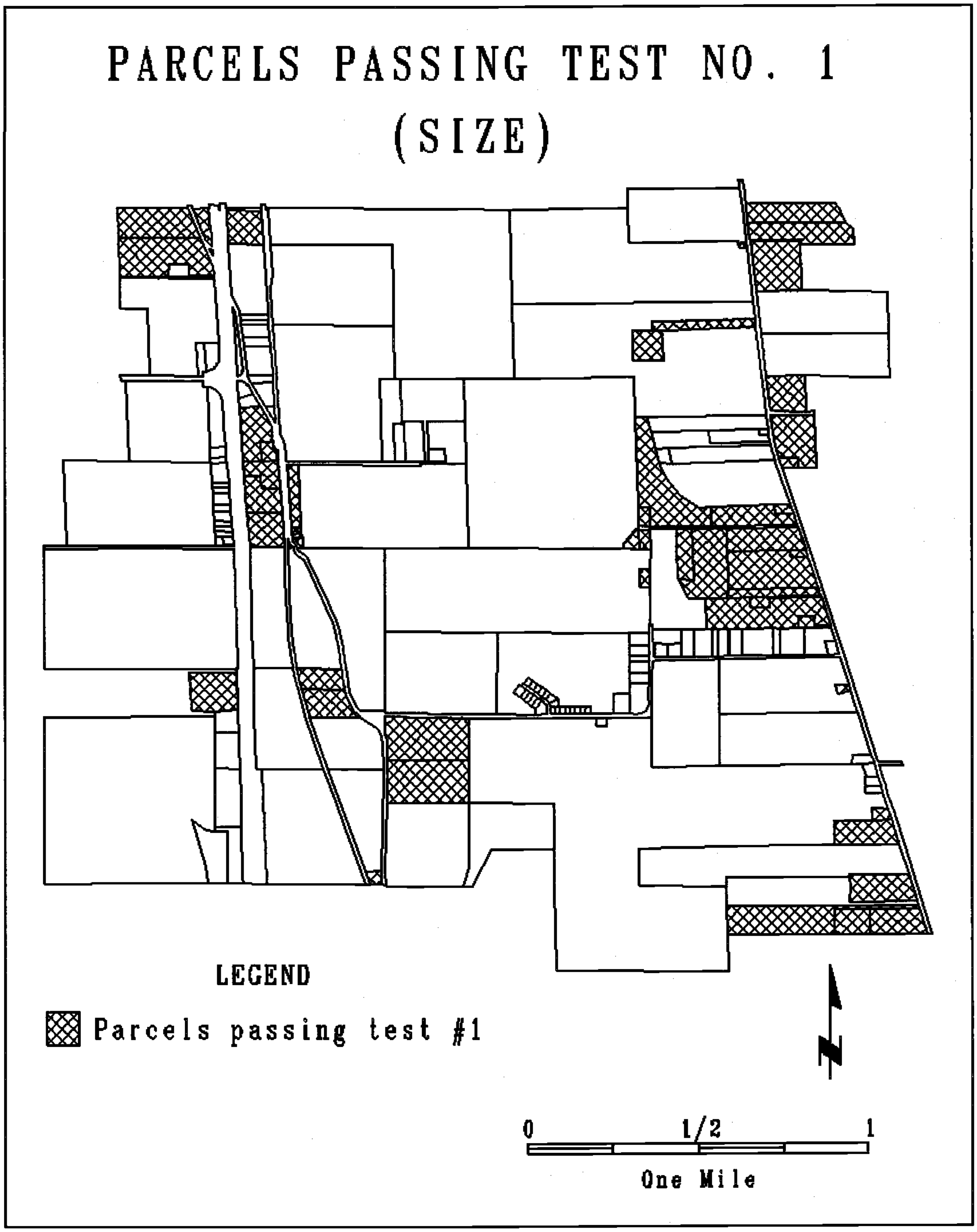

Figure 6-1. Parcels passing test #1.

Soil quality test

The soil quality test is comprised of two parts as discussed earlier in Chapters III and IV. The first part,

Table 6-1. Agricultural tax lots less than 20-acres.

Lot Number	Acreage	Lot Number	Acreage
1604080000200	6.45	1604090001301	0.98
1604082000100	4.27	1604090001801	8.29
1604082000200	17.79	1604090001802	0.92
1604082000201	12.97	1604090002000	4.40
1604082000300	0.69	1604090002100	14.65
1604083100801	1.48	1604090002200	9.77
1604083100802	14.88	1604150001000	0.54
1604083400100	0.49	1604150002600	8.27
1604083400200	0.20	1604150003200	1.13
1604083400300	0.33	1604160000100	0.63
1604083400400	3.72	1604160000200	16.87
1604083400500	9.03	1604160000201	4.49
1604083400600	6.78	1604160000503	18.37
1604083400602	5.78	1604160000519	1.44
1604090000100	9.83	1604160000520	1.18
1604090000200	11.43	1604160001500	9.40
1604090000201	0.30	1604160001502	19.10
1604090000400	13.32	1604160001506	7.65
1604090000500	0.23	1604160001507	4.90
1604090000800	5.04	1604162000101	1.17
1604090000801	7.34	1604170000400	10.01
1604090000803	5.12	1604170000502	5.17
1604090001000	1.20	1604170000503	6.89
1604090001001	1.25	1604170001900	1.03
1604090001003	1.22	1604170002000	18.95
1604090001100	19.93	1604170002001	19.68
1604090001300	10.83		

test #2, determines that a parcel is potentially secondary when all of its soils are either medium or low quality soils or both. No parcels in the study area passed this criterion during the Model analyses in Chapter V.

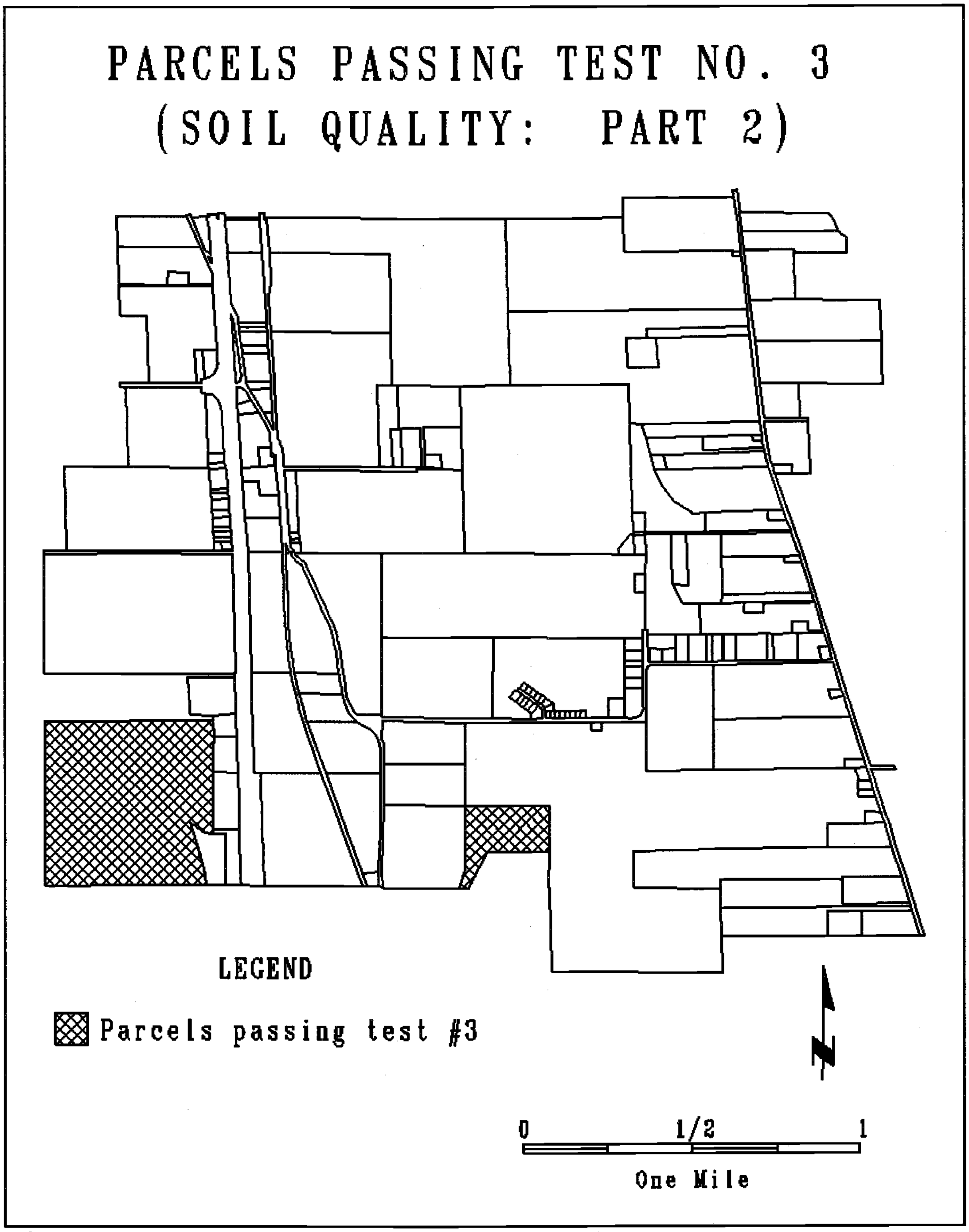

Figure 6-2. Parcels passing test #3.

Test #3 will designate a parcel as secondary when it has any measure of high quality soils, but the high soils are less than 20-acres in size and comprise less than 50%

of the total parcel soils. The RESELECT command is used once again to extract those parcels qualifying under test #3 from TXF-GE20, the coverage of eligible parcels remaining after tests #1 and #2. Two parcels pass this test, '1604170001400' and '1604160001600,' and are presented in Figure 6-2. The tabular breakdown of their soil composition by parcel is shown in Table 6-2.

Table 6-2. Tabular breakdown of parcels passing test #3.

MAPLOT	HML CLASS	POLY-ID	ACREAGE	
1604160001600				
	H			
		# 161	1.62	
		# 163	0.37	
		# 165	1.32	
		# 170	0.68	

			3.99	
	M			
		# 162	21.01	
			======	
			25.00	Total parcel
1604170001400				
	H			
		# 122	0.28	
		# 139	1.63	
		# 124	0.64	
		# 137	3.92	
		# 121	0.25	
		# 141	2.62	
		# 144	5.30	
		# 154	0.42	
		# 156	2.97	
		# 168	2.96	

			20.98	
	M			
		# 120	131.75	
			======	
			152.73	Total parcel

The parcels are located in the southwestern corner of the study area on a broad band of Awbrig and Conser silty clay loam soils that run throughout the Willamette Valley. The soils are rated as medium quality for resource use under the Huddleston-Latshaw soil rating scheme used in the

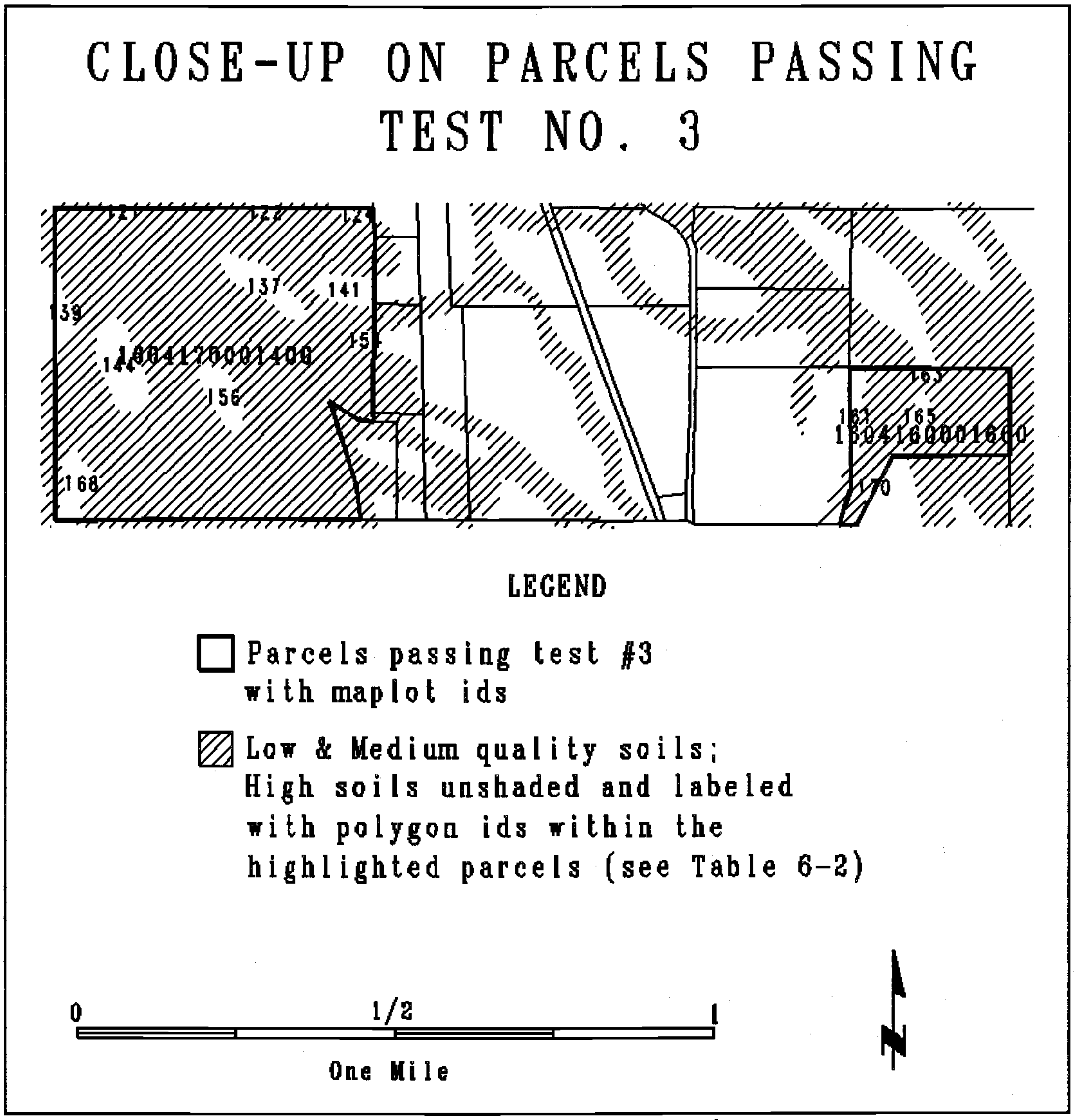

Figure 6-3. Close-up on parcels passing #3.

Model (Chapter III). Looking at the parcels closer with the medium quality soils shaded-in (Figure 6-3), there are small pockets of high quality soils dispersed throughout the qualifying parcels, but they aren't very big--average size is 1.5-acres--and don't account for more than 16% of the parcels' area in either case (Table 6-2).

Density and parcelization test

Model criterion #4 tests for the effect of surrounding housing density and lot parcelization on a tax lot that

Table 6-3. Summary data on test #4 candidate parcels.

Maplot	Dwellings in area	Percentage of of area acreage in lots < 20 ac.
1604080000400	43	20.1
1604080000900	41	12.1
1604090001002	40	13.0
1604090001900	44	25.6
1604160000600	39	13.2
1604162002800	47	13.1
1604170000100	65	14.9
1604170000200	30	11.4
1604170000500	14	14.3
1604170000601	33	7.2

hasn't passed the previous three tests. To restate, if 60% of the area (¼-mile for farmland) around a candidate parcel contains parcels less than 20-acres and more than 10 dwellings, it passes the test. The results of the analyses carried out on trial parcel '1604162002800' in Chapter V and the remaining candidate parcels are shown in Table 6-3.

It can be easily seen from the results of the test that none of the parcels passed. This may seem surprising given the high number of dwellings in the area around each candidate parcel, which are far in excess of the 10 required to pass the criterion. On average, there are approximately 37 dwellings around each tax lot. However, the percentage of the buffer areas comprised of parcels under 20-acres is about 14%, on average. This is far below the 60%, in addition to the 10 dwellings, required to pass the test.

Even though it may run counter to what one would assume at first glance, the elevated dwelling count probably comes from capturing pieces of the rural-residential blocks which have many homes on small lots. Also, if a lot is zoned as rural-residential and it doesn't have a dwelling on it at the time of the analysis, it is still counted as having one to account for the allowance of one house under the zoning guidelines and the likelihood that one will be built.

Another important point to consider is that when the acreage is summed by each parcel located inside or across the buffer, the area of the whole parcel contributes to the buffer area--not just the portion of the parcel found in the buffer. This can greatly contribute to the influence of large parcels on the total area around a test parcel by effectively 'watering down' the percentage of small parcels in each buffer as seen in the test numbers (Table 6-3).

Block test

The block test, Model section B, is the final test applied through the GIS analyses in Chapter V. For those adjacent parcels passing any of the previous tests, #1 through #4, they must block into groups of 640-acres or greater. Pease (1988a, 2) also proposed alternative blocking sizes for counties starting at 480-acres and going down to 160-acres by 80-acre decrements. This allows the county applying the Model to create secondary lands out of smaller blocks as long as all of the designated secondary lands are less than 5% of all privately owned forest and agricultural lands (Pease 1988a, 2; Appendix A).

Table 6-4. Block summary.

Block #	Acreage
1	33.6
2	35.1
3	10.2
4	19.1
5	6.4
6	30.7
7	104.6
8	1.2
9	0.5
10	9.4
11	41.1
12	63.6

Fifteen blocks of secondary lands were identified from the analyses (Figure 5-15) and their acreage is summarized in Table 6-4. Only block #15 (Figure 5-15) possibly qualifies as a secondary block of land with a total area of 163-acres. It is comprised of parcels '1604170001400' (153-acres) which passed test #3 and '1604170000400' (10-acres) which passed test #1. Even though the two lots appear not to be adjacent, they are only separated by a driveway. Likewise, some of the other blocks in the study area have driveways or other easements separating them. As long as the width of the division isn't greater than 100-feet, as is the case between blocks 1 and 5 which are separated by Oregon Highway 99, then the split is allowed when creating blocks.

Other tests

The analyses haven't been applied to the remainder of the Model since they are special case provisions and involve some outside review, as in the case of Section C., the past commercial use test (Chapter III; Appendix A). If the past commercial use test was applied to block #15 it probably wouldn't pass and therefore be returned to the primary lands. This is because the lots are part of grass seed farms which, even though they are located on medium quality soils discussed previously under the soil quality test, have been operating for many years and are a significant industry in the Willamette Valley.

The results of the analyses therefore show no potential secondary lands for this particular area. This is due to the fact that the study area is made up of large tracts of long-established farms on relatively good soils. Any 'dense' parcelization that exists has, in most cases, already been zoned as an exception area of some type.

CHAPTER VII

CONCLUSIONS

The results in Chapter VI clearly show that there are little, if any, Secondary lands in the 'Coburg Hills' study area when the OSU Model is applied. Notwithstanding, the point of the research is to demonstrate how the pcARC/INFO GIS can be applied to a land use planning problem. Questions raised about using GIS for Model analyses mirror issues and concerns that planners, or anyone using a GIS, should have before employing this technology.

THE OSU SECONDARY LANDS MODEL

Data preparation

Data preparation, especially from analog sources, is the most time consuming part of using a GIS. It can account for up to eighty or ninety percent of a project's life. Even though the investment of time is always greatest when setting up a GIS, numerous benefits are realized over time as the GIS is used for a wider variety of projects and routine spatial data queries. But, the GIS must be set up with care so that it can meet the demands of the people using it.

The basic building block of all land use planning programs and models is the parcel--legal, tax, and otherwise. Since a parcel can take on any of these forms depending on how the term is used and who is using it, it must be accommodated as such in the GIS. That's easier said then done, of course, as was demonstrated during the data preparation stage of the Model analyses. The parcel data were compiled from tax maps and flysheets which are available from all tax assessor's offices.

The first problem encountered when tracking parcels through the tax assessor's office is that tax lots often don't constitute 'legal' parcels. To make matters worse, to find out what a legal parcel really is can take a day or more of title research per parcel. Pease (1988a 1; Appendix A), in an effort not to get bogged down in determining what the legal parcels were for a county when applying the Model, defined an ownership tract (parcel) as 'contiguous ownership tax lots, with the same name on assessor records.' This method works fine some of the time except when combining adjacent tax lots in a GIS because the database fields containing the names have to match exactly. Numerous variations on recording names get in the way of this 'simple' process, such as: a mixture of upper- and lowercase spellings, adding or dropping a spouse's name, adding or dropping initials, and misspellings, to name a few.

Transportation routes are physical barriers to maintaining contiguous parcels composed of tax lots lying on either side of a road, railroad, etc. and having the same name. The resolution of this problem during application of the Model was to tie contiguous tax lots split by a transportation polygon (≤ 100-feet wide) together with the MAPLOT field in the database on the basis that the MAPLOT value for both lots was the same. Huddleston's students, during preparation of the digital tax lot data, used character suffixes to differentiate constituent lots which were easily split off for Model analyses. Should this be dealt with in the same manner for an entire county? Close inspection of the tax lots is required to settle the issue because one doesn't want to inadvertently tie tax lots together by the same name on the flysheet that aren't contiguous. This is cumbersome at best when carried out for Model analyses across a county.

For the Model, and any other types of analyses used by planners, data preparation shouldn't be the proverbial 'reinventing of the wheel' for each project. The data have to be maintained in a manner that is useful to <u>all</u> projects or at least should not require a substantial reinvestment of time each time a new project is developed or a simple query made of the data. To further complicate matters, county planning departments often can't and shouldn't develop a GIS around their needs alone because of a lack of funding and a danger of duplicating similar such efforts by other departments using the same data such as the county engineer's or highway departments and emergency services.

Therefore, to reduce costs and meet everyone's needs, a county should accurately portray parcels in a manner that fulfills the missions of the various departments using the GIS. A tax parcel used in a planning model, for example, could be assembled from tax lots linked together with appropriate identifiers through a GIS and relational database structure. Accurate portrayal of the data, or scale of resolution, though not dealt with in this research, must be agreed to by all parties and be able to meet the strictest criteria, often set by the engineering or utility departments if they're involved in the GIS design. Once the initial data are input and preparation complete, the GIS should be ready to be used by all for an assortment of work. Maintenance of the data--updates, corrections, etc.--is still required throughout the life of the system, but is far less time consuming than each entity in the county possessing its own GIS and entering data on a project-by-project basis.

Critique of pcARC/INFO implementation of the Model

The OSU Secondary Lands Model basically 'sifts' through all of the ownership tracts in a proposed secondary zone or in an entire county to determine which parcels should make up secondary blocks of land on the basis of size, soil quality, and density and parcelization. The 'sifting' occurs as parcels are put through each test in succession; those failing are dropped from further consideration and the remainder proceed through the Model. Successful candidates must form blocks of a minimum size and pass review by a team of local natural resource specialists. These procedures provide a basis for proposed secondary lands to pass final review by the LCDC (Chapter III).

The first three Model tests, size and soil quality (two parts), are fairly simple to apply using a GIS. Size is an elemental part of a parcel's, or polygon's, database attributes and therefore is easy to sort out according to the criterion (Test #1). Likewise, the soil quality tests (#2 and #3) aren't much more difficult to apply once the parcels and soils data have been overlain and the resultant database processed with a few commands to ascertain which parcels have passed.

The fourth and final test to be applied to individual parcels is the 'density and parcelization' criterion. In theory, the intent of the criterion is to measure the effects of surrounding density and parcelization on an ownership tract. This is also the first chance to account for the influence of adjacent parcels zoned as exception areas, such as rural-residential lots. If the levels of housing density and lot parcelization are at a predetermined level, then the parcel under consideration passes the test.

In practice, this is a complex and time consuming test to apply because only one parcel can be tested at a time using the GIS; this was also the case during manual testing. As was shown, each candidate parcel had to be isolated from the study area in order to create a ¼-mile buffer and overlain back with the study area parcels in order to complete the analysis through manipulation of the database. Also, the buffer generated by pcARC/INFO is rounded at the corners though Pease had a 'sharp' cornered buffer in mind when he drafted this criterion. This may have potentially eliminated a few very large parcels from the area of influence when determining the results.

Finally, no parcels passed criterion #4 and the results from the analysis can be considered 'mixed' at best (Table 6-3). Even though all of the parcels tested have over ten dwellings in their areas, none come close to meeting the prescribed parcelization level of 60% (of the area in parcels of 20-acres or less). In fact, for the study area, the average size of the area captured by the ¼-mile buffers is 877-acres (Table 6-3). There would have to be 526-acres in 20-acre, or smaller, parcels around a candidate parcel in order to capture 60% (of the area) needed to pass the test. This would require the presence of substantial blocks of rural-residential parcels in the vicinity to have any effect, which is difficult at best in most agricultural and forested areas in the Willamette

Valley. It may still be possible to come up with the necessary levels of parcelization in mixed forest and farmland areas to produce positive results, but further review of the criterion may be necessary, especially if the Model is applied using a GIS to a larger area such as a county.

The block test (Section B) is the last Model criterion applied with pcARC/INFO. Even though the blocks of secondary parcels were identified interactively through pcARC-EDIT, this did not involve much effort. A fully digital approach was deemed too complex to undertake, especially for this research, since it was difficult to group adjacent parcels (of different ownership) that were non-contiguous because they were split by an easement or transportation polygon (less than 100-feet wide).

Digital Determinism

A model attempts to represent reality, natural or cultural in this case, in the simplest terms possible. There is always the danger that the model through its simplification of reality can impose an erroneous impression of reality on the subject that it is supposed to represent. It is difficult to strike a balance between over-simplification and creating an overly-complicated model that no one can use.

Translating a model that is carried out in an analog manner, such as the OSU Secondary Lands Model, into a format that can be executed by a GIS can introduce another layer of distortion. *Digital determinism* can occur when a test in a model is not easily translatable into a routine executed by a digital system and therefore is altered in some way to fit into the digital methodology. It can be argued that if by altering the test one can still retain the intent of the original test, or even clarify its purpose and the model's, then translation to a digital system is not unduly influencing the model or further distorting its representation of reality. Others still disagree and feel that digital tools, notably GIS, factor too significantly in the natural resource fields such as land use planning and other areas where environmental modelling is an important method. GIS is viewed by some critics as a 'slippery slope' leading to a vast over-simplification of reality because its supported data structures and routines have limited adaptability to widely varying situations.

RECOMMENDATIONS

Many of the problems presented that occur when using ARC/INFO or any other GIS can be avoided by having skilled analysts trained in spatial data handling and possessing a good grounding in the theories and practices of the natural or social sciences, such as geography. They should know when a model utilizing spatial data may be impractical before it is applied with a GIS, or when any of its criteria run the risk of being misrepresented because they have to be altered to fit within the supported functions or routines of the GIS package. In particular, there are a few things to keep in mind when using a GIS that can also help one avoid digital determinism.

Break down data

Keeping features in a GIS broken down into the smallest constituent parts required is the first and easiest step towards efficient data preparation, discussed previously, and maintenance. The intent of this method is to give the GIS user maximum flexibility when undertaking a wide variety of projects and answering routine queries since the data can be recombined in any number of ways and the output stored where required (Robinove 1986, 7).

Data structures

Data structures present a wide array of potentially confusing choices for GIS users and even the 'experts' who have debated this topic since the inception of GIS (Chapter II). The topic was also my original research thrust into the GIS application of the OSU Secondary Land Model. However, many current GIS software packages, along with progressively faster, cheaper, and bigger computers, can accommodate spatial data layers in their native data structures. For example, parcel boundaries are best represented by discrete lines which lend themselves to the vector data structure, whereas a soils or land cover data layer has 'fuzzy' boundaries which are easily accommodated by a raster data structure. The soils data used in the GIS Model analyses in this research were maintained in a vector structure in pcARC/INFO since it originated from SCS data which were compiled into polygonal boundaries. These data also had to be in a vector format in order to be digitally combined with other vector data layers--the parcels data in this case. Maintaining data in their original format also minimizes the error associated with data translation from one structure to another (Knapp 1980, 52).

Parcel data present another challenge to the data structure issue because parcels are technically represented by descriptions on titles to the land. The descriptions, more often than not, aren't consistent with their digital counterparts in a GIS because they aren't adjusted to geographic coordinate systems or datums, and don't translate well to a more precise digital environment. COGO (COordinate GeOmetry) modules, available in many GIS software packages, offer a means by which land survey data can be input, edited, and maintained. However, since coordinate data aren't legally admissible in boundary matters in court

(Marble 1984, 1-5), then the legal description for a parcel must still be accounted for in the GIS. This can be done with additional database fields which contain relevant information or by including scanned images of the deed(s) which can also be accessed through the database or a user interface.

The tools and routines available in most GIS software today can help planners create or translate existing models into a digital system which can provide them with an endless number of scenarios and answers to their questions. GIS still depends solely on the rationale behind the model used and the quality of the data manipulated. Appropriately, C.J. Robinove (1986, 14) stated that 'the translation problem between human and machine language is where GIS will have the greatest problems, also the greatest potential.'

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APPENDICES

APPENDIX A

WILLAMETTE VALLEY
SECONDARY LANDS DRAFT MODEL

DATE: June 1, 1988

By

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Department of Geosciences
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NOTE: Italic print indicates proposed changes/additions to the model made by Professor Pease in this draft.

A. LCDC will review county proposals for secondary lands designation in accordance with the following standards based on soils quality, parcelization, and potential non-compatibility with existing uses. This review may consist of a review of all *ownership tracts* or a random sample of *tracts* within the proposed secondary zone. *An ownership tract is defined as contiguous ownership tax lots, with the same name on assessor records.*

Ownership tracts may be potentially eligible for secondary resource use *if such ownership tracts are: a) less than x miles from a UGB on a paved public use road; x miles on an unpaved public use road, and b) accessed by existing public use roads adequate to serve the secondary development and within x feet of the public use road.*

NOTE: The county will designate distances for each of the above criteria indicated by an 'x.'

<u>AND</u>

One of the following tests is met:

<u>Size</u> <u>Test</u>

1. That are smaller than 20 acres in size.

NOTE: We will track these tracts in the testing to determine which tracts come up secondary on the basis of this criterion alone.

<u>OR</u>

<u>Soil</u> <u>Quality</u> <u>Test</u>

2. That consist entirely of medium or low soils.

<u>OR</u>

3. For *tracts* ≥ 20 acres, that consist of contiguous high soils less than 20 acres and all high soils make up less than *50%* of the *tract's* soils.

<u>OR</u>

Density and Parcelization Test

4. That are in an area with a parcelization and development pattern (including exception area, but not the area inside a UGB) in accordance with the following criteria:

   > 60% of the area consists of *tracts* of < 20 acres AND > 10 D.U. in the area

NOTE: Area = ½ mile for forestland and ¼ mile for cropland, pasture, rangeland, and mixed farm/forest uses. 'D.U.' is/are dwelling unit(s).

B. Block Test (may cross jurisdictions)

The *tracts* which qualify for secondary lands designation must compose a contiguous block of 640 acres or more (also will test 320-acre block). Blocks of less than 640 acres may be justified under 'D. Special Cases.' If a proposed block contains no high soils, then an acknowledged exception area may be *included in the calculation* of block size.

Primary blocks of less than 160 acres of farmland or 500 acres of forestland/mixed farm-forest land may be designated secondary under 'D. Special Cases.'

Alternative Block Test

As an alternative to the 640-acre block size, counties may use a 160-acre block size if all secondary lands under the 640-acre block test are less than 5% of all privately own forest and agricultural lands. If the alternative block test lands total more than 5%, then the following priorities for designations will be used to limit the total secondary designations to 5% of all private farm and forest lands.

1. > 480-acre block
2. > 320-acre block
3. > 240-acre block
4. > 160-acre block

In addition to the standards in 'E. Primary/Secondary Buffer Provisions, a dwelling unit may not be located closer than 500' to a primary use tract.

C. Past Commercial Use Test

For Agriculture:

Those tracts which are potentially secondary because of criterion one and that have < 50% high soils may be designated secondary without a past use test. Those tracts which are potentially secondary because of criterion one that have > 50% high soils and for tracts which are potentially secondary because of criteria 2, 3, or 4 are subject to the following past use test: Any such tract with a history of use between 1980 and 1988 as part of a ranch, farm, or forestry operation that is capable of grossing more than $40,000 per year shall be designated primary. A local review team consisting of Extension Service, SCS, ASCS, S&WD, and two to six farmers, ranchers or foresters, will review proposed secondary resource blocks and identify tracts which, because of past use, shall be retained in a primary designation. The team shall base their assessment on aerial photography, personal knowledge, soils yield data, commodity price data, census data, or other reports and data sources.

For Forestry:

Applies only to *tracts* designated potentially secondary because of soils or size.

Tracts shall be designated primary that are:

1. a) 80 acres or more *b) < 80 acres without a D.U.*

NOTE: We will test criterion b).

AND

2. part of a forestry block of 500 acres or more

AND

3. currently stocked to quality for *forest* tax deferral.

D. Special Cases *(Supersedes all other tests)*

For any block of secondary land which does not meet the block test criteria the county may submit documentation and findings to LCDC to support its designation for secondary lands. The findings will show why, based on soils quality, parcelization, conflict, and/or buffering of an exception area from conflicts with adjacent primary lands must be fully addressed.

For certain *tracts* that do not meet the secondary criteria, the county may submit findings to LCDC to support a secondary designation. *Such tracts may include, but are not limited to, the following circumstances:*

1. the *tract(s)* form(s) an island (of < 160 acres of farmland or < 500 acres of forest/mixed land) in a secondary block, an *exception area*

OR

2. the *tract(s)* is/are a peninsula (< 160 acres of agriculture or < 500 acres of forest/mixed land) bordered on three sides or 75% of its boundary by secondary lands or *exception areas.*

3. Certain *tracts*, because of existing services, access, terrain, or other factors, are part of a larger area designated secondary.

E. Primary/Secondary Buffer Provision

The purpose of the buffer provision is to prevent a 'creeping' effect of secondary characteristics on primary *tracts*. The boundary between Primary and Secondary Lands shall be designated and documented so that the resulting density of the proposed secondary block, when fully developed, will not exceed 10 D.U. on *tracts* within ¼ mile of a *tract* within the primary zone, and not more than 50% of the perimeter of a *tract* within a primary zone will be bordered by a *tract(s)* smaller than 20 acres with a dwelling unit on it or which will be eligible under zoning regulations for a dwelling unit. A buffer zone may be established, if necessary, to achieve this standard. The county may utilize a variety of techniques, including density transfer, lot size, or purchase of development rights, to achieve buffer standards. A roadway, canal, river, ridge or other man-made or natural features *with a width of 100 feet* or *greater* may substitute for the buffer standard. The county will explain its reasoning in establishing an adequate buffer.

APPENDIX B

'TERRARC.PAS' PROGRAM LISTING

```
PROGRAM TERRA_TO_ARC;

        {Program to convert the TerraSoft GIS ASCII output file format
         into an ASCII input file format readable by the PcARC/INFO
         GIS.  Written by Robert Harmon, M.S. Geography Candidate,
         Oregon State University, Fall 1988}


Uses Crt,Dos,Graph;

Var

  terrafil,idtic,xtic,ytic,lines,labels,sectno,points,tim: text;
  g,rot,numtics, ticnum,linenum,ptnum,null,i,j,k,m: integer;
  starthr,startmin,startsec,endhr,endmin,endsec,sec100,
  yr,mon,date,dayw: word;
  lablx,lably,nullrx,nullry,ptx,pty,
  ticx,ticy,linx,liny: real;
  hed: array [1..3] of integer;
  typ,void,answ: char;
  ssect: string[2];
  rsect: string[3];
  pt,labl: string[6];
  days: string[8];
  filename: string[14];


Procedure Tax;
Begin
  while not eof(terrafil) do
  begin
    readln(terrafil,hed[1],hed[2],hed[3]);
    if hed[1]=3 then      {get arcs}
    begin
      for j:=1 to 5 do
        read(terrafil,null);
      readln(terrafil,ptnum);
      writeln(lines,linenum);
      linenum:=linenum+1;
      for k:=1 to ptnum do
      begin
        readln(terrafil,linx,liny);
        writeln(lines,linx:14:4,liny:14:4);
        write('working...');
        gotoxy(1,1)
      end;
      writeln(lines,'END')
    end
    else     {if  hed[1]=2 then get poly user ids & labels}
    begin
      if hed[2]=16 then  {get poly labels}
      begin
        for m:=1 to 11 do
          read(terrafil,null);
        readln(terrafil,rot);
        read(terrafil,nullrx,nullry);
        readln(terrafil,lablx,lably);
```

```
        readln(terrafil,labl);
        writeln(labels,lablx:14:4,lably:14:4,rot:5,' ',120,' ',labl)
      end
      else {if hed[2]=15 then get poly user ids}
      begin
        readln(terrafil);
        read(terrafil,nullrx,nullry);
        readln(terrafil,ptx,pty);
        readln(terrafil,pt);
        if length(pt)<2 then
          writeln(points,rsect+'0'+pt,' ',ptx:14:4,pty:14:4)
        else
          writeln(points,rsect+pt,' ',ptx:14:4,pty:14:4)
      end
    end
  end; {while not eof}
End; {Tax}

Procedure Sectionnums;
Begin
  for m:=1 to 11 do
    read(terrafil,null);
  readln(terrafil,rot);
  read(terrafil,nullrx,nullry);
  readln(terrafil,lablx,lably);
  readln(terrafil,labl);
  writeln(sectno,lablx:14:4,lably:14:4,rot:5,' ',300,' ',labl);
End;  {Sectionnums}

Procedure Soilpolys;
Begin
  for j:=1 to 5 do
    read(terrafil,null);
  readln(terrafil,ptnum);
  writeln(lines,linenum);
  linenum:=linenum+1;
  for k:=1 to ptnum do
    begin
      readln(terrafil,linx,liny);
      writeln(lines,linx:14:4,liny:14:4);
      write('working...');
      gotoxy(1,1)
    end;
  writeln(lines,'END')
End;  {Soilpolys}

Procedure Userids;
Begin
  readln(terrafil);
  read(terrafil,nullrx,nullry);
  readln(terrafil,ptx,pty);
  readln(terrafil,pt);
  if pos('w',pt) > 0 then
  begin
    if pt='w0' then
      pt:='900';
    if pt='w1' then
      pt:='901';
    if pt='w2' then
      pt:='902';
    if pt='w3' then
      pt:='903';
```

```
    if pt='w4' then
      pt:='904';
    if pt='w5' then
      pt:='905';
    if pt='w6' then
      pt:='906';
    if pt='w7' then
      pt:='907';
    if pt='w8' then
      pt:='908';
    if pt='w9' then
      pt:='909';
    if pt='w10' then
      pt:='910';
    if pt='w11' then
      pt:='911';
    if pt='w12' then
      pt:='912';
    if pt='w13' then
      pt:='913';
    if pt='w14' then
      pt:='914';
    if pt='w15' then
      pt:='915';
    if pt='w16' then
      pt:='916';
    if pt='w17' then
      pt:='917';
    if pt='w18' then
      pt:='918';
    if pt='w19' then
      pt:='919';
    if pt='w20' then
      pt:='920'
  end;  {if pt=w#}
  if length(pt)=1 then
    writeln(points,ssect+'00'+pt,' ',ptx:14:4,pty:14:4)
  else
    if length(pt)=2 then
      writeln(points,ssect+'0'+pt,' ',ptx:14:4,pty:14:4)
    else  {if length(pt)=3)}
      writeln(points,ssect+pt,' ',ptx:14:4,pty:14:4)
End; {Userids}

Procedure Soiltypes;
Begin
  for m:=1 to 11 do
    read(terrafil,null);
  readln(terrafil,rot);
  read(terrafil,nullrx,nullry);
  readln(terrafil,lablx,lably);
  readln(terrafil,labl);
  writeln(labels,lablx:14:4,lably:14:4,rot:5,' ',120,' ',labl)
End; {Soiltypes}

Procedure Nullsymbl;
Begin
  if hed[1]=3 then  {null lines}
  begin
    for i:=1 to 5 do
      read(terrafil,null);
    readln(terrafil,ptnum);
```

```
    for j:=1 to ptnum do
      readln(terrafil)
  end   {if}
  else    {hed[1]<>3}
  begin
    if (hed[1]=1) or (hed[1]=4) then {null circle or cell}
    begin
      readln(terrafil);
      readln(terrafil)
    end
    else    {hed[1]=2; null labels}
      for k:=1 to 3 do
        readln(terrafil)
  end     {else hed[1]<>3}
End; {Nullsymbl}

Procedure Soils;
Begin
  assign(sectno,filename+'.ANS');rewrite(sectno);
  While not eof(terrafil) do
  begin
    readln(terrafil,hed[1],hed[2],hed[3]);
    case hed[2] of
      3: Sectionnums;
      4: Soilpolys;
      5: Userids;
      6: Soiltypes;
      2,7..9: Nullsymbl
    end  {case}
  end;   {while not eof}
  writeln(sectno,'END');close(sectno)
End;  {Soils}


BEGIN {main}

  textcolor(14);
  clrscr;

  writeln('***********************************************************-
*******');
  writeln('***********TERRASOFT TO ARC/INFO CONVERSION PRO-
GRAM**************');
  writeln('***********************************************************-
*******');
  writeln;
  writeln('   written by Robert Harmon');
  writeln('                OSU Geography');
  writeln;
  writeln;
  textcolor(3);

  Repeat      {file conversion process}
    write('-----> File type converting (T(ax) or S(oil)):  ');
    readln(typ);
    writeln;

    repeat    {Terrasoft file check if not found}
    writeln('-----> Subdirectory (if necessary ) & Terrasoft');
    write('       file name: ');
    readln(filename);
    assign(terrafil,filename+'.ASC');
```

```
  {$I-}
  reset(terrafil);
  {$I+}
  if IOResult<>0 then
      writeln('***FILE NOT FOUND, TRY AGAIN***')
  until IOResult=0;

  writeln;
  writeln('-----> Range and section number (3 consecutive digits),');
  write('       or soil map sheet number (2 consecutive digits): ');
  if (typ='s') or (typ='S') then
    readln(ssect)
  else
    readln(rsect);
  writeln;
  write('-----> Number of tics in the Terrasoft file: ');
  readln(numtics);

  ticnum:=1;
  linenum:=1;

  gettime(starthr,startmin,startsec,sec100);

  for i:=1 to 41 do       {skipping file header info}
    readln(terrafil);

  clrscr;

{tic retrieval section}

  assign(idtic,filename+'.TCN');rewrite(idtic);
  assign(xtic,filename+'.TCX');rewrite(xtic);
  assign(ytic,filename+'.TCY');rewrite(ytic);
  for m:=1 to numtics do
  begin
    readln(terrafil);             {skipping tic header info}
    readln(terrafil);
    readln(terrafil,ticx,ticy);
    writeln(idtic,ticnum);
    writeln(xtic,ticx:14:3);
    writeln(ytic,ticy:14:3);
    ticnum:=ticnum+1
  end;
  close(idtic);close(xtic);close(ytic);

  assign(lines,filename+'.LIN');rewrite(lines);
  assign(labels,filename+'.ANN');rewrite(labels);
  assign(points,filename+'.PTS');rewrite(points);

  if (typ='S') or (typ='s') then
    soils
  else
    tax;

  clrscr;
  writeln('done...');
  writeln;
  textcolor(12);
  gettime(endhr,endmin,endsec,sec100);
  getdate(yr,mon,date,dayw);
  case dayw of
    0 : days:='Sun.,';
```

```
        1 : days:='Mon.,';
        2 : days:='Tues.,';
        3 : days:='Wed.,';
        4 : days:='Thurs.,';
        5 : days:='Fri.,';
        6 : days:='Sat.,'
      end;  {case of days}
      writeln(days,' ',mon,'/',date,'/',yr,':');
      write('Execution time was:  ',endhr-starthr:3,' hours  ');
      writeln(endmin-startmin:3,' minutes  ',endsec-startsec:3,' sec-
onds');
      assign(tim,filename+'.TIM');rewrite(tim);
      writeln(tim,days,' ',mon,'/',date,'/',yr,':');
      writeln(tim,'Execution time for ',filename,':');
      write(tim,endhr-starthr:3,' hours  ',endmin-startmin:3,' minutes
');
      write(tim,endsec-startsec:3,' seconds');
      close(tim);
      writeln;
      textcolor(3);

      write('-----> Do you wish to convert another file? (Y or N): ');
      readln(answ);
  Until  upcase(answ)='N';  {Repeat file conversion process until No}

  writeln;
  writeln(lines,'END');close(lines);
  writeln(labels,'END');close(labels);
  writeln(points,'END');close(points);
  close(terrafil)

END.  {main}
```

APPENDIX C

LANE COUNTY SOIL RESOURCE CLASSIFICATION

Map Unit		Ag. Rating	Timber Rating	Resource Rating
001A	ABIQUA SICL, 0-3%	H	H	H
001B	ABIQUA SICL, 3-5%	H	H	H
002E	ASTORIA SIL, 5-30%	L	H	H
003E	ASTORIA_VARIANT SIL, 3-30%	L	H	H
003G	ASTORIA_VARIANT SIL, 30-60%	L	H	H
004G	ATRING-ROCK_OUTCROP_COMPLEX , 30-60%	L	L	L
005	AWBRIG SICL, 0-2%	2	3	M
006	AWBRIG-URBAN_LAND_COMPLEX , 0-2%	2	3	M
007B	BANDON SL, 0-7%	4	M	M
007C	BANDON SL, 7-12%	4	M	M
007F	BANDON SL, 12-50%	L	M	M
008	BASHAW C, 0-1%	M	3	M
009	BASHAW-URBAN_LAND_COMPLEX , 0-1%	2	3	M
010	BEACHES , 0-3%	L	L	L
011C	BELLPINE SICL, 3-12%	H	H	H
011D	BELLPINE SICL, 12-20%	M	H	H
011E	BELLPINE SICL, 20-30%	M	H	H
011F	BELLPINE SICL, 30-50%	L	H	H
012E	BELLPINE COB_SICL, 2-30%	M	H	H
013F	BLACHLY CL, 30-50%	L	H	H
013G	BLACHLY CL, 50-70%	L	H	H
014E	BLACHLY SICL, 3-30%	L	H	H
014F	BLACHLY SICL, 30-50%	L	H	H
015E	BLACHLY-MCCULLY CLS, 3-30%	L	H	H
016D	BOHANNON GR_L, 3-25%	L	H	H
016F	BOHANNON GR_L, 25-50%	L	H	H
016H	BOHANNON GR_L, 50-90%	L	H	H
017	BRALLIER_MUCK_DRAINED , 0-1%	M	3	M
018	BRALLLIER_MUCK-TIDAL , 0-2%	L	3	L
019	BRENNER SICL, 0-2%	M	3	M
020B	BRIEDWELL COB_L, 0-7%	M	M	M
021B	BULLARDS-FERRELO LOAMS, 0-7%	M	M	M
021C	BULLARDS-FERRELO LOAMS, 7-12%	M	M	M
021E	BULLARDS-FERRELO LOAMS, 12-30%	M	M	M
021G	BULLARDS-FERRELO LOAMS, 30-60%	L	M	M
022	CAMAS GR_SL, 0-3%	L	L	L
023	CAMAS-URBAN_LAND_COMPLEX , 0-3%	3	3	L
024	CHAPMAN L, 0-3%	H	1	H
025	CHAPMAN-URBAN_LAND_COMPLEX , 0-3%	1	1	H
026	CHEHALIS SICL, 0-3%	H	1	H
027	CHEHALIS-URBAN_LAND_COMPLEX , 0-3%	1	1	H
028C	CHEHULPUM SIL, 3-12%	L	3	L
028E	CHEHULPUM SIL, 12-40%	L	3	L
029	CLOQUATO SIL, 0-3%	H	1	H
030	CLOQUATO-URBAN_LAND_COMPLEX , 0-3%	1	1	H
031	COBURG SICL, 0-3%	H	1	H
032	COBURG-URBAN_LAND_COMPLEX , 0-3%	1	1	H
033	CONSER SICL, 0-2%	M	3	M
034	COURTNEY GR_SICL, 0-3%	M	3	M

Map Unit		Ag. Rating	Timber Rating	Resource Rating
035D	CRUISER GR_CL, 3-25%	L	M	M
035F	CRUISER GR_CL, 25-50%	L	M	M
035G	CRUISER GR_CL, 35-70%	L	M	M
036D	CUMLEY SICL, 2-20%	L	H	H
037C	CUPOLA COB_L, 3-12%	L	H	H
037E	CUPOLA COB_L, 12-30%	L	H	H
038	DAYTON SIL_CLAY_SUB, 0-2%	M	3	M
039E	DIGGER GR_L, 10-30%	L	H	H
039F	DIGGER GR_L, 30-50%	L	H	H
040H	DIGGER-ROCK_OUTCROP_COMPLEX , 50-85%	L	M	M
041C	DIXONVILLE SICL, 3-12%	M	M	M
041E	DIXONVILLE SICL, 12-30%	M	M	M
041F	DIXONVILLE SICL, 30-50%	L	M	M
042E	DIXONVILLE-HAZELAIR-URBAN_LAND , 12-35%	3	3	L
043C	DIXONVILLE-PHILOMATH-HAZELAIR , 3-12%	M	L	M
043E	DIXONVILLE-PHILOMATH-HAZELAIR , 12-35%	L	L	L
044	DUNE_LAND , 0-0%	L	L	L
045C	DUPEE SIL, 3-20%	M	2	M
046	EILERTSEN SIL, 0-3%	M	H	H
047E	FENDALL SIL, 3-30%	L	H	H
048	FLUVENTS , 0-0%	L	L	L
049E	FORMADER L, 3-30%	L	H	H
049G	FORMADER L, 30-60%	L	H	H
050G	FORMADER-HEMBRE-KLICKITAT , 50-80%	L	H	H
051B	HAFLINGER-JIMBO_COMPLEX , 0-5%	M	H	H
052B	HAZELAIR SICL, 2-7%	L	L	L
052D	HAZELAIR SICL, 7-20%	L	L	L
053	HECETA FS, 0-2%	L	L	L
054D	HEMBRE SIL, 5-25%	L	H	H
054G	HEMBRE SIL, 25-60%	L	H	H
055E	HEMBRE-KLICKITAT_COMPLEX , 3-30%	L	H	H
055G	HEMBRE-KLICKITAT_COMPLEX , 30-60%	L	H	H
056	HOLCOMB SICL, 0-3%	H	2	H
057D	HOLDERMAN EXT_COB_L, 5-25%	L	M	M
057F	HOLDERMAN EXT_COB_L, 25-50%	L	M	M
057G	HOLDERMAN EXT_COB_L, 50-75%	L	M	M
058D	HONEYGROVE SICL, 3-25%	L	H	H
058F	HONEYGROVE SICL, 25-50%	L	H	H
059E	HULLT L, 2-30%	M	H	H
059G	HULLT L, 30-60%	L	H	H
060D	HUMMINGTON GR_L, 5-25%	L	M	M
060F	HUMMINGTON GR_L, 25-50%	L	M	M
060G	HUMMINGTON GR_L, 50-75%	L	M	M
061	JIMBO SIL, 0-3%	H	H	H
062B	JIMBO-HAFLINGER_COMPLEX , 0-5%	M	H	H
063C	JORY SICL, 2-12%	H	H	H
063D	JORY SICL, 12-20%	H	H	H
063E	JORY SICL, 20-30%	M	H	H
064D	KEEL COB_CL, 3-25%	L	M	M
064F	KEEL COB_CL, 25-45%	L	M	M
064G	KEEL COB_CL, 45-75%	L	M	M
065G	KILCHIS ST_L, 30-60%	L	M	M
065H	KILCHIS ST_L, 60-90%	L	M	M
066D	KINNEY COB_L, 3-20%	L	H	H
067F	KINNEY COB_L, 20-50%	L	H	H
067G	KINNEY COB_L, 50-70%	L	H	H
068F	KINNEY COB_L, 20-50%	L	H	H
068G	KINNEY COB_L, 50-70%	L	H	H

Map Unit		Ag. Rating	Timber Rating	Resource Rating
069E	KINNEY COB_L, 3-30%	L	H	H
070E	KLICKITAT ST_L, 3-30%	L	H	H
071F	KLICKITAT ST_L, 30-50%	L	H	H
071G	KLICKITAT ST_L, 50-75%	L	H	H
072F	KLICKITAT ST_L, 30-50%	L	H	H
072G	KLICKITAT ST_L, 50-75%	L	H	H
073	LINSLAW L, 0-3%	H	2	H
074B	LINT SIL, 0-7%	H	H	H
074C	LINT SIL, 7-12%	H	H	H
074D	LINT SIL, 12-20%	M	H	H
074E	LINT SIL, 20-40%	L	H	H
075	MALABON SICL, 0-3%	H	1	H
076	MALABON-URBAN_LAND_COMPLEX , 0-3%	1	1	H
100	OXLEY SIL, 0-3%	M	2	M
101	OXLEY-URBAN_LAND_COMPLEX , 0-3%	2	2	M
102C	PANTHER SICL, 2-12%	L	3	L
103C	PANTHER-URBAN_LAND_COMPLEX , 2-12%	3	3	L
104E	PEAVINE SICL, 3-30%	L	H	H
104G	PEAVINE SICL, 30-60%	L	H	H
099H	OCHREPTS_&_UMBREPTS VS, 20-60%	L	2	L
077B	MARCOLA COB_SICL, 2-7%	M	M	M
078	MCALPIN SICL, 0-3%	H	H	H
079	MCBEE SICL, 0-3%	H	1	H
080F	MCCULLY CL, 30-50%	L	H	H
080G	MCCULLY CL, 50-70%	L	H	H
081D	MCDUFF CL, 3-25%	L	H	H
081F	MCDUFF CL, 25-50%	L	H	H
081G	MCDUFF CL, 50-70%	L	H	H
082C	MEDA L, 2-12%	L	M	M
083B	MINNIECE SICL, 0-8%	L	M	M
084D	MULKEY L, 5-25%	L	L	L
085	NATROY SICL, 0-2%	L	3	L
086	NATROY SIC, 0-2%	L	3	L
087	NATROY-URBAN_LAND_COMPLEX , 0-2%	3	3	L
088	NEHALEM SIL, 0-3%	M	H	H
089C	NEKIA SICL, 2-12%	H	H	H
089D	NEKIA SICL, 12-20%	M	H	H
089E	NEKIA SICL, 20-30%	M	H	H
089F	NEKIA SICL, 30-50%	L	H	H
090	NEKOMA SIL, 0-3%	M	H	H
091D	NESKOWIN SIL, 12-20%	L	H	H
091E	NESKOWIN SIL, 20-40%	L	H	H
092G	NESKOWIN_SALANDER SIL, 40-60%	L	H	H
093	NESTUCCA SIL, 0-3%	M	3	M
094C	NETARTS FS, 3-12%	L	M	M
094E	NETARTS FS, 12-30%	L	M	M
095	NEWBERG FSL, 0-3%	H	1	H
096	NEWBERG L, 0-3%	H	1	H
097	NEWBERG-URBAN_LAND_COMPLEX , 0-3%	1	1	H
098	NOTI L, 0-3%	M	3	M
105A	PENGRA SIL, 1-4%	H	2	H
106A	PENGRA-URBAN_LAND_COMPLEX , 1-4%	1	2	H
107C	PHILOMATH SIC, 3-12%	L	L	L
108C	PHILOMATH COB_SIC, 3-12%	L	L	L
108F	PHILOMATH COB_SIC, 12-45%	L	L	L
109F	PHILOMATH-URBAN_LAND_COMPLEX , 12-45%	3	3	L
110	PITS , 0-0%	L	L	L
111D	PREACHER L, 0-25%	L	H	H

Map Unit		Ag. Rating	Timber Rating	Resource Rating
111F	PREACHER L, 25-50%	L	H	H
112G	PREACHER-BOHANNON-SLICKROCK_COMPLEX , 50-75%	L	H	H
113C	RITNER COB_SICL, 2-12%	M	M	M
113E	RITNER COB_SICL, 12-30%	L	M	M
113G	RITNER COB_SICL, 30-60%	L	M	M
114	RIVERWASH , 0-3%	L	L	L
115H	ROCK_OUTCROP-KILCHIS_COMPLEX , 30-90%	L	L	L
116G	ROCK_OUTCROP-WITZEL_COMPLEX , 10-70%	L	L	L
117E	SALANDER SIL, 12-30%	L	H	H
118	SALEM GR_SIL, 0-3%	H	2	H
119	SALEM-URBAN_LAND_COMPLEX , 0-2%	1	2	H
120B	SALKUM SIL, 2-6%	H	H	H
121B	SALKUM SICL, 2-8%	H	H	H
121C	SALKUM SICL, 8-16%	H	H	H
122	SATURN CL, 0-5%	M	H	H
123	SIFTON GR_L, 0-3%	H	H	H
124D	SLICKROCK GR_L, 3-25%	L	H	H
124F	SLICKROCK GR_L, 25-50%	L	H	H
125C	STEIWER L, 3-12%	M	L	M
125D	STEIWER L, 12-20%	M	L	M
125F	STEIWER L, 20-50%	L	L	L
126F	TAHKENITCH L, 20-45%	L	H	H
126G	TAHKENITCH L, 45-75%	L	H	H
127C	URBAN_LAND-HAZELAIR-DIXONVILLE , 3-12%	3	3	L
128B	VENETA L, 0-7%	H	H	H
129B	VENETA_VARIANT SIL, 0-7%	H	H	H
130	WALDO SICL, 0-3%	M	3	M
131C	WALDPORT FS, 0-12%	L	L	L
131E	WALDPORT FS, 12-30%	L	L	L
131G	WALDPORT FS, 30-70%	L	L	L
132E	WALDPORT FS_THIN_SURF, 0-30%	L	L	L
133C	WALDPORT-URBAN_LAND_COMPLEX , 0-12%	3	3	L
134	WAPATO SICL, 0-3%	H	3	H
135C	WILLAKENZIE CL, 2-12%	H	H	H
135D	WILLAKENZIE CL, 12-20%	H	H	H
135E	WILLAKENZIE CL, 20-30%	M	H	H
135F	WILLAKENZIE CL, 30-50%	L	H	H
136	WILLANCH FSL, 0-3%	M	3	M
137F	WINBERRY V_GR_L, 10-45%	L	L	L
138E	WITZEL V_COB_L, 3-30%	L	L	L
138G	WITZEL V_COB_L, 30-75%	L	L	L
139	WOODBURN SIL, 0-3%	H	1	H
140	YAQUINA LFS, 0-3%	4	3	L
141	YAQUINA-URBAN_LAND_COMPLEX , 0-3%	3	3	L
142G	YELLOWSTONE-ROCK_OUTCROP , 10-60%	L	L	L

APPENDIX D

pcINFO 'HML.FIL' PROGRAM LISTING

```
PROGRAM NAME: HML.FILL
05/09/1989
 10000  PROGRAM SECTION ONE
 20000 PROGRAM SECTION TWO
 20001 IF $1RES_RATE-CROP = 'H'
 20002   MOVE 'H' TO HML_CLASS
 20003   GOTO FINISH
 20004   ELSE
 20005   IF $1RES_RATE-CROP = '1'
 20006     MOVE 'H' TO HML_CLASS
 20007     GOTO FINISH
 20008     ELSE
 20009     IF $1RES_RATE-CROP = '4'
 20010       MOVE 'H' TO HML_CLASS
 20011       GOTO FINISH
 20012       ELSE
 20013       IF $1RES_RATE-FOR = 'H'
 20014         MOVE 'H' TO HML_CLASS
 20015         GOTO FINISH
 20016         ELSE
 20017         IF $1RES_RATE-FOR = '1'
 20018           MOVE 'H' TO HML_CLASS
 20019           GOTO FINISH
 20020         ENDIF
 20021       ENDIF
 20022     ENDIF
 20023   ENDIF
 20024 ENDIF
 20025 IF $1RES_RATE-CROP = 'M'
 20026   MOVE 'M' TO HML_CLASS
 20027   GOTO FINISH
 20028   ELSE
 20029   IF $1RES_RATE-CROP = '2'
 20030     MOVE 'M' TO HML_CLASS
 20031     GOTO FINISH
 20032     ELSE
 20033     IF $1RES_RATE-FOR = 'M'
 20034       MOVE 'M' TO HML_CLASS
 20035       GOTO FINISH
 20036       ELSE
 20037       IF $1RES_RATE-FOR = '2'
 20038         MOVE 'M' TO HML_CLASS
 20039         GOTO FINISH
 20040       ENDIF
 20041     ENDIF
 20042   ENDIF
 20043 ENDIF
 20044 MOVE 'L' TO HML_CLASS
 20045 LABEL FINISH
 30000  PROGRAM END
```

APPENDIX E

pcINFO REPORT FORMS FOR MODEL TEST #4

MODEL TEST #4 REPORT FORM #1

```
FORM NAME: TXS4.RPT
05/09/1989
MAPLOT,20,
MAPLOT,
ZONE,10,
ZONE,
DWELL,T,10,
DWELL,
ACRES,T,10,
ACRES,
 '1604170000601 1/4 ML BUFFER'
```

MODEL TEST #4 REPORT FORM #2 (executed for parcels less than 20-acres)

```
FORM NAME: TXS4.RPT2
05/09/1989
MAPLOT,15,
MAPLOT,
ZONE,5,
ZONE,
DWELL,T,3,
DWL,
ACRES,T,8,
ACRES,
'1604170000601 1/4 ML BUF: <20AC'
```