

THE DEVELOPMENT OF A GEOGRAPHIC INFORMATION SYSTEM (GIS)
FOR THE GREENBELT LAND TRUST OF CORVALLIS, OREGON

by

Desiree Scarlett

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Dr. A. Jon Kimerling

Introduction

Corvallis, Oregon and surrounding communities have experienced significant growth in recent years. In response to this rapid development, residents in these areas have become increasingly concerned about the preservation of the local character of their small towns. The historically agricultural economies of towns such as Corvallis and Philomath are being replaced by healthy growing economies due to flourishing new industry. To accommodate the newcomers, land that was once agricultural is quickly being transformed into new residential subdivisions. The concern from citizens over this loss of open space precipitated the establishment of a nonprofit organization, the Greenbelt Land Trust (GLT). One of the primary goals of the GLT is to "review and identify open space areas that should be protected and/or acquired in and/or near Corvallis." (Greenbelt Land Trust 1990:1). Desirable open space is that which enhances the entryways into the community, has high scenic value, access to waterways, high productivity, significant ecological importance, and/or potential or existing recreational use (Greenbelt Land Trust 1990:1). The GLT may protect and acquire such parcels of land through gifts, purchases, or by conservation easements and zoning restrictions.

Since its establishment, the GLT has acquired several large tracts of open space in and around Corvallis. In the future, it will be desirable to connect these discrete patches of land with corridors. This would create a true "greenbelt" encircling Corvallis and Philomath, and would allow residents to easily travel from one open space to another. A strategic design such as this is favored over the random acquisition of land parcels which would likely have the effect of a patchwork quilt. In order to best identify potential areas for acquisition, therefore, the GLT needs to be able to access geographic data. The location of natural and cultural features, as well as information on parcel size and land ownership, are of primary importance to the

GLT. One way of easily maintaining and analyzing this type of data is through the implementation and utilization of a geographic information system, commonly referred to as a GIS.

A geographic information system (GIS) is defined as "a computer system that stores and links nongraphic attributes or geographically referenced data with graphic map features to allow a wide range of information processing and display operations, as well as map production, analysis and modeling" (Antenucci et al. 1991: 281). The Greenbelt Land Trust is interested in nongraphic geographic attributes such as land ownership or parcel size, as well as in graphic map features such as the location of streams or roads, or the boundaries of land parcels. A GIS would benefit the GLT in its decision-making processes by simplifying geographic spatial analysis. For example, the GLT may be interested in identifying land parcels greater than five acres which have access to waterways and trails, and which are located adjacent to existing open space areas. The analytical capability of a GIS would allow for the quick identification of such parcels. In addition, a GIS would allow the Greenbelt Land Trust to easily generate and display a variety of maps. This is important to the GLT because maps are useful in portraying geographic information to the public or to potential land donators, as well as for including with reports and inventories.

A GIS would provide the Greenbelt Land Trust with easy access to geographic data and a tool to aid in decision making processes. In addition, a GIS would be beneficial to the GLT because of the rapid rate of change of characteristics which are crucial to the GLT. The continual changes in land ownership and modifications in zoning codes result in data that become quickly out-of-date. A GIS, however, can be easily updated with new information as it becomes available, so that the GIS database remains current.

The purpose of this project, therefore, is to develop a GIS for a small geographical area that is currently of high priority to the GLT. The development of

this GIS will be documented in a sequential fashion, so that it may serve as a framework for future endeavors. This paper is the first step in creating a GIS manual for the GLT, and will focus on how to use AutoCAD and ARC/INFO for data collection and analysis.

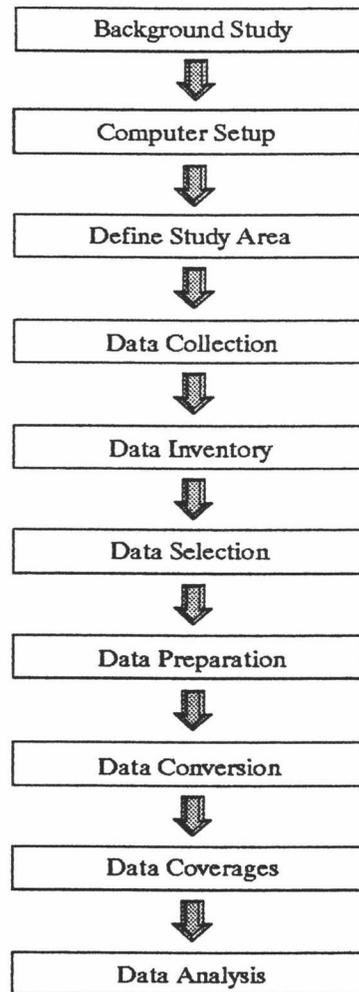


Figure 1. Project Design

Research Design

In order to successfully develop and utilize a GIS for the Greenbelt Land Trust, an appropriate research plan must be implemented. The study plan consists of a series of steps which are required to complete the project. A flow chart describing the general research design is provided in Figure 1. Each step will be discussed to provide

a general guide to the development of a GIS.

Background Study

Before developing a GIS for an organization, it is necessary to become well-acquainted with the functions and objectives of the association. This is important so that the GIS will be successful in meeting the needs of the organization. Attending GLT committee meetings and accompanying members on field excursions provided a worthwhile way to learn about the strategies and goals of the organization.

In addition to studying the Greenbelt Land Trust, a literature search was undertaken to locate articles and information on similar GIS endeavors. There are a multitude of nonprofit organizations across the country that have benefitted from developing small-scale geographical information systems. Because nonprofit organizations have limited budgets and staffs, they often must rely on government agencies to provide much of the data for the GIS. This limits the available data to some extent, but it provides a very cost-effective method to develop a GIS. Also, the utilization of university facilities and students is another way to minimize costs for the nonprofit group. This is also beneficial to students by providing hands-on experience outside the classroom, and it allows them to contribute to the improvement of the community.

A preliminary survey was performed to determine which types of software and hardware would be needed for the project. This was necessary so that the appropriate computer facilities could be located and accessed. Because of the nature of the project, the city and the county are presumed to be the primary data providers. In exchange, the city and county will be provided with the data from the completed project. Therefore, it is important to identify and understand the data formats and software that are used by these agencies. This is done by contacting the agencies and discussing their GIS practices and facilities.

Software and Hardware Setup

The results of the background study and preliminary survey indicated that the city and county use three primary types of software: AutoCAD, ARC/INFO, and ArcView. All three of these will be utilized in completing the project, so a description and discussion of each will follow.

AutoCAD is a type of software used for computer aided design (CAD). This sort of software is used most commonly in civil and mechanical engineering. AutoCAD has very intricate and comprehensive drawing capabilities, which make it ideal for such engineering applications. AutoCAD is not a GIS, however, because it does not have any analytical power and features do not have any attribute data stored in a database. AutoCAD is a system for displaying complex drawings and it provides extensive tools for creating and editing such drawings. AutoCAD displays are called drawings, and they are often drawn at large scales, due to the high degree of detail. AutoCAD drawings covering geographical areas are generally stored in a series of individual tiles, or map sheets, because of the large volumes of data they contain. AutoCAD drawings may be important to a GIS project, since they provide a convenient form of data from which features can be easily extracted and then converted to a GIS format.

ARC/INFO is an important software system used primarily for geographical information systems. It has the capability to develop digital spatial databases, to perform spatial analyses and modeling, and to generate and display maps. ARC/INFO does this by linking geographic data to attribute data. The ARC component of ARC/INFO stores the location of features based on the coordinates of the lines, or arcs, which define the features. The INFO component stores the attribute data for each feature, which may include descriptions or characteristics of the features, as well as their relation to other features. Together, these two components allow ARC/INFO to perform spatial queries based on attribute data, making it an extremely powerful

tool for geographical analysis.

ArcView is a software tool that allows for the display of geographic information from an ARC/INFO database. ArcView provides a user-friendly environment that simplifies the display and query of ARC/INFO data. ArcView uses a windows platform and the tools and commands are easy to use, unlike ARC/INFO where the user must correctly type each command manually. Therefore, ArcView is a valuable software for displaying ARC/INFO coverages. Because ArcView uses ARC/INFO databases, the views in ArcView are always updated as the database itself is changed and updated. Thus, the displays in ArcView are dynamic and reflect the current status of the database. ArcView allows many ARC/INFO coverages to be added, and the user can turn these layers on or off as he or she chooses. Because ArcView is linked to the GIS database, it also has the capability to perform simplified spatial queries and analyses. In addition, ArcView provides a much easier format for generating and producing maps than ARC/INFO. Although the analytical powers of ArcView are limited in comparison to ARC/INFO, ArcView is an excellent tool with which to create professional quality maps based on ARC/INFO coverages.

In order to use these types of software, access to the appropriate hardware is required. The computer hardware that will be used for this project consists of a 1.6 gigabyte Pentium personal computer with a CD-ROM and a zip drive. The zip drive is an excellent way to store and access large data sources without using valuable disk space on the hard drive. Each zip disk holds 100 megabytes of information, and the cost is minimal. In addition, the zip disks are an appropriate medium to collect, use, and return data to the various agencies involved. The CD-ROM is only needed for this project because the city provided its data in CD format. If a CD-ROM was not accessible, it would be possible to collect all data on zip disks and eliminate the need for the CD-ROM.

Study Area

The Greenbelt Land Trust has acquired two large parcels of land in the area of west Corvallis and north Philomath. The first is Bald Hill Park, which is located between Oak Creek Road and Reservoir Road, just west of 53rd Street. Bald Hill Park contains over 300 acres of open space, including a paved bike path and several trails. The second acquisition is called Open Space Park, which lies approximately two miles northwest of Bald Hill Park.

As discussed earlier, it is desirable to connect large open spaces with trails or paths so that people can move from one park to another. Therefore, a plan to connect Bald Hill Park to Open Space Park via a trail system has been proposed. Some trails have already been established, but they are not connected to make a continuous corridor between the two parks. Trails are generally established by obtaining access easements from landowners, so it is necessary to be able to identify possible routes and the associated landowners.

In addition to such a corridor between these two large open areas, there is also interest in connecting Open Space Park to open space in north Philomath. This requires the identification of parcels of land which are both large and which can be integrated to provide a passage from Open Space to north Philomath.

Thus, there is significant demand by the GLT for geographical analyses in this area of west Corvallis and north Philomath. Because of this need, the area from Bald Hill Park westward to Open Space Park and extending southward to West Hills Road and northward to Cardwell Hill Drive has been selected as the study area for this project (see Figure 2).

There are a variety of features that the GLT would like to see incorporated into a GIS covering this area. One of these is information on land parcels, such as the number of acres and the names of land owners, as well as the parcel boundaries. In addition, it is desired that the GIS include the location of hydrologic features (rivers

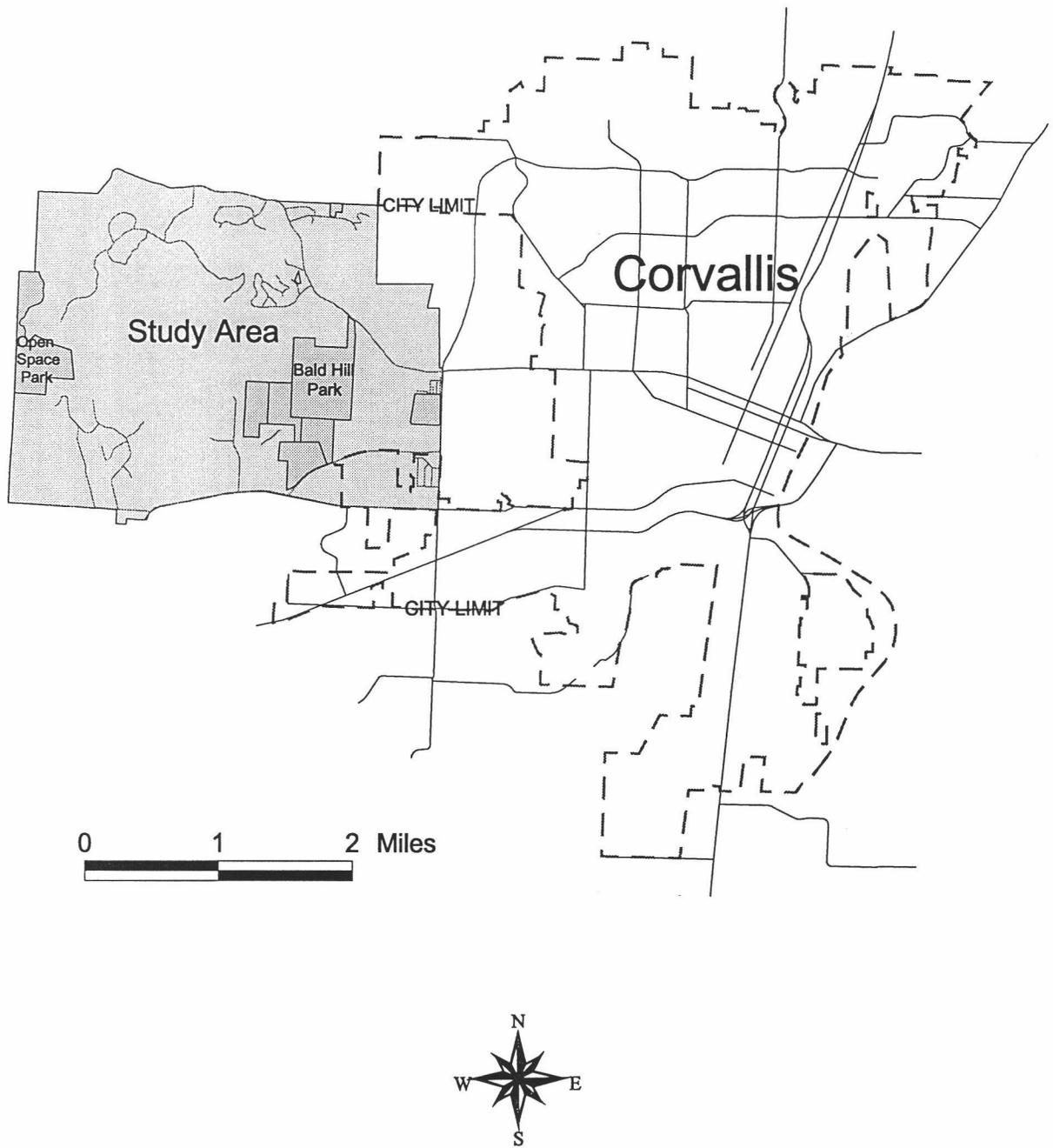


Figure 2. Study Area

and streams, wetlands), natural features (vegetation, topography), and transportation features (streets and roads, railroads, trails). Figure 3 provides a schematic illustration of a GIS containing these sorts of coverages. This diagram portrays the concept of having an array of layers for the same geographic area which can be used individually or in any combination for geographic analyses.

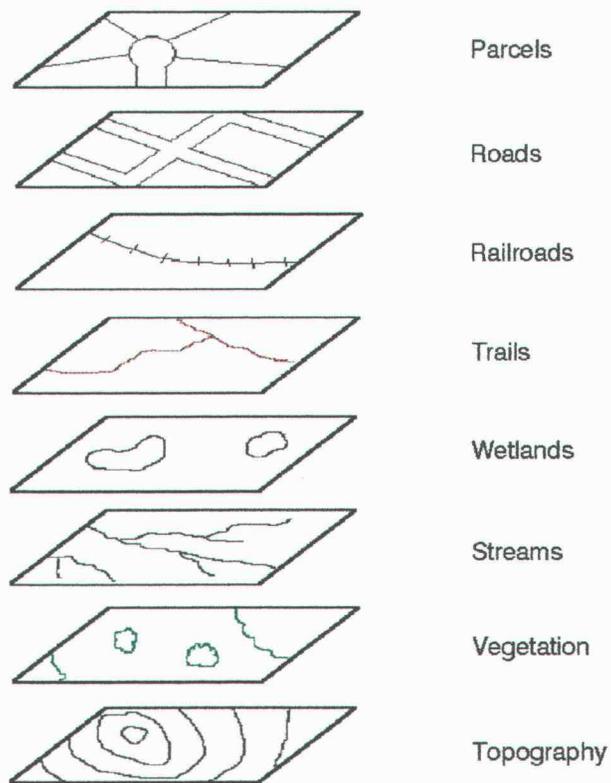


Figure 3. GIS Layers

Data Collection

With the boundaries of the study area established and a clear idea as to what types of coverages are desired, a search for existing data is undertaken. Because the study area lies partly inside the urban growth boundary of Corvallis, the City of Corvallis Mapping and GIS Agency is contacted. The entire study area lies in Benton County, so the GIS Department for Benton County is also consulted. Using these agencies for data collection is a cost-effective way to collect acceptable data.

The city and the county possess an abundance of information, so it is important to limit the information to the study area. This decreases the amount of data that will need to be inventoried in later steps. All available data pertaining to the study area should be collected, even if it is questionable whether they will be included in the GIS.

The data collection process yielded sufficient data sources to obtain the desired

coverages for the entire study area. The characteristics of the different sources vary considerably, however, in such important aspects as geographical extent, digital format, and projection. In order to identify and select which data is best-suited for the project, a comprehensive inventory of the existing data is needed.

Data Inventory

After contacting the appropriate agencies and collecting all the available data for the study area, it is necessary to examine the data carefully and take a complete inventory. The inventory includes determining such characteristics as the projection, original source, scale, format, and content of the data. These characteristics are important because they indicate whether the data will be useful to the project and also reflect the level of accuracy and reliability of the data sources.

The projection of a digital data source is of utmost importance. When developing a GIS, it is necessary that all layers used in the GIS are based on the same projection and coordinate system so that they will correctly overlay one another for geographic analysis. Therefore, it is important to understand the fundamentals of map projections.

A map projection must be used to display any section of the earth on a flat surface. This is because the earth is round, and even a small area of the earth contains a slight curvature and cannot be flattened onto a two-dimensional surface without some distortion. Therefore, the points on the earth are projected onto a surface which can be flattened, such as a cylinder or a cone. By doing this, a three-dimensional surface is represented on a flat surface. There are many types of projections, but generally the projection which creates the least amount of scale distortion is chosen.

In order to locate features on the projected map, a system of coordinates is required. One familiar system of coordinates is the system of latitude and longitude.

This system is not desirable for large scale maps, however, because a small area has only minimal curvature, and the calculations of latitude and longitude become quite complicated. Instead, other coordinate systems have been developed. In the 1930s, for example, the United States implemented a system of rectangular coordinates to be used by each of the 50 states (Robinson et al. 1995: 107). These grid structures are referred to as State Plane Coordinates. Each state has its own State Plane Coordinate System, and many larger states have two or more overlapping zones to minimize scale variation. The state of Oregon, for example, is divided into a north zone and a south zone. Both zones are based on Lambert's conic conformal projection. This system allows cartographers to map features at a local-scale as though the earth was a planar surface. So that all coordinates are positive, a false origin is placed to the south and west of the rectangle coordinate system. Coordinates are measured in the number of feet north (called the false northing) and the number of feet east (called the false easting) from this origin.

The State Plane Coordinate System is also based on a datum of horizontal networks used as a reference for mapping. The North American Datum of 1927 (NAD27) was the original datum used in State Plane Coordinate Systems, but a new datum was established in 1983 (NAD83) and many recent maps are based on this datum. The primary difference between the two datums is the ellipsoid on which they are based. The NAD27 is based on the Clarke 1866 ellipsoid, while the NAD83 is based on the more accurate WGS (World Geodetic System) 84 ellipsoid (Robinson et al 1995: 44-56). The newer datum uses more precise measurements and takes into account the horizontal shifts that have occurred in the earth's crust. If a mapping project has little geographical extent, a map in one datum can be changed to fit the other with a slight shift in the coordinates. USGS topographic maps often provide information on the number of units required for the shift.

Both the city and the county provided AutoCAD files based on the

interpretation of 1:800 scale aerial photographs. These drawing files are arranged in tiles based on State Plane coordinates, with each tile measuring 2000 feet by 3000 feet (see Figure 4). These files contain very detailed coverages of features such as roads, railroads, trails, streams, rivers, vegetation and contour lines. A list of all the layers in these AutoCAD drawings, as well as a ranking of priority, is included in Appendix A. The files from the city and county are identical except that the county coverages are based on the NAD83, and the city coverages are based on the NAD27.

The county provided parcel data that covered most of the study area, with the exception of a strip along the eastern edge of the study area. These parcel data are based on tax lot information from the Benton County Assessor and are in AutoCAD format. As with all of the county data, the data are in State Plane NAD83 coordinates. These files contain an abundance of information in addition to the parcel data. Such features as the surveying notes and measurements, all of the Oregon Department of Transportation right-of-ways and easements, and a multitude of other details are all included in these files. Therefore, it is necessary to identify and describe each of the AutoCAD layers. An inventory of these assessor files with priority rankings is provided in Appendix A.

The city also provided parcel data covering much of the study area. A mile wide stretch along the northern edge of the study area is missing from the city coverage, however. The parcel data from the city are in both ArcView and ARC/INFO formats. Therefore, there are many attributes associated with these coverages, which makes them quite useful to the GLT. The coverages show all the parcel boundaries and each parcel is linked to the attribute database containing characteristics such as the area, land owner, land value, and zoning code. A list of the attributes associated with each parcel in the ARC/INFO database is included in Appendix A.

Data Selection

Once the collected data are inventoried, the next task is to select the data best suited to the needs of the project. This is based on several considerations.

The first consideration is whether or not the data source covers the entire study area. Obviously, it is preferred to utilize a data source that will include all of the study area, rather than attempting to create a coverage for the study area by joining data from different sources. This maintains consistency and will create fewer problems when developing the GIS coverages.

Another guideline is to attempt to utilize as much data as possible that uses the same projection, grid system, and datum. This is important to minimize the amount of time spent in preparing data for inclusion into the GIS.

In addition, the purpose of the GIS is another major factor in selecting which data sources to use. The time that will be needed to prepare the data must be weighed against the importance of including the data in the resulting GIS. For example, those coverages that are of highest priority should be included even if they will demand a lot of time, while those of lower priority may be omitted from the GIS.

Based on these considerations, the following table presents the data sources selected for each of the desired coverages.

Coverage	Format	Source
Topography	AutoCAD	City of Corvallis
Vegetation	AutoCAD	City of Corvallis
Streams	AutoCAD	City of Corvallis
Wetlands	AutoCAD	City of Corvallis
Trails	AutoCAD	City of Corvallis
Railroads	AutoCAD	City of Corvallis
Streets	AutoCAD	City of Corvallis
Parcels	AutoCAD	Benton County
"	ARC/INFO	City of Corvallis

Table 1. Coverages and Data Sources

The data from the city are all based on the North American Datum of 1927 (NAD27) and all the desired coverages except for a portion of the parcel coverage can be extracted from these sources. Therefore, this will serve as the standard datum for the GIS, and the county parcel data will need to be adjusted.

Data Preparation

Because much of the data is in AutoCAD drawings, data will need to be exported out of AutoCAD in a format which can then be used by ARC/INFO. This process will be discussed later in the section on data conversion. Before the data can be exported, however, they need to be edited, corrected, and compiled. This is done prior to conversion because editing is much simpler in AutoCAD than in ARC/INFO, and because it will simplify the data conversion process if the source data are in good form.

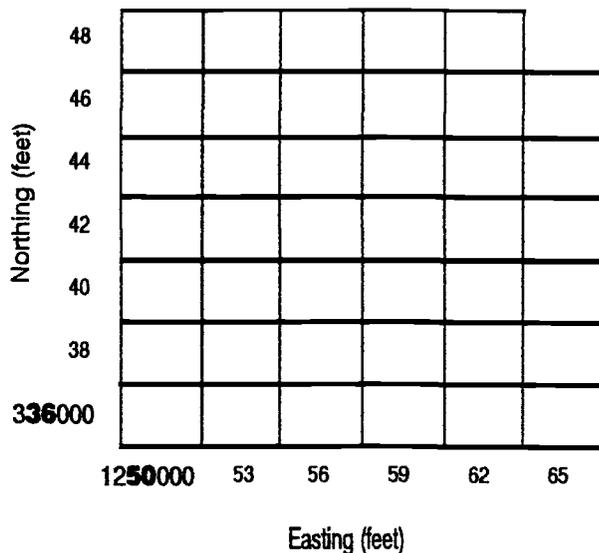


Figure 4. Topo Sheets Based on State Plane Coordinates (Oregon North Zone)

To obtain coverage for the entire study area, 42 topographic map sheets, or tiles, were needed. These tiles were used to extract the data to create the following coverages: roads, gravel roads, railroads, trails, streams, wetlands, vegetation, and contour lines. These tiles are identified by the State Plane Coordinates of their southwest corners, and the tiles covering the designated study area are shown in the following diagram (see Figure 4).

The first step in the data preparation is to go through each of the 42 tiles and check to see that all the lines are properly connected and all the polygons are closed. In order to do this, several basic AutoCAD commands are used extensively. The following is a list of some fundamental commands with a brief description of each:

PEDIT - this command is used to join two polylines together. In order for the join to be successful, the two polylines must share one endpoint.

PLINE - this command is used to draw a polyline, which is a single line made up of a series of shorter connected lines connected.

TRIM - this command uses a line as the blade to trim another line. It is useful to erase the end of polylines in the case of overshoots.

EXTEND - this command asks for a boundary and then extends a line to that boundary. It is useful for undershoots and at "T" shaped intersections to assure a proper link.

These commands are used to join line segments so that they form one continuous line. In many of the AutoCAD files, lines that should be a single entity are made up of numerous broken or disjointed lines, rather than a single line. These need to be joined using the commands discussed. In addition, where two different line segments meet, there should be an intersection without undershoots or overshoots (see Figure 5). Polygons are those features, such as ponds, which have areas bounded by lines. All polygons should be closed, meaning that they start and end at exactly the same point.

The line features in these files are the paved roads, gravel roads, railroad, trails, streams, and contour lines, while the polygon features are the wetlands (ponds, swamps, marshes), and vegetation. The paved roads and gravel roads are shown both by double lines and single lines (centerlines) in many of the AutoCAD files, but in some cases the road centerlines are missing. This is especially common with the gravel roads. In such cases, the PLINE command can be used to manually draw in the

centerline for such features, since the centerlines are needed for export to ARC/INFO.

These tiles could be joined either in AutoCAD or in ARC/INFO to create a single drawing. Since AutoCAD provides tools for easy editing and a more user-friendly environment, however, it is the preferred format for such tasks. After the 42 files have been edited and corrected, they are then combined using the DDINSERT command in AutoCAD. This command asks for the name of the file to be inserted, and one by one, each of the 42 files is inserted. The result is one very large file which contains all 42 tiles appended together. In order to separate all of the features into their proper layers, the EXPLODE command is executed on all entities.

After the 42 tiles are appended, there is additional editing necessary along the edges of all the tiles. Many features in the coverages extend from one tile to another and some cross several tiles. These types of entities, therefore, need to be edited and joined to form single continuous lines.

In addition to the topographic tiles, there is a small portion of the study area for which the city has no ARC/INFO coverage. The county, however, provided AutoCAD drawings from the Assessor's Office. These drawing files contain an abundance of data, including parcel boundaries. Unlike the ARC/INFO coverages from the city, these drawings are in AutoCAD and therefore do not have any attribute data, such as land owner and land value. However, the boundaries of the parcels can still be exported from AutoCAD to ARC/INFO, and attribute data can be added later.

The first step in preparing these files is to adjust the coordinates to reflect the NAD27, rather than the NAD83, projection. This is done by selecting all the entities and executing the MOVE command in AutoCAD. The X-Y coordinates of (-6201804, 45) are entered as the new coordinates, the units being feet. The reason the eastward shift is so large is because the county has based their coordinates on a false origin located very far westward.

After the assessor files have been adjusted to fit the NAD27 projection, they

must be edited and cleaned in a similar fashion as the topographic tiles. It is important that each parcel is bounded properly to form a closed polygon. If any of the parcel polygons are not correctly closed, they will create problems later in the creation of ARC/INFO coverages.

Data Conversion

After data preparation, the data are ready to be exported from AutoCAD and imported into ARC/INFO. This is done through a series of steps which involve exporting the data in the AutoCAD Drawing Exchange Format (DXF) so that it can be then be used to create ARC/INFO coverages.

The first step in this process is to open the selected file in AutoCAD. Then, under the FILE menu, the option for exporting in DXF format is selected. Unless the user then selects the option of exporting only chosen entities, all the entities and layers, regardless of whether they are turned on or off or are frozen or thawed, will be included in the DXF file. The option for selecting only specific entities is useful, however, when the file is quite large, and only a portion of the data is needed in the DXF format. The layers which are not needed are turned off or frozen so that only those layers which contain needed data are present in the display. After selecting these entities, AutoCAD prompts the user for the number of decimals of accuracy to be carried into the new file format. The default is six decimals of accuracy which is sufficient for the scale and detail of this project. When the command prompt returns to the screen, the export command has been successfully executed.

The next step is to determine which AutoCAD layers will be included in each ARC/INFO coverage. After entering ARC/INFO, a list of all the AutoCAD layers that were exported in the DXF format can be displayed by entering the command DXFINFO followed by the file name at the arc prompt. The following table provides the names of the AutoCAD layers and the names of the new ARC/INFO coverages that

will be created with the AutoCAD layers. Each coverage type and a description is also identified.

ARC/INFO Coverage	AutoCAD Layers	Feature Type	Description
VEG	VEGE	Polygons	presence of vegetation
ROAD	ST-CL, ST-N, RD-N	Lines	centerline roads & names
CON_10	CON-10, CON-10D, CON-TEXT	Lines	10 foot contours
GRAVEL	STCL-G	Lines	centerline gravel rds
RAILRD	RR-CL, RR-N	Lines	railroads & names
TRAIL	TRAIL, PATH	Lines	trails, paths
STREAM	STREAM, STREAM-N, RIVER	Lines	streams, rivers
WETLAND	POND, MARSH, SWAMP	Polygons	wetlands
PARCEL	TAX-BND, TAX-LINE, CNTY-RW, RW-CNTY, PRIRD-RW	Polygons	parcel boundaries

Table 2. AutoCAD Layers and ARC/INFO Coverages

The next step is to import the data into ARC/INFO so that the coverages can be created. This is done by entering the command DXFARC followed by the DXF file name and then the name of the ARC/INFO coverage which is to be created. For example, to create the trails coverage, the following command would be entered at the arc prompt: DXFARC filename.DXF TRAIL. Then, the user is asked to enter the names of the AutoCAD layers to be included in the coverage, which in this case would be TRAIL and PATH. After the user finishes entering the layer names, ARC/INFO creates a new coverage using the given data to create the new coverage TRAILS. This command must be executed individually for each of the new ARC/INFO coverages.

Creating the ARC/INFO Coverages

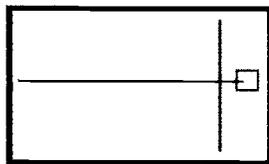
At this point, the data have been entered into ARC/INFO, but the coverages are not yet acceptable for ARC/INFO analysis. In order to perform spatial queries and other analyses, a GIS must store the spatial relationships between objects in a database. With ARC/INFO, this is done using the mathematical approach called topology. Topology explicitly defines the geometric relationships among features in a database, which allows the data to be stored more efficiently and results in faster processing. With topological relationships stored in the database, ARC/INFO is capable of performing complex analyses, modeling, and overlays. Therefore, the use of topology to create and store spatial relationships is fundamental in developing a GIS database in ARC/INFO.

The three major topological concepts of ARC/INFO are connectivity, area definition, and contiguity (Understanding GIS 1995:2-10). In ARC/INFO, all lines are called arcs. Points along a line are called vertices, and the endpoints are called nodes. ARC/INFO records the vertices and nodes which make up all lines. Where different lines intersect, they share common nodes which tells ARC/INFO that the arcs are connected, which is called connectivity. In ARC/INFO, an enclosed area is called a polygon. Polygons are stored in ARC/INFO according to the arcs which make up the polygon. This is called area definition. The third concept is contiguity, which means that all arcs have direction, allowing ARC/INFO to record which polygons exist to the right and left of each arc. It is important to understand the topological concepts of ARC/INFO so that the coverages can be correctly created and maintained.

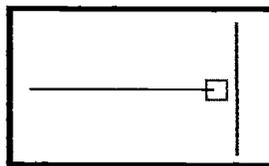
The first step in creating a coverage in ARC/INFO, after initially importing the data, is to build the topology. The procedure is different according to the feature type. Since this project contains both polygon and line features (see Table 2), the method for each will be discussed.

For line features, the creation of topology records the from-node and the to-

node and records the polygons to the left and right of the line. This information is stored as attributes in the arc attribute table (AAT). It is necessary to build the topology by executing the build command with the line option. This command will create the topology and associated AAT for line features. For example, the following is the command to build topology for the trails coverage at the arc prompt: BUILD TRAIL LINE. This command needs to be executed for each of the line coverages.



Overshoot



Undershoot

Figure 5. Dangling Nodes

Polygon features require a different type of topology called polygon topology. In order to build polygon topology, however, each polygon must be closed and contain a single label point. The command EDITPLOT in ARC/INFO is used to display a coverage on the monitor screen. There are several options with this command. One important option is to show dangling nodes. A dangling node occurs where a line ends and does not intersect with any other lines (see Figure 5). It is useful to identify all

dangling nodes in a given coverage because often they are errors resulting from polygons that are not closed properly or where there is an undershoot or overshoot. The display of dangling nodes from the EDITPLOT command is examined to determine if the dangling nodes are errors, or if they are acceptable, such as along the edge of the study area. To correct dangling nodes which are errors, the CLEAN command is used.

The CLEAN command in ARC/INFO performs coordinate editing on the coverage, which is useful for correcting small overshoots or undershoots. The CLEAN command can be executed with user-input values for fuzzy tolerance and dangle length. Fuzzy tolerance is the maximum distance at which nodes will be snapped together to form a single node during the CLEAN command. In other words, all nodes

which are within the specified tolerance will be joined together. The dangle length setting is the minimum distance for dangling nodes. All dangles that are shorter than the dangle length will be removed during the CLEAN command. These two settings are measured in coverage units, which are feet in this project. A coverage may need to undergo a series of CLEAN commands with progressively larger values input for fuzzy tolerance and dangle length. After each CLEAN command has been executed, the coverage is reexamined for dangling nodes using EDITPLOT. This process is repeated until all errors have been eliminated. It is important that the value for fuzzy tolerance is not too large, or the CLEAN command will begin to collapse polygons.

In addition to having closed polygons, each polygon must also be assigned a unique label point to serve as identification. This is necessary so that attributes from the database can be linked to the correct polygons based on this user identification number (called a User I.D.). After the coverage has been successfully cleaned, the polygons can be assigned label points by executing the CREATELABEL command in ARC/INFO. This command assigns unique User I.D.s to all polygons which do not already have label points, and is useful in this project because none of the polygons have label points. The EDITPLOT command is used again with the option of displaying only polygons with label point errors. This command shows any polygons with either no label points, or with more than one label point. There is always one polygon in each coverage which will appear to have no User I.D. because its User I.D. is zero. This is the universal polygon which is made up of all the interior polygons, and it is not considered an error. After all the polygons are cleaned and the label points have been correctly added, the next step is to create polygon topology by executing the BUILD command with the polygon option. The following is an example of the BUILD command to create the wetlands coverage at the arc prompt: BUILD WETLANDS POLY.

After the coverages have been created in ARC/INFO, the last step is to either

trim or join coverages so that there is one coverage for each feature. The coverages extracted from the large AutoCAD file all extend beyond the extent of the study area and will need to be trimmed back. The parcel data that were imported from AutoCAD need to be joined with two existing ARC/INFO parcel coverages from the city.

To trim coverages, the CLIP command is used, but first a clip cover must be created. Using the parcel and topographic AutoCAD files for reference, a boundary of the study area is drawn in AutoCAD, exported in digital exchange format out of AutoCAD, and imported into ARC/INFO, where it is cleaned and built with polygon topology. This coverage is called CLIPCOV and is used with the CLIP command, which erases any part of a coverage that extends beyond the boundary of the clip cover. This clip cover is used to clip the following coverages: ROAD, GRAVEL, TRAIL, RAILRD, STREAM, WETLAND, VEG, and 10_CON. An example of the CLIP command for trimming the trail coverage is as follows: CLIP ROAD CLIPCOV CLPROAD. This clips the road coverage with the clip cover to create a new coverage called CLPROAD.

To join the parcel coverages, the first step is to examine the polygon attribute tables (PAT) of the ARC/INFO coverages from the city. In order to join coverages they must all have identical attribute types. The TABLES module of ARC/INFO is entered with the command TABLES at the arc prompt. In this module, the polygon attribute table for a given coverage is selected by entering SELECT filename.PAT . Then, the command ITEMS is executed to display all the attribute items. This includes the item name, its type, and its width. This information is recorded so that identical items can be added to the new parcel coverage that has been created. This is done by selecting the PAT for the new parcel coverage and using the command ADDITEM. Each item is then entered exactly as it appeared in the city data.

After all the items have been added to the new parcel coverage, the BUILD command is executed. Then the coverages are ready to be joined. This is done using the MAPJOIN command at the arc prompt. In order to maintain unique User I.D.s

when joined the three coverages, the features option is used with the join command. The command is as follows: MAPJOIN ALLPARC FEATURES. Then ARC/INFO will prompt the user to input the names of the coverages to be joined. The result is a coverage called ALLPARC which contains all the polygons from the three separate coverages. The last step is to clip the ALLPARC coverage so that it covers only the present study area and will match the other coverages in geographical extent. The command is: CLIP ALLPARC CLIPCOV.

Copies of the basic coverages that have been created in this project are included in Appendix B. In addition, a metadata dictionary describing the fundamental characteristics of each coverage is provided in Appendix C.

Data Analysis

The real power and utility of a GIS is its ability to perform geographic analyses and spatial queries. Now that the basic coverages for this study area have been created, they are usable for such sorts of spatial analysis. For example, the GLT may want to create a new coverage which contains only those parcels with areas greater than five acres. This can be done with the RESELECT command in ARC/INFO in which all the parcels fitting that description will be extracted. Another new coverage showing all parcels that are public lands may also be generated. Again using the parcel coverage and the RESELECT command, the polygon attribute table can be queried for those parcels who have the city of Corvallis, Benton County, or Oregon State University listed as the owner. This type of spatial querying using only one layer is fairly simple, but there are a multitude of analyses and new coverages that could be created by combining two or more coverages.

By utilizing data and attributes from more than one coverage in an analysis, some very complex analyses can be performed. For example, the GLT may want to concentrate on parcels of land with riparian habitat and access to waterways.

Therefore, those parcels which are over 10 acres and which lie within 100 feet of a stream may be of interest. This type of analysis could be approached in several different ways. One approach would be to first use the RESELECT command to obtain the parcels that are over 10 acres. Next, the BUFFER command would be executed on the streams coverage to select all land which lies within a 100-foot distance from all streams. Finally, an overlay of the coverages with parcels over 10 acres and the buffered streams would be performed with the IDENTIFY command to identify those parcels which are within 100 feet of streams.

There are numerous other types of analyses that could be performed, especially as more coverages are added to the original ones. In the future, coverages showing zoning or soil types may be obtained, which would further broaden the possibilities for analysis.

Conclusion

This project has culminated in the production and implementation of a basic geographic information system for the Greenbelt Land Trust. The major steps have been thoroughly discussed to serve as a general guideline for any future GIS endeavors on the part of the GLT, as additional coverages are added to this study area, or new coverages are generated for new study areas. These procedures are highly generalized and much simplified, discussing only the major steps and concepts.

Utilizing a geographic information system as a tool for querying and displaying spatial data will be highly beneficial to the GLT. The ease with which complex analyses can be performed is one of the major strengths of a GIS. In addition, the databases can be kept current, which is of great importance when dealing with the ever-changing landscape of an urban area.

Because the GLT is a nonprofit organization, it has a limited budget and staff. The cost associated with developing and maintaining a GIS database is typically quite

high, but the utilization of university students and facilities presents a cost-effective solution. Taking advantage of these resources is beneficial not only to the Greenbelt Land Trust, but to students as well, by providing the opportunity to apply their skills and knowledge outside the classroom.

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Appendix A: Data Inventory

ASSESSOR TILES
SOURCE: BENTON COUNTY MAPPING AND GIS

PRIORITY	AUTOCAD LAYERS	DEFINITION
TRANSPORTATION		
L	RW-ODOT	state highway right of way boundary lines
L	RW-CNTY	country road right of way boundary lines
L	RW-CITY	city street right of way boundary lines
L	RW-PRIRID	private right of way boundary lines
L	RW-RR	railroad right of way boundary lines
L	RW-BPA	Bonneville Power transmission easement right of way boundaries
L	RW-EASE	utility easement right of way boundary lines
L	RW-APPROX	uncertain right of way boundaries
L	CL-ODOT	centerline of state highway right of ways
L	CL-CNTY	centerline of county roads rights of ways
L	CL-CITY	centerline of city street rights of ways
L	CL-PRIRID	centerline of private rights of ways
L	CL-BPA	centerline of Bonneville Power transmission line easements
L	CL-EASE	centerline of utility and misc. easement rights of ways
L	CL-RR	centerline of railroad rights of ways
L	TX-ODOT	state highway name and number
L	TX-CNTY	county or public road name and number
L	TX-CITY	city or public street name and number
L	TX-PRIRID	private access road name and number
L	TX-BPA	Bonneville Power transmission line branch name
L	TX-RR	railroad right of way width and stations
L	TX-EASE	type and purpose of easement and instrument number
L	RWTX-ODOT	state highway right of way width and stations
L	RWTX-CNTY	county road right of way width and stations
L	RWTX-CITY	city street right of way width and stations
L	RWTX-PRIRD	access easement, driveway, BLM, and forest road width
L	RWTX-BPA	Bonneville Power transmission line easement width
L	RWTX-RR	railroad right of way width and stations
L	RWTX-EASE	easement right of way width
L	RWTX-CURVE	curve data on right of ways such as degree of curve
L	RWTX-DATA	deed references
HYDROLOGIC FEATURES		
L	LAKE	boundary of lakes and ponds
L	RIVER	banks of river channel
L	CREEK	banks of creek
L	CANAL	bank or boundary of canal
L	MISC-H2O	misc. water boundaries
L	TX-LAKE	name of lake or pond
L	TX-RIVER	name of river
L	TX-CREEK	name of creek
L	TX-CANAL	name of canal
PARCEL		
L	CENTROID	tax centroid
H	BND-TAX	tax lot boundary line
L	BND-SUP	supplemental boundary-old tax lot, subdivision lot, etc.

L BND-SUB subdivision boundary line
 H TAX-ID tax lot number and acreage
 H TAX-LINE supplemental parcel lines
 L TX-CB all bearings
 L TX-CE all distances in english units
 L TX-CM all distances in metric units
 L REFNOTES property corner referenced by deed, subdivision, plats
 L JUDICIAL court decisions affecting property ownership or boundaries
 L SUB-NAME subdivision or partition pat name
 L SUB-LOT subdivision lot and block number or parition plat number

PUBLIC LAND SURVEY

L LINE-SEC section lines that are not tax lot boundaries
 L LINE-DLC donation land claim lines that are not tax lot boundaries
 L LINE-MEAN river meander line
 L TIC-SED tic mark @ 1/4, 1/16 section corners and text
 L TIC-DLC tic mark @ donation land claim corners and text
 L TIC-MEAN tic mark @ meander corners and text
 L PARALLEL standard parallel text
 L TX-SEC section numbers and text
 L TX-DLC corner designation, name and number of claim
 L TX-MEAN bearing and distance, year, etc.
 L GOVT-LOT government lot number and area

TAXING DISTRICTS

L BND-SCHOOL taxing boundary of school district
 L BND-CITY taxing boundary
 L BND-FIRE taxing boundary of rural fire district
 L BND-ROAD taxing boundary of road district
 L BND-SERV taxing boundary of counry service district
 L BND-MISC taxing boundary of miscellaneous districts
 L BND-LID boundary of local improvement districts
 L TAX-CODE tax code numbers

MISCELLANEOUS

L ZONING zone boundaries and identifiers
 L PARKS park name and related text
 L COUNTIES adjacent county name
 L INDEX-TX map identifier
 L HEADING map heading and referencnes
 L CITY-LIMIT actual service boundary and text for cities
 L RFD-LIMIT actual service boundary and text for rural fire districts
 L LANDMARK physical monuments
 L INDEX-BND map boundary

TOPOGRAPHIC TILES
SOURCE: CITY OF CORVALLIS MAPPING AND GIS

PRIORITY	AUTOCAD LAYERS	DESCRIPTION
TRANSPORTATION		
L	BRIDGE	bridges
L	DRVWY	driveways
L	DRVWY-GRV	gravel driveways
L	DW-G	gravel driveways
H	RD-N	names of roads
H	RD-PAVED	paved roads
L	RR	railroads
L	RR-N	name of railroads
H	ST-CL	centerline of streets
M	ST-G	gravel streets
H	ST-N	names of streets
H	ST-P	paved streets
L	SWDW-P	paved driveways
TOPOGRAPHY/ELEVATION		
H	CON-10	10 foot contour lines
H	CON-10D	10 foot contour lines
L	CON-2	2 foot contour lines
L	CON-2D	2 foot contour lines
H	CON-TEXT	elevation of contour lines
L	ELEV	elevations at selected points
L	TOPOTEXT	miscellaneous topographic text
HYDROLOGIC FEATURES		
M	MARSH	boundaries of marshes
M	POND	boundaries of ponds
H	RIVER	boundaries of channels
H	STREAM	boundaries of stream banks
H	STREAM-N	name of streams
M	SWAMP	boundaries of swamps
MAN-MADE FEATURES		
M	BUILD	building footprints
L	CULVERT	culverts
L	DAM	dams
L	DITCH	ditches
L	FENCES	fences
L	GUARDRAIL	guardrails
L	HYDRANT	fire hydrants
L	MH	manholes
H	PATH	paths
L	STORM	storm drains
H	TRAIL	trails
L	WALL	retaining walls
L	RETAIN	retaining walls

CARTOGRAPHIC FEATURES

L	CONTROL	control points from air photos
L	COORD	eastings/northings State Plane Coordinates
L	GRID	base grid for topo tiles
L	MATCH	which topo tiles match along edges
L	PHOTOCENTER	center of air photos

VEGETATION

H	VEG	presence of vegetation
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MISCELLANEOUS

L	MISCPOST	miscellaneous posts
L	SYMBOLS	miscellaneous symbols
L	TEXT	miscellaneous text

ITEMS IN PARCEL.PAT

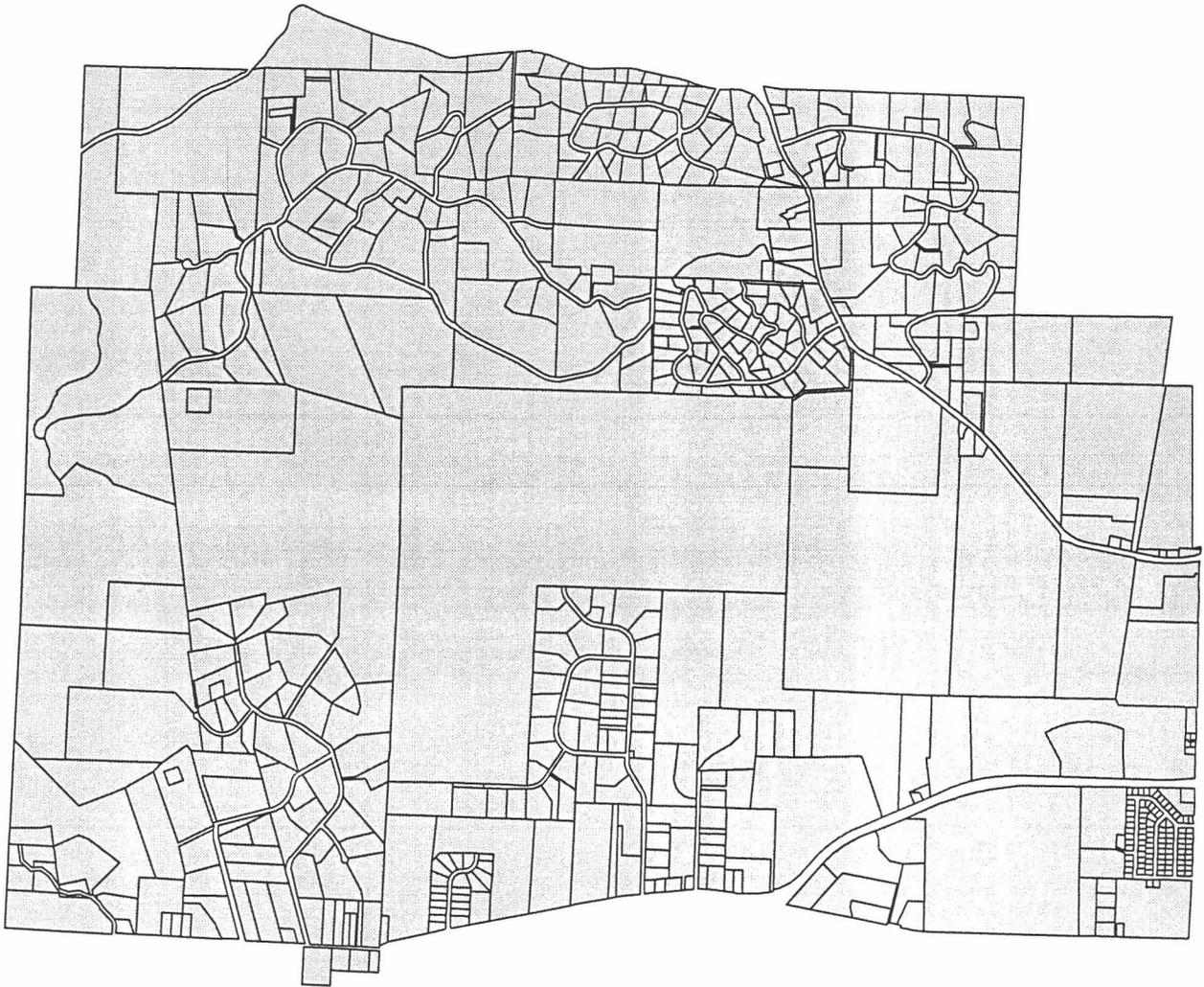
Source: City of Corvallis GIS and Mapping

Item	Length	Type*
\$RECNO	13	N
AREA	13	N
PERIMETER	11	N
PARCEL_	11	N
PARCEL_ID	11	N
ACAD_HAND	11	C
ACCT_	11	N
ACRES	11	N
ADDR1	32	C
ADDR2	32	C
AGENT	32	C
CITY	25	C
CLASS	6	C
CODE	4	C
CRDATE	9	C
DATE_ORIG	9	C
DEED_	10	C
EXTTLN	2	C
IMPVAL	12	N
IMPYR	11	N
LNDVAL	12	N
MAP	7	C
OBJN	11	N
OWNER	32	C
STATE	2	C
STREET	30	C
ST_NAME	20	C
ST_NMBR	15	C
ST_PFX	2	C
ST_TYPE	4	C
TLN	11	N
UNIT	5	C
ZIP	10	C
ZONE	25	C

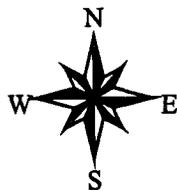
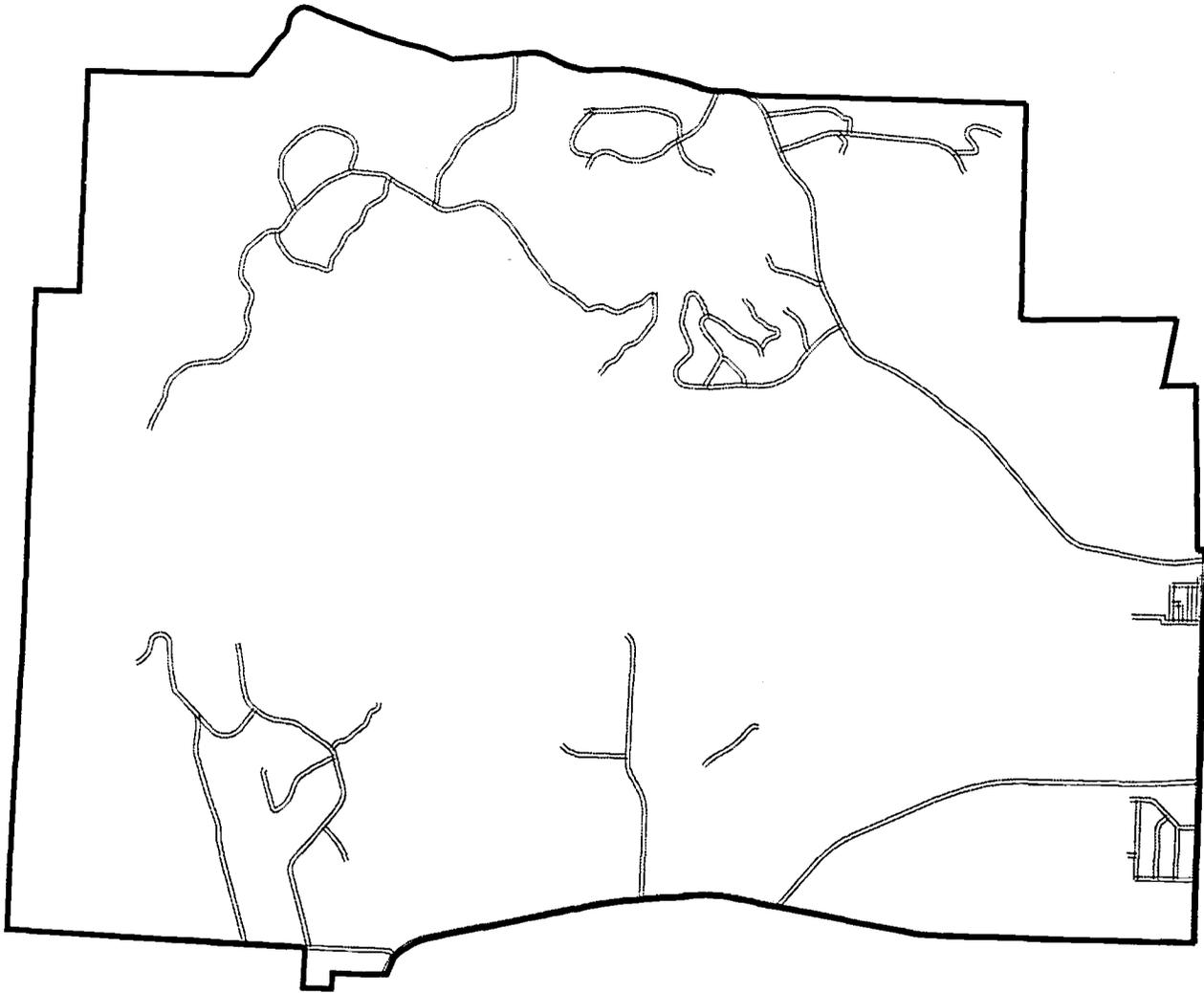
* (C=Character, N=Numerical)

Appendix B: ARC/INFO Coverages

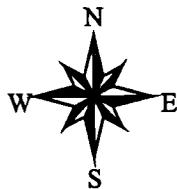
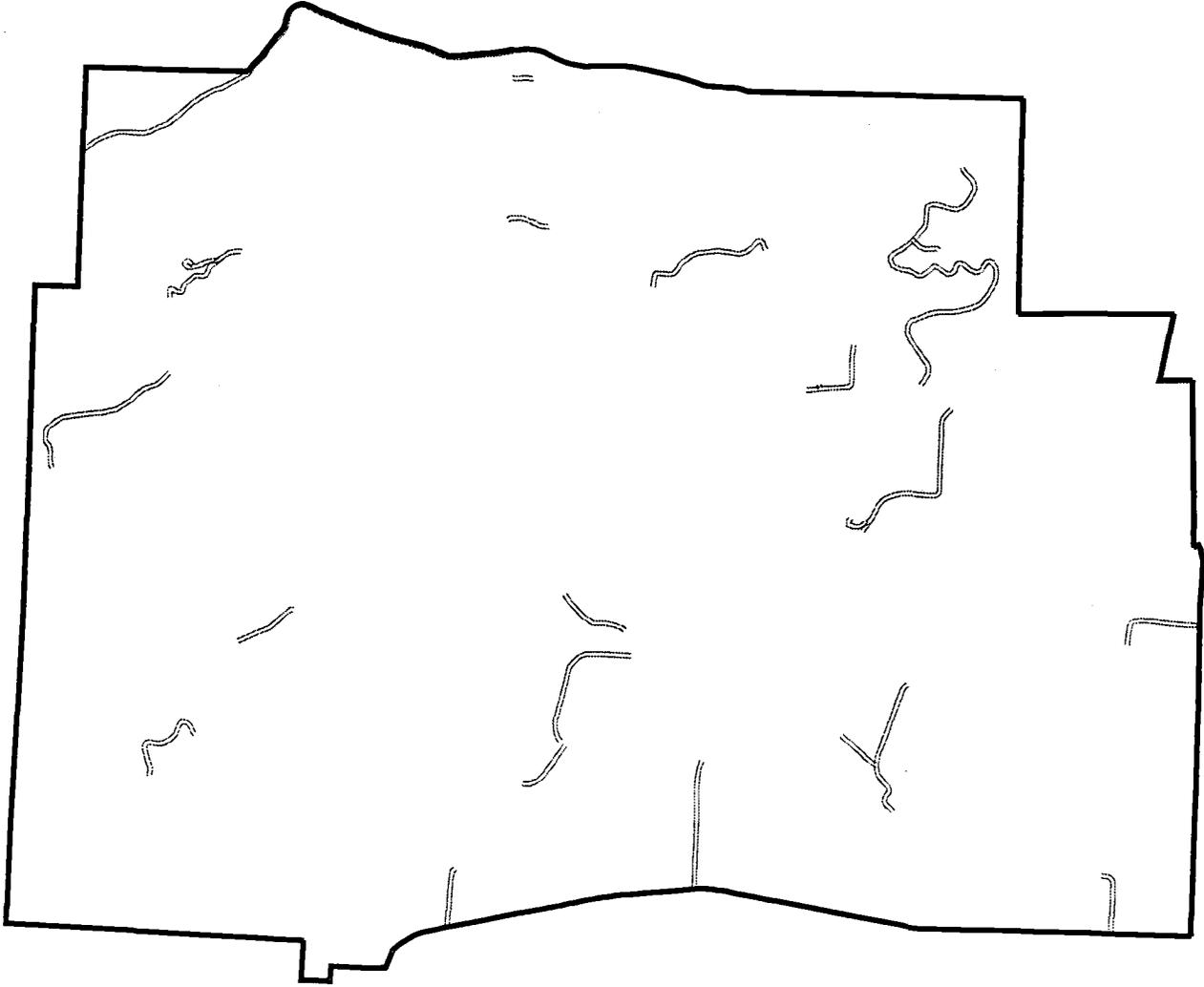
Parcel Coverage



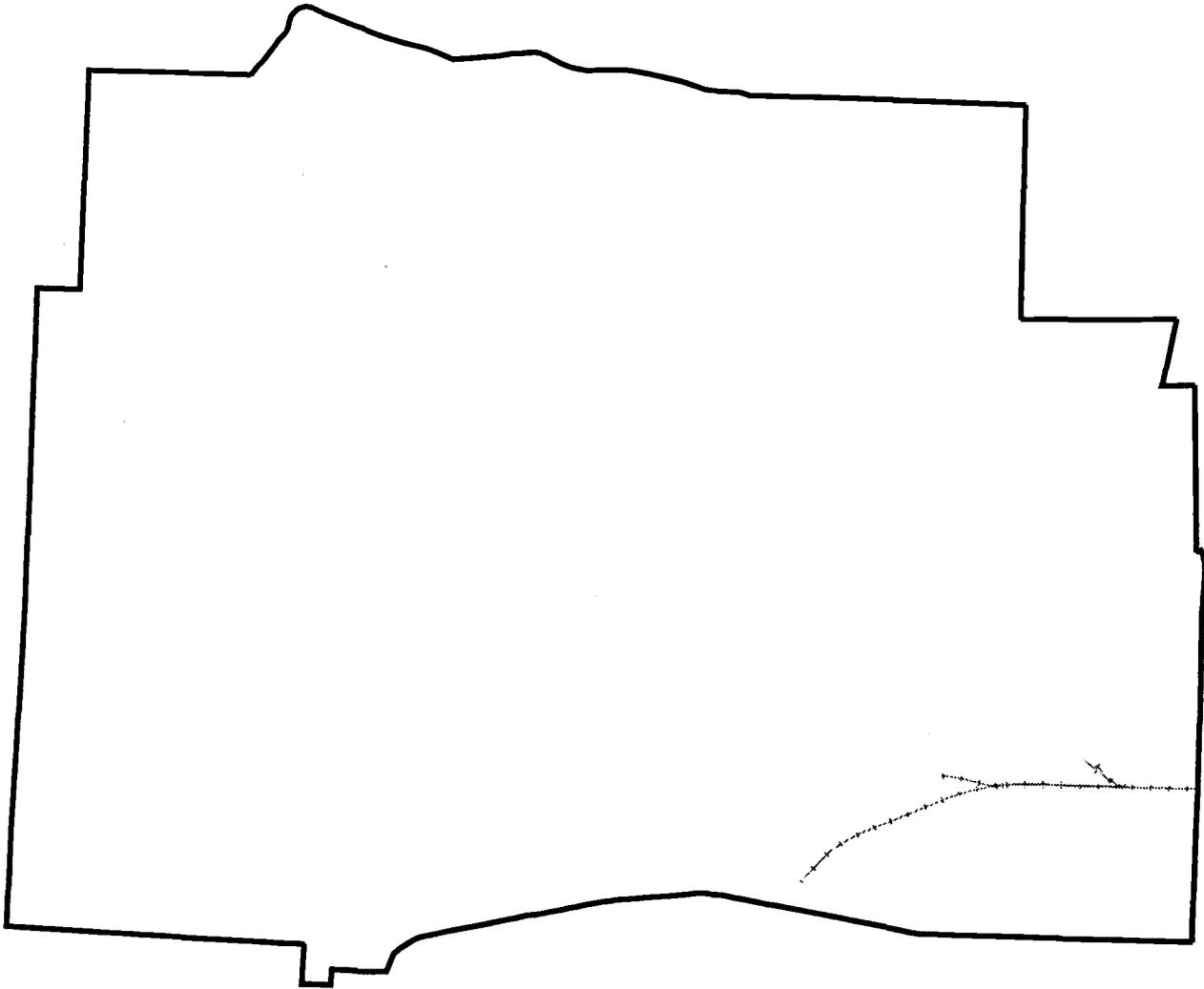
Road Coverage



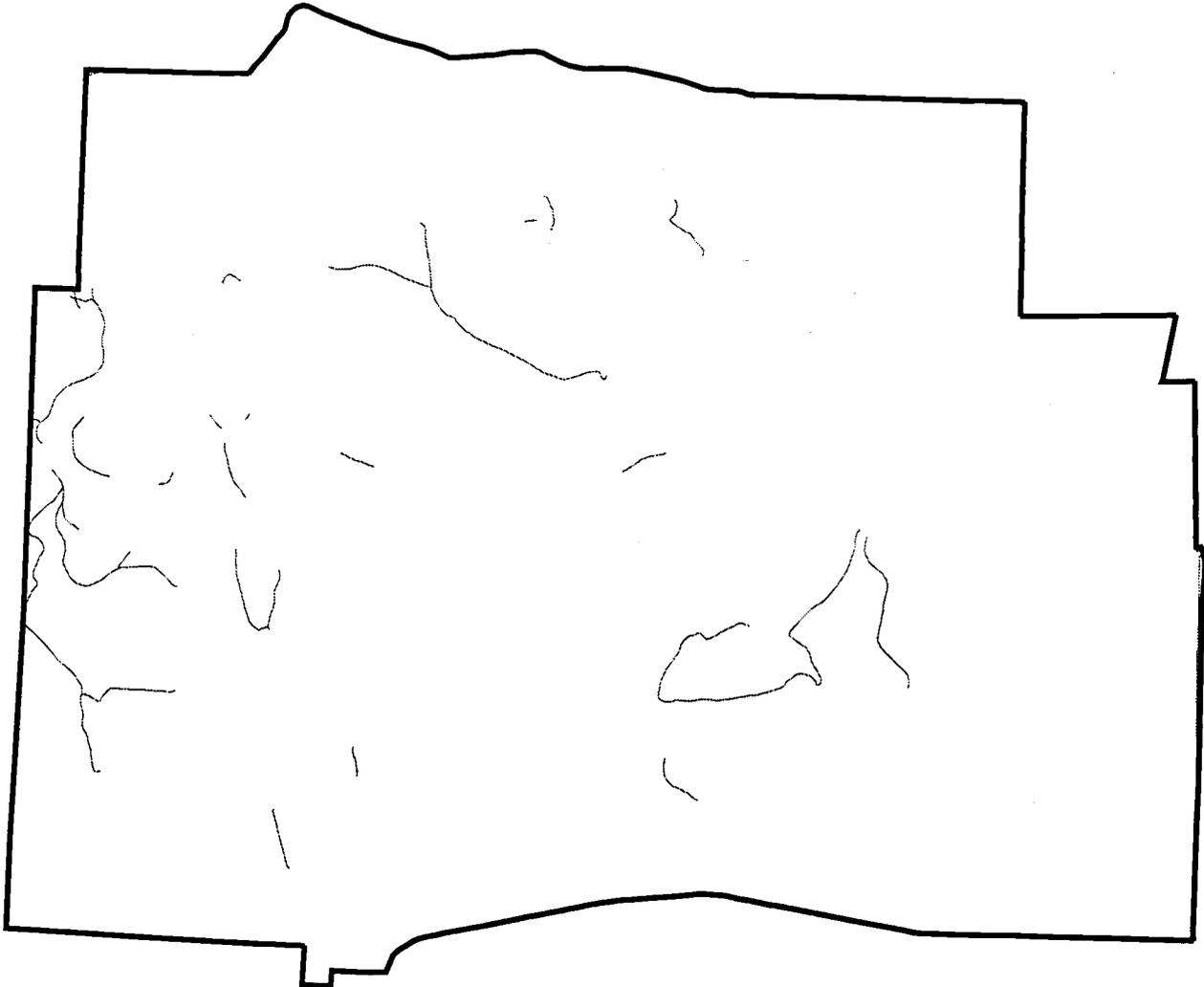
Gravel Road Coverage



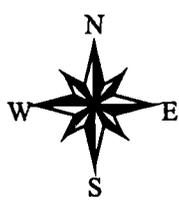
Railroad Coverage



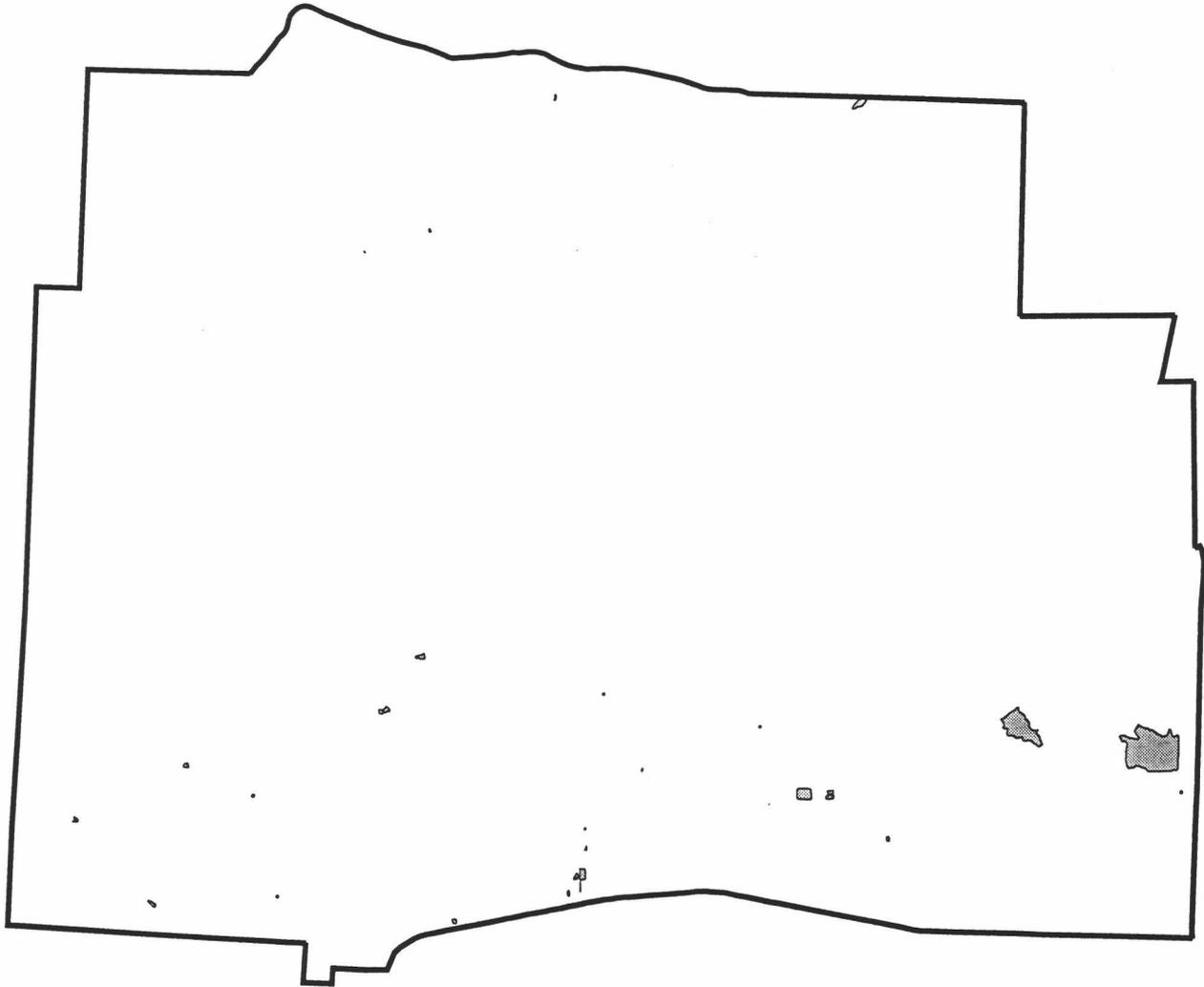
Trail Coverage



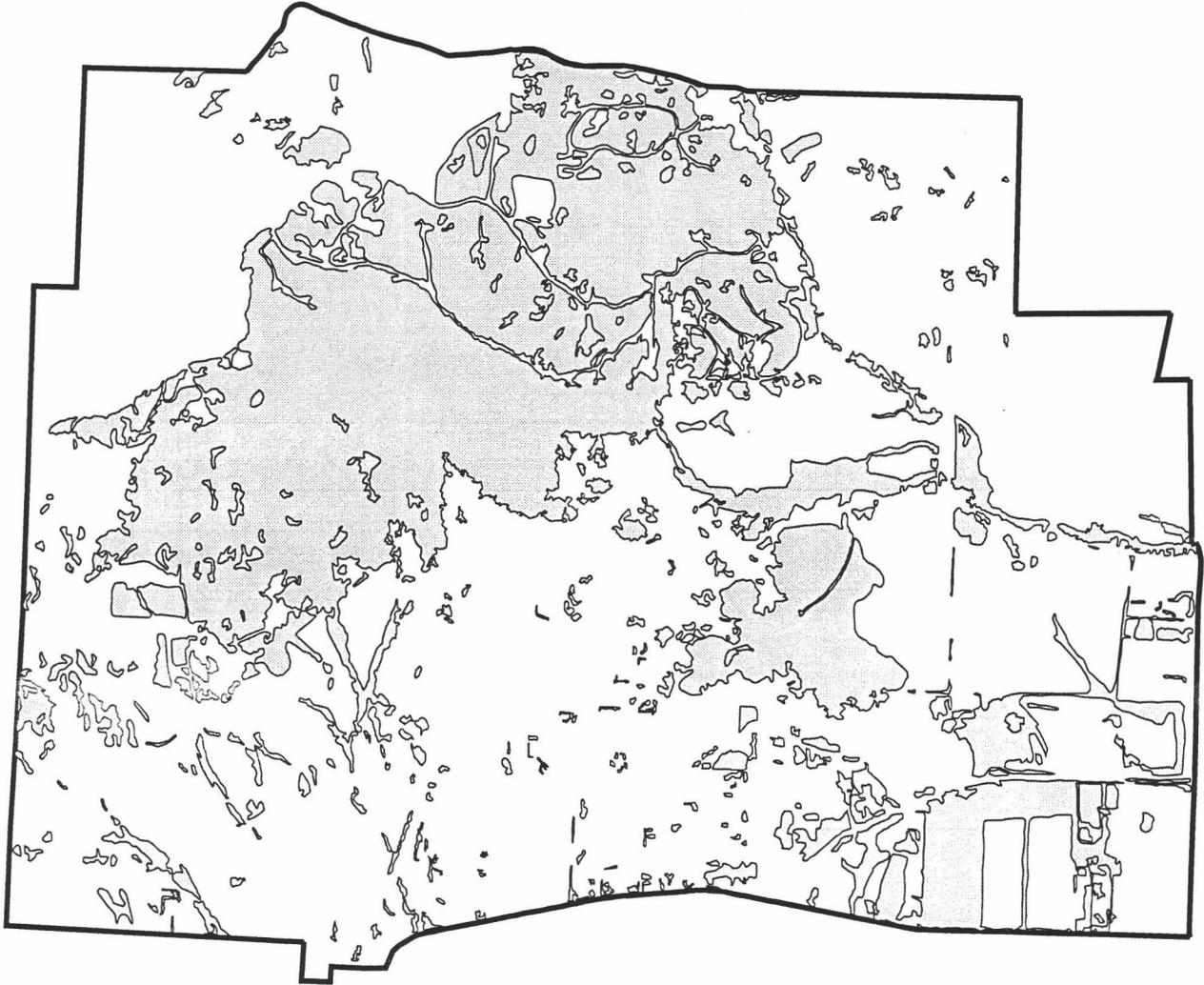
Stream Coverage



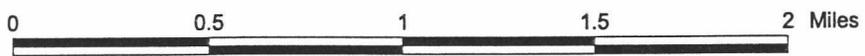
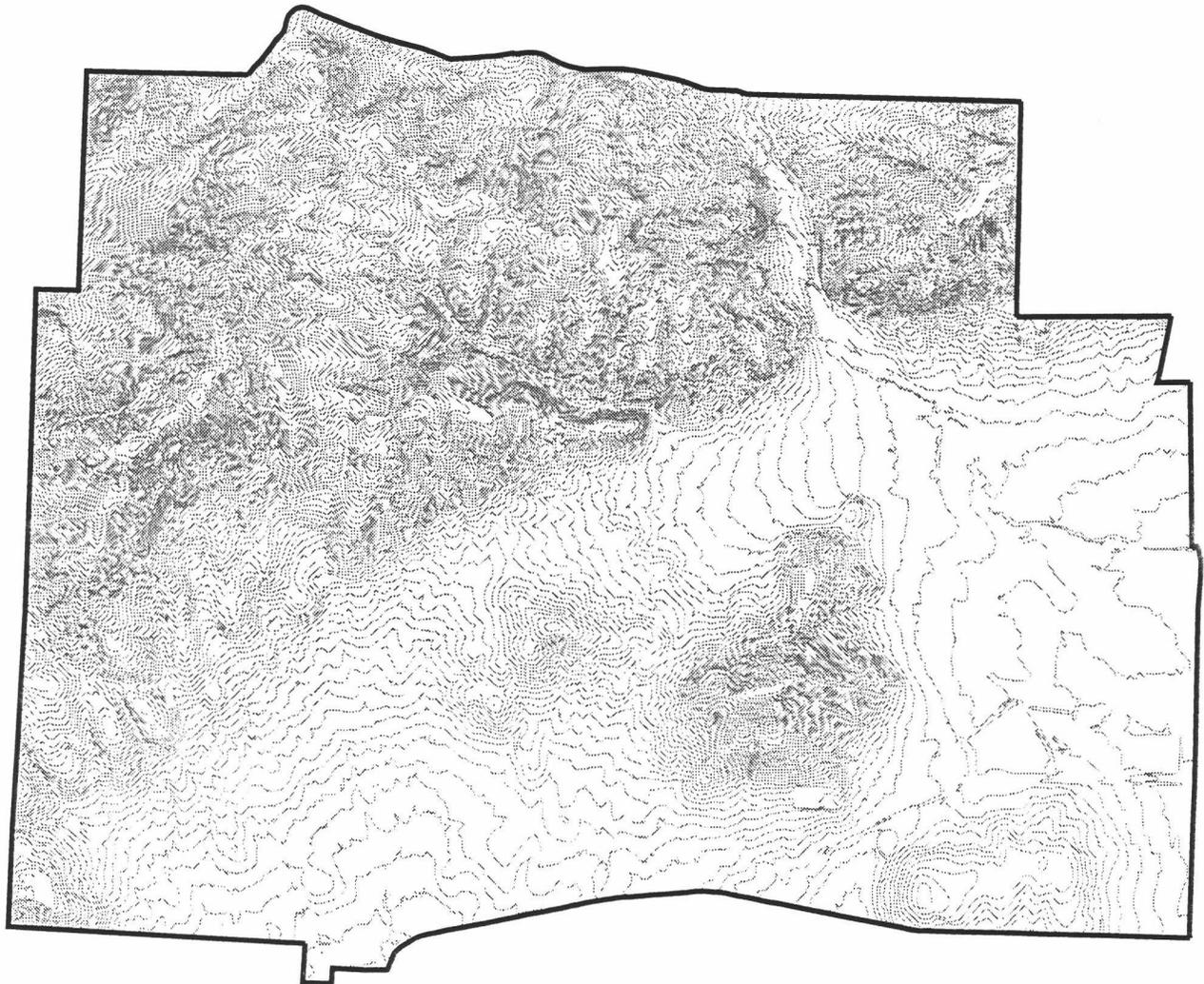
Wetland Coverage



Vegetation Coverage



Topography (10 Foot Contours) Coverage



Appendix C: Metadata Dictionary

Coverage: **CON_10**
Type: Lines
Source: City of Corvallis Mapping and GIS
Projection: State Plane Coordinates NAD27
Description: 10 foot contours lines
Comments: The lines were very fragmented, so they were connected in AutoCAD. There are no z-values associated with the contours.

Coverage: **GRAVEL**
Type: Lines
Source: City of Corvallis Mapping and GIS
Projection: State Plane Coordinates NAD27
Description: Centerlines of gravel and unpaved roads
Comments: Gravel roads were shown with double lines in AutoCAD, so centerlines were drawn in by hand in AutoCAD

Coverage: **PARCELS**
Type: Polygon
Source: City of Corvallis Mapping and GIS, Benton County GIS Dept.
Projection: State Plane Coordinates NAD27
Description: Parcel boundaries with attributes regarding owner, value, size, etc. for most parcels
Comments: This coverage was created by adjusting the county data from the State Plane Coordinates NAD83 to NAD27. Then the data from the two different sources could be joined. The county data has no attributes

Coverage: **RAILRDS**
Type: Lines
Source: City of Corvallis Mapping and GIS
Projection: State Plane Coordinates NAD27
Description: Railroad tracks
Comments:

Coverage: **ROADS**
Type: Lines
Source: City of Corvallis Mapping and GIS
Projection: State Plane Coordinates NAD27
Description: Centerline of paved roads and streets
Comments: The centerlines were missing from some roads, so they were drawn in freehand in AutoCAD

Coverage: **STREAM**
Type: Lines
Source: City of Corvallis Mapping and GIS
Projection: State Plane Coordinates NAD27
Description: Streams and rivers
Comments:

Coverage: **TRAIL**
Type: Lines
Source: City of Corvallis Mapping and GIS
Projection: State Plane Coordinates NAD27
Description: Trails and paths
Comments:

Coverage: **VEG**
Type: Polygons
Source: City of Corvallis Mapping and GIS
Projection: State Plane Coordinates NAD27
Description: Shows the presence/absence of vegetation
Comments: This coverage tells nothing about the types of vegetation

Coverage: **WETLAND**
Type: Polygons
Source: City of Corvallis Mapping and GIS
Projection: State Plane Coordinate NAD27
Description: Ponds, Marshes, and Swamps
Comments: This coverage was created by combining the pond, marsh, and swamp layers from AutoCAD