LESSON 1

GIS Concepts

Formal Definition of a GIS

•An organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information.

Simple Definition of a GIS

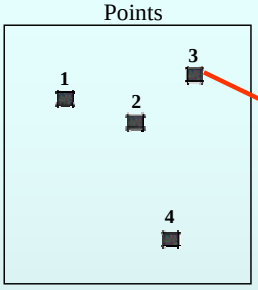
•A computer system capable of holding and using data describing places on the earth's surface.

Geographic Database

- A GIS doesn't hold maps or pictures - it holds a database.
- In a GIS you need to know three things about every feature stored in the computer:
  - What it is
  - Where it is
  - How it relates to other features

Spatial to DataBase

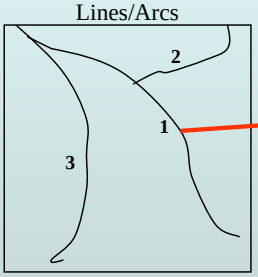
Points



SURFACE WATER MONITORING

ID	LOCATION-ID	WATER LEVEL	Ph	TDS
1	MW-3	1353.6	7.3	378
2	MW-55	1287.4	6.4	477
3	MW-36	1466.7	5.6	965
4	MW-14	1147.2	6.3	892

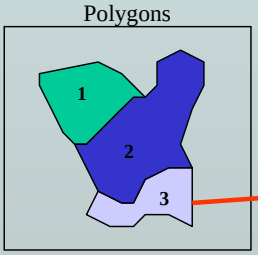
Lines/Arcs



ROADS

ID	LENGTH	SURFACE	TYPE
1	5378.3	GRAVEL	ANCILLARY
2	12458.6	DIRT	TRAIL
3	8244.9	PAVED	PUBLIC

Polygons



TOPSOIL

ID	MAPUNIT	SALVAGE_DEPTH
1	21	3.6
2	16	2.8
3	43	0.0

Questions a GIS can answer

- Location - What is at ….? (What exists at a particular location)
- Condition - Where is it? (Find a location where certain conditions are satisfied)
- Trends - What has changed since …? (Find the differences within an area over time.)
- Patterns - What spatial patterns exist? (e.g., where are acid mine seeps appearing with respect to a certain geology.)
- Modeling - What if…? (How will the hydrologic structure be affected if certain slopes are increased.)

GIS in Mining & Reclamation

- Permit Boundaries
- Roads
- Disturbed Areas
- Track Areas under Bond Release
- Acid Mine Release Locations
- Seeding
- Grading
- Topography - Premine, Existing & Postmine
- Monitoring Sites - Air, Surface Water, Blasting, etc.
- Imagery - Aerial, Space, DRGs, Photographs, etc.
- Topsoil
- Hydrology

GIS vs CAD

CAD systems were originally developed for engineers, architects, and other design professionals who needed more efficient means to create and revise precise drawings of machine parts, construction plans, and the like. CAD data consist of digital features, each of which is composed of a set of point locations. Calculations of distances, areas, and volumes can easily be automated once features are digitized. CAD systems typically do not encode attribute data in forms that support spatial queries. CAD systems would be useful for depicting the roads, property boundaries, and facilities footprints of a mine. A typical CAD system could not automatically shade each polygon based on certain values in a database.

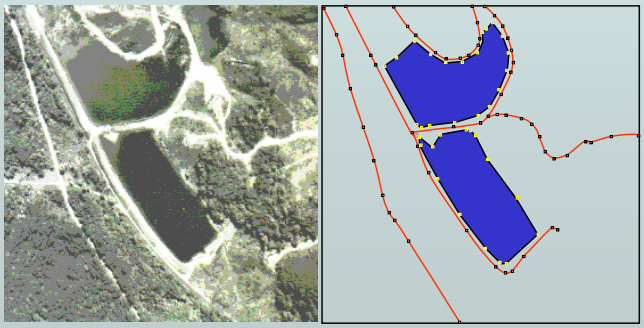
GIS specializes in helping users transform geographic data into geographic information. GIS is a decision support tool that combines the attribute data handling capabilities of relational database management systems with the spatial data handling capabilities of CAD and desktopmapping systems. GIS enables decision makers to identify locations or parcels whose attributes match multiple criteria, even though entities and attributes may be encoded in many different data files.

General GIS Concepts

•There are two general strategies for representing locational data in digital form: **vector and raster**.

Each represents some kinds of geographic phenomena better than other kinds.

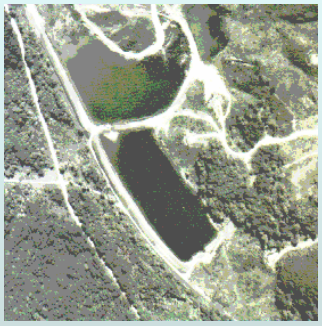
•The vector strategy involves using positions to approximate the shapes of real world entities. Entities may be represented by point features, line features, and polygon features. Line and polygon features are made up of points sampled at intervals along the length of linear entities (like roads), or around the perimeter of areal entities (like water bodies). When connected by lines, the sampled points form line features and polygon features that approximate the shapes of their real- world counterparts.

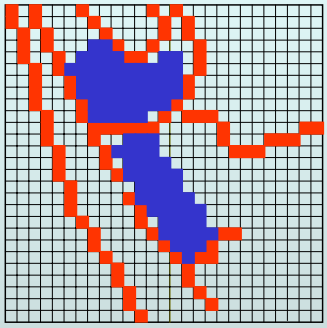


A vector representation of roads and ponds.

Vector strategy is well suited to mapping entities with well-defined edges, such as roads, permit boundaries, and contour lines.

•The raster approach involves sampling attributes at fixed intervals. Each sample represents one cell in a checkerboard-shaped grid. Raster data consists of a list of numbers, one number for each grid cell, each number representing an entity. For example, grid cells that represent the road might be represented with the number "1" and grid cell representing the pond might be coded with the number "2".





A raster representation of ponds and roads.

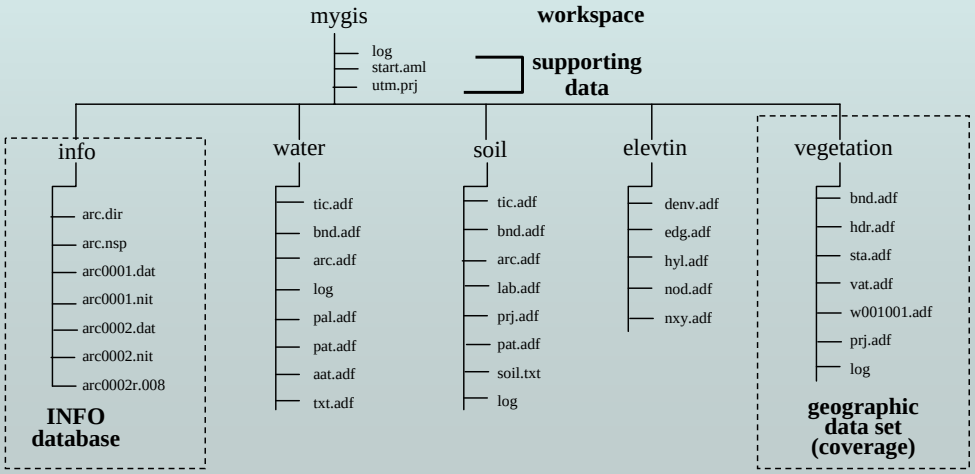
The raster data model is a smart choice for representing features that lack clear-cut boundaries, such as vegetation and precipitation.

•Raster models are very dependent on the density of the grids for accuracy - known as grid resolution

GIS Data Formats

•An ARCINFO *workspace* is a work area used during an ARCINFO session. Within the computer file system, the workspace is a directory containing one or more geographic data sets (e.g., coverage, tin, grid), a local INFO database, and other supporting data.

•Coverage - The *coverage* is the framework for vector data storage in ARCINFO Workstation. It generally represents a single set of geographic objects such as roads, parcels or soil units in a given area. A coverage supports the georelational model - it contains both the spatial (location) and attribute (descriptive) data for geographic features.



•Shapefiles - native to ArcView - *shapefiles* are a simple, **non-topological format** for storing the geometric location and attribute information of geographic features. The shapefile format defines the geometry and attributes with specific file extensions that must be stored in the same project directory/folder. These files are:

.shp - the file that stores the feature geometry. *Required*

.shx - the file that stores the index of the feature geometry. *Required*

.dbf - the dBASE file that stores the attribute information of features. *Required*

.sbn and **.sbx** - the files that store the spatial index of the features. *Optional*

.fbn and **.fbx -** the files that store the spatial index of the features for shapefiles that are read-only. *Optional*

.ain and **.aih** - the files that store the attribute Index of the active fields in a table or a theme's attribute table. *Optional*

.prj - the file that stores the coordinate system information. *Optional*

.xml - metadata for ArcInfo 8.x, for using shapefiles on the Internet. *Optional*

•GRID - A proprietary ESRI format that supports 32-bit integer and 32-bit floating-point raster grids. Grids are useful for representing geographic phenomena that vary continuously over space and for performing spatial modeling and analysis of flows, trends, and surfaces such as hydrology.

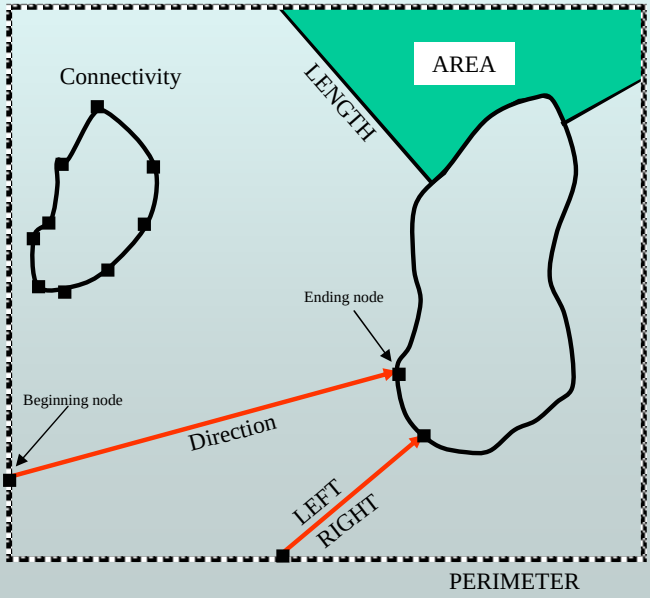
•TIN - A TIN dataset contains points with x, y, and z values and a series of edges joining these points to form triangles. The triangular mosaic forms a continuous faceted surface, which can be used to analyze and display terrain and other types of surfaces. TINs offer an alternative to the raster data model for representing surfaces.

•DXF - Graphics data in DXF format includes engineering blueprints, geographic data, or symbol drawings from an AutoCAD application. DXF files are treated as map entities which can be scaled and rotated.

•TIFF (Tag Image File Format) - A standard bitmap interchange format for data storage and data transfer across operating systems. A lot of image data, such as digital photo, scanned images, and aerial/satellite imagery, takes advantage of this format.

•Geodatabase - Geodatabases organize geographic data into a hierarchy of data objects. These data objects are stored in feature classes, object classes, and feature datasets. An object class is a table in the geodatabase that stores nonspatial data. A feature class is a collection of features with the same type of geometry and same attributes.

Topology
(Defining Spatial Relationships)



- Spatial properties of topology
  - Length
  - Direction
  - Area
  - Perimeter
  - Connectivity
  - Adjacency

Each arc has a beginning node and an ending node. - Length of arc and Directionality

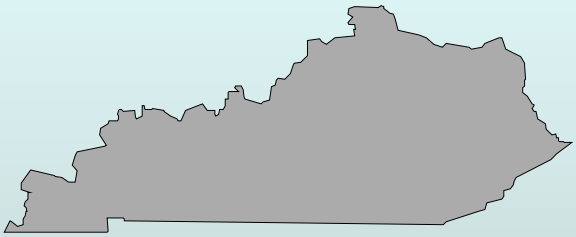
Arcs connect to other arcs at nodes - Connectivity

Connected arcs form polygon boundaries - Area of polygon and Perimeter of polygon

Arcs have polygons on their left and right sides - Adjacency

Map Projections

•Sphere (globe)
Three-dimensional



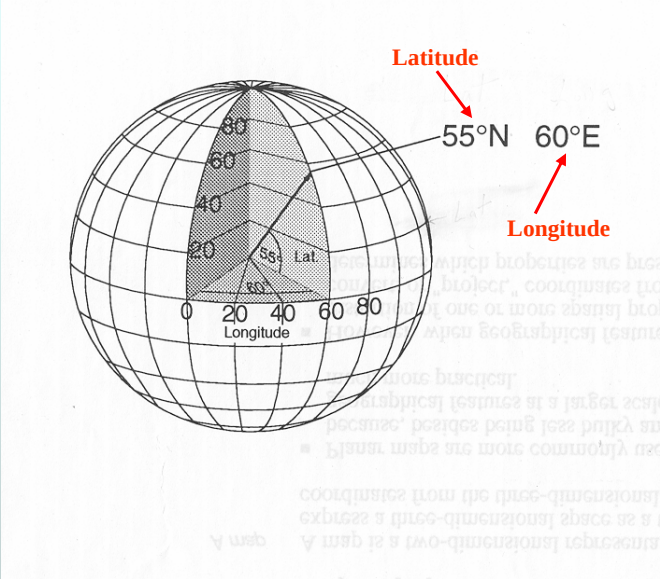
•Plane (map)
Two-dimensional

•Spatial properties include area, shape, distance, and direction.

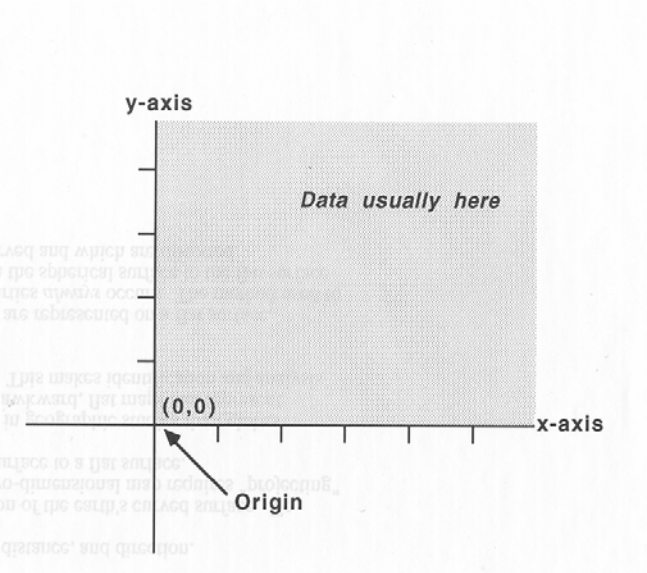
•When geographical features are represented on a flat surface, distortion of one or more spatial properties *always* occurs.

•The method used to convert, or "project" , coordinates from the spherical surface to the flat surface determines which properties are preserved and which are distorted.

Coordinate Systems

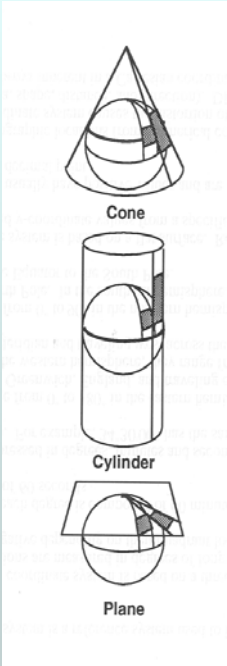


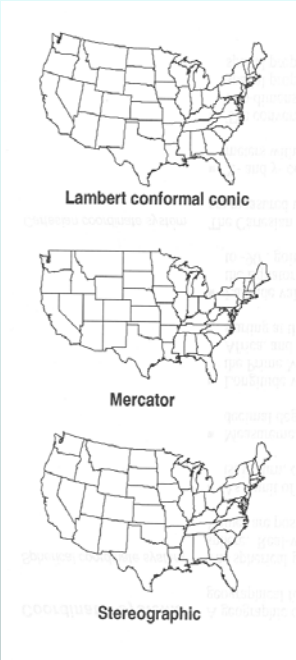
Spherical Coordinate System



Cartesian Coordinate System

Map Projections



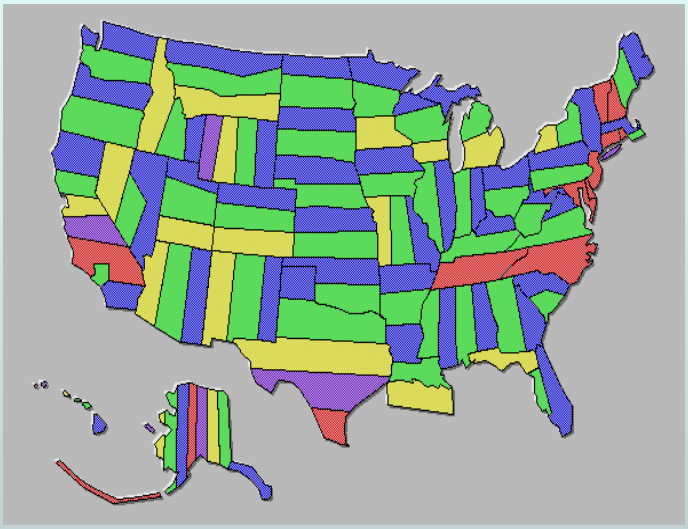


Projections are flat representations of the earth drawn on paper or displayed on a computer screen. They express a three-dimensional surface in two dimensions.

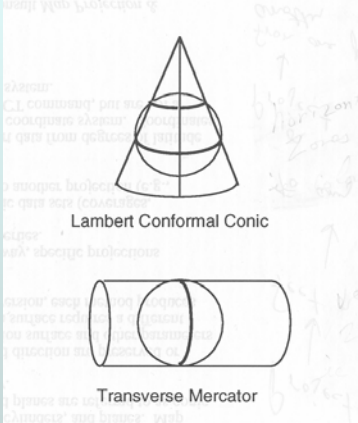
The spatial properties of shape, area, distance, and direction are preserved or distorted differently on maps based on the projection surface and other parameters of the projection.

Although all projections are distorted in some way, specific projections eliminate or minimize distortion of certain properties.

State Plane Coordinate System

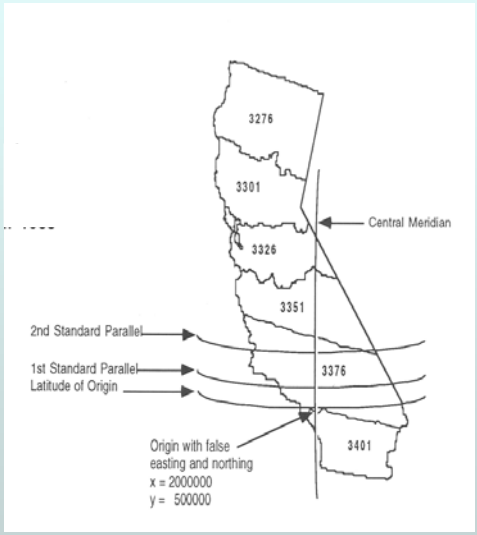


Each State is divided into one or more SPCS zones with a projection and a defined set of parameters which best suit that zone.



Commonly used projections

Example: State Plane Coordinate System for California



- Lambert conformal conic
- Six State Plane Zones
- North American Datum 1983

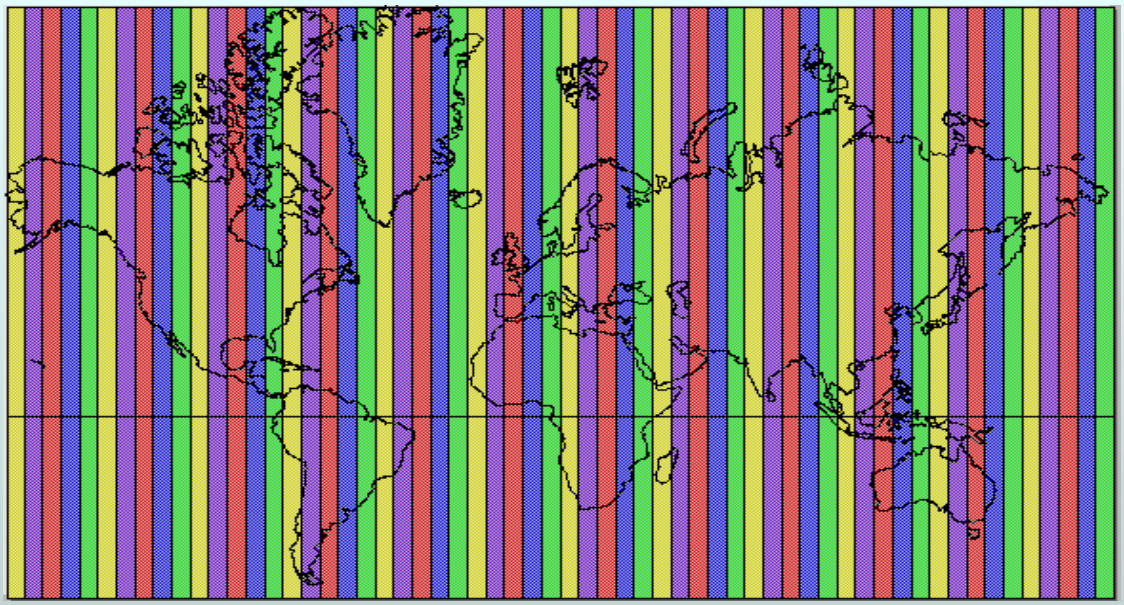
State Plane Zone	FIPS zone	1st standard parallel	2nd standard parallel	Central Meridian	Latitude of origin	False Easting	False Northing
3276	0401	40°00'00"	41°40'00"	-122°00'00"	39°20'00"	2000000	500000
3301	0402	38°20'00"	39°50'00"	-122°00'00"	37°40'00"	2000000	500000
3326	0403	37°04'00"	38°26'00"	-120°30'00"	36°30'00"	2000000	500000
3351	0404	36°00'00"	37°15'00"	-119°00'00"	35°20'00"	2000000	500000
3376	0405	34°02'00"	35°28'00"	-118°00'00"	33°30'00"	2000000	500000
3401	0406	32°47'00"	33°53'00"	-116°15'00"	32°10'00"	2000000	500000

California is divided into six zones, each having its own set of parameters. Zones are referenced with both a State Plane zone number and the Federal Information Processing Systems (FIPS) zone number.

California uses the Lambert conformal conic projection for its State Plane Coordinate Systems. To minimize spatial distortion, the Lambert conformal conic projection is constructed so that the cone intersects the earth at two line of latitude. Spatial distortion is minimized near lines of tangency.

- The two lines of tangency are called the 1st and 2nd parallels.
- The intersection of a meridian and a parallel define the origin for measurement within the coordinate system. These are called the central meridian and latitude of origin, respectively.
- Because the central meridian normally runs through the center of the area, arbitrary false x- and y- values (false easting/northing) are applied to the origin to ensure that all measurements throughout the zone are positive values.

Universal Transverse Mercator (UTM) Projection



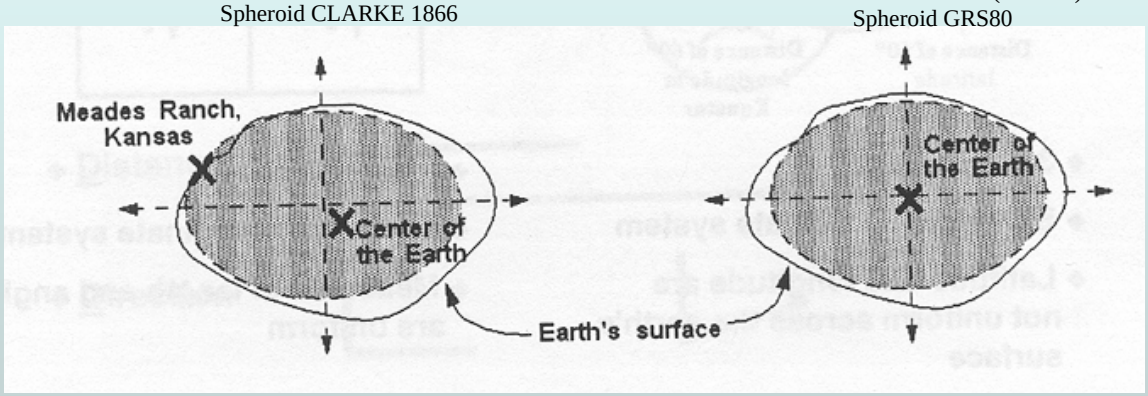
•Globe is divided into 60 zones, 6 degrees wide

•A separate Transverse Mercator projection is applied to each zone

Datums

•A frame of reference for measuring locations on the surface of the earth

•Maps in the same projection, using different datums can have very different coordinates



A datum is defined by a spheroid and that spheroid's position relative to the earth. There are two types of datums: earth-centered and local. An earth-centered datum has its origin placed at the earth's currently known center of mass and is more accurate overall. A local datum is aligned so that it closely corresponds to the earth's surface for a particular area and can be more accurate for that particular area.

GIS Functions

•Capture - A GIS must provide methods for inputing geographic (coordinate) and tabular (attribute) data.

•Store - A GIS should be able to store both vector and raster types of data.

•Query - A GIS must provide utilities for finding specific features based on their location or attribute values.

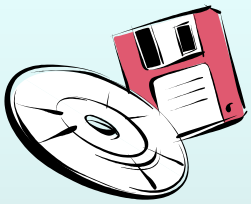
•Analyze - A GIS must have the ability to answer questions regarding the interaction of spatial relationships between multiple datasets.

•Display - There must be tools for visualizing the geographic features .

•Output - Results of display should be able to be output in a variety of formats.

Capturing Data

Paper maps

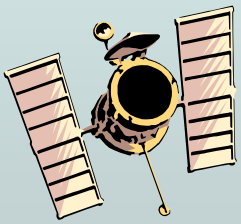


Digital data

GIS Data

1, 500345.56 889331.48
2, 500788.31 889511.73
3, 501048.82 889037.14
4, 500578.28 889901.63
5, 501147.69 888964.04
6, 500577.41 889789.04

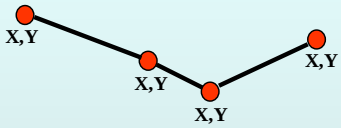
Coordinates



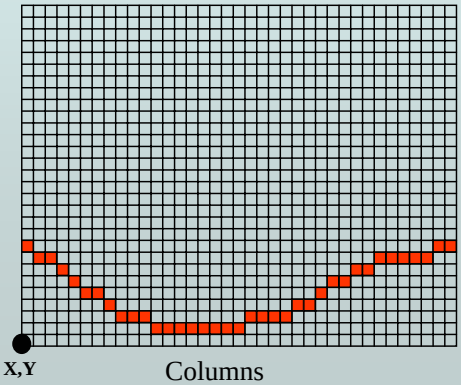
GPS

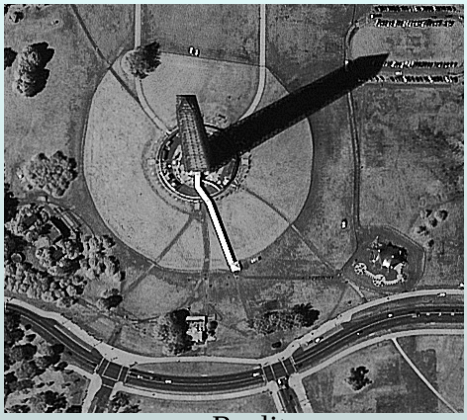
Storing Data

- Vector formats



- Raster formats
  - Use square cells to model reality

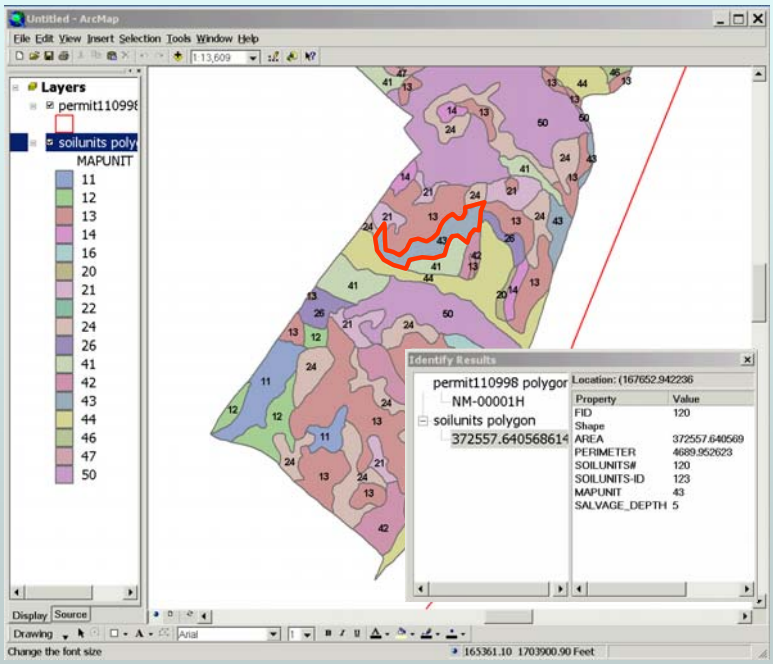




Reality
(A highway)

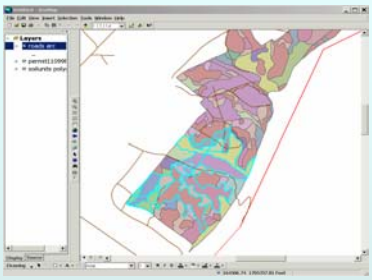
Query

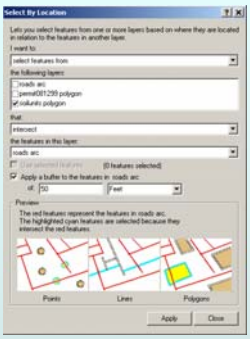
•Identifying specific features



Analysis

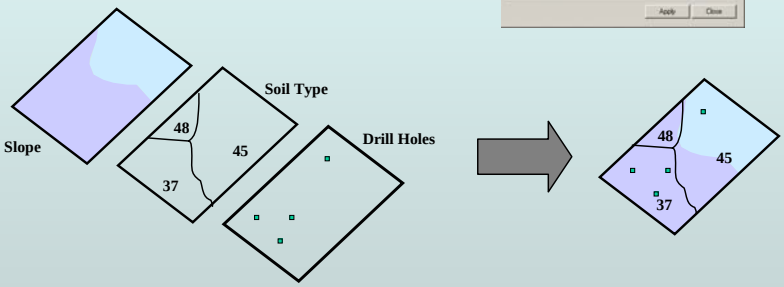
•Proximity



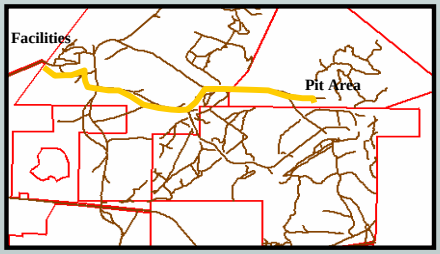


Which soil units are within 50’ of the selected road section.

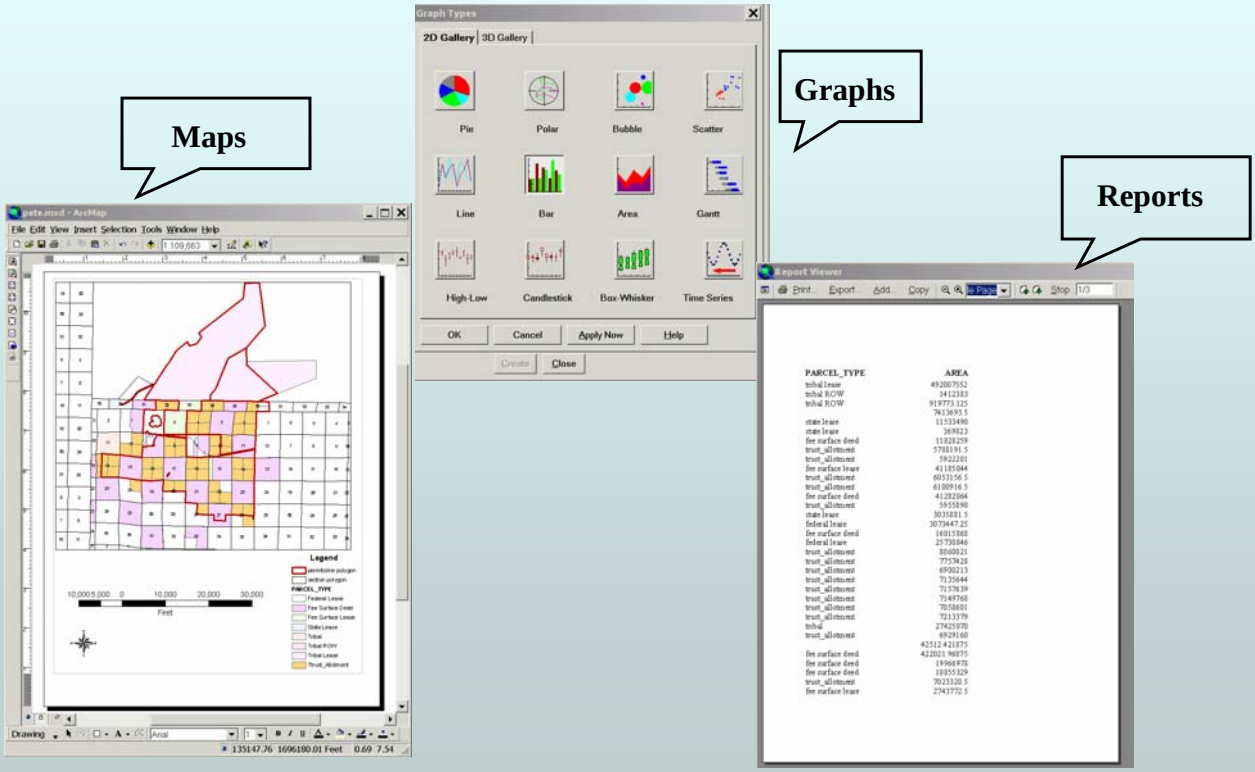
•Overlay



•Network



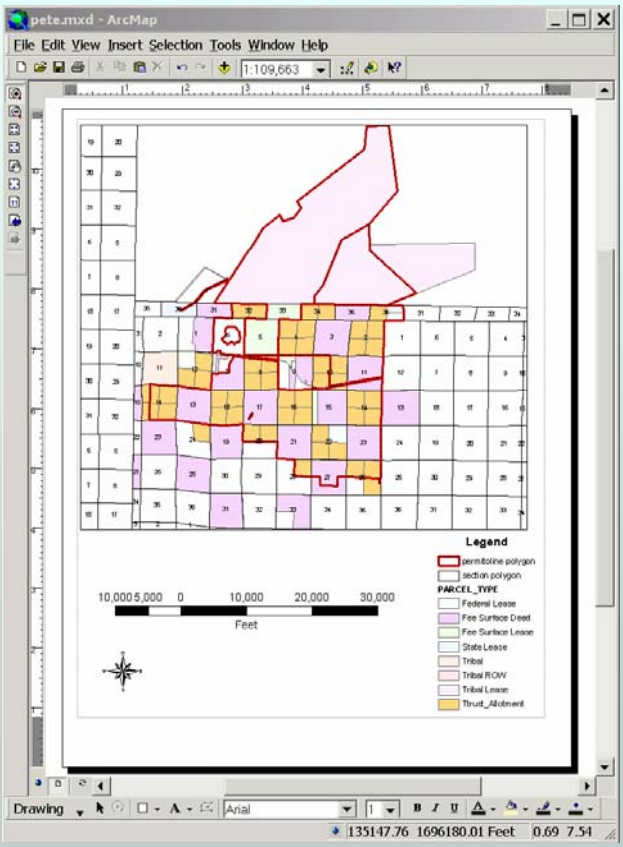
Display


Maps
Graphs
Reports
Graph Types
2D Gallery
3D Gallery
Pie
Polar
Bubble
Scatter
Line
Bar
Area
Gantt
High-Low
Candlestick
Box-Whisker
Time Series
OK
Cancel
Apply Now
Help
Close
Report Viewer
PARCEL_TYPE
AREA

Output

Paper Map

Internet



Embedded in Document

Image

Selected ESRI Products

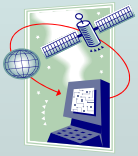
ArcGIS

ArcView 3.x

ArcExplorer (free)

ArcPress

Products noted in red are provided by TIPS



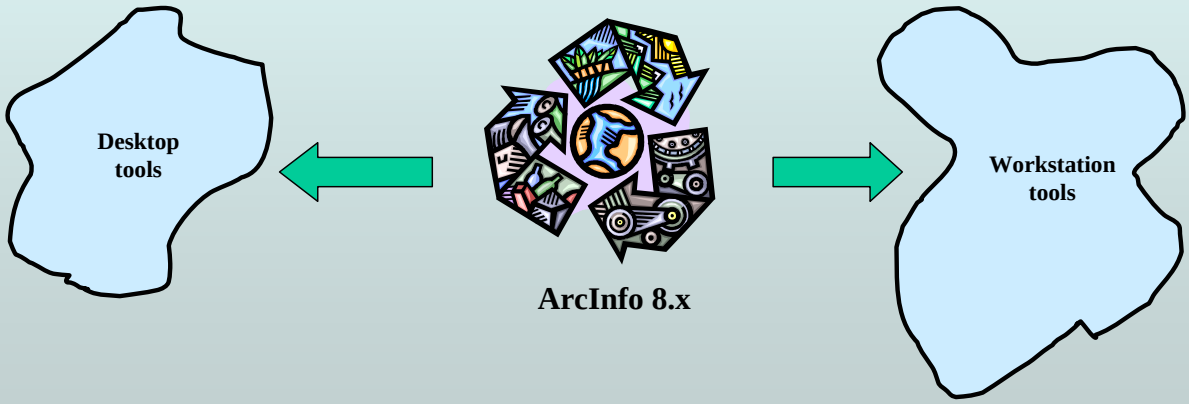
ArcPad

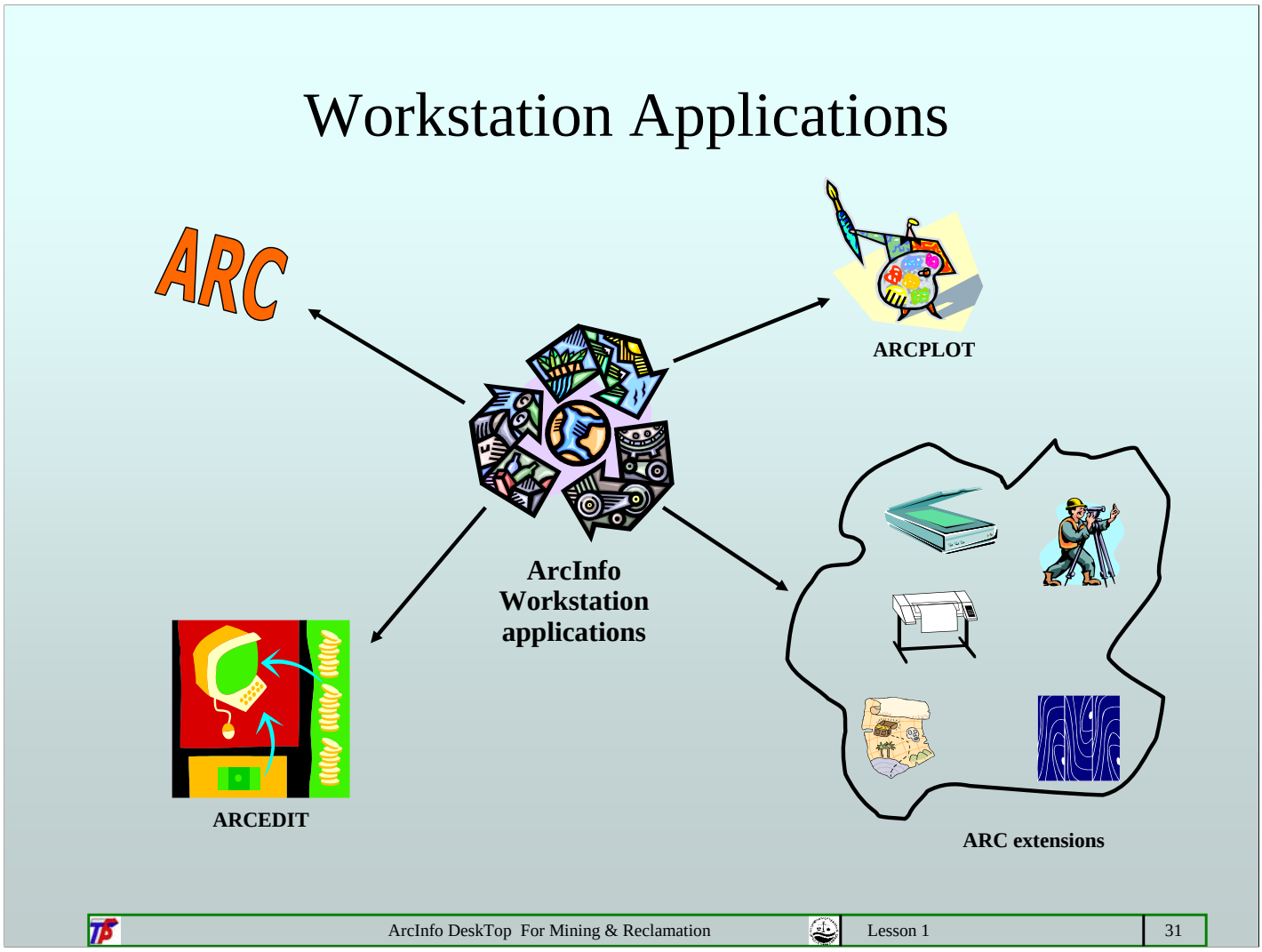
GIS database

- ArcView 8.x is a *light* version of ArcInfo 8.x - Much of the analytical, editing and non shapefile capability is turned off.
- ArcInfo Editor 8.x has more capability than ArcView 8.x - Still has much of the analytical capability turned off but can edit and display most data formats.
- Extensions - 3D Analyst, Spatial Analyst, ArcPress, Geostatistical Analyst, and StreetMap USA
- ArcInfo 8.x - Full capability plus all extensions.
- TIPS has 28 copies of ArcInfo 8.x with extensions available for the users.
- TIPS is currently doing R&D work on ArcSDE and ArcIMS

ArcInfo 8.x Overview

- Two primary applications in ArcInfo 8.x
  - Workstation (command line)
  - Desktop (windows based)
- Add-on Extensions





ARC - ARC is the overall GIS manager. ARC is used to generate and manage geographic data, convert data from other formats, manipulate data, and create relationships.

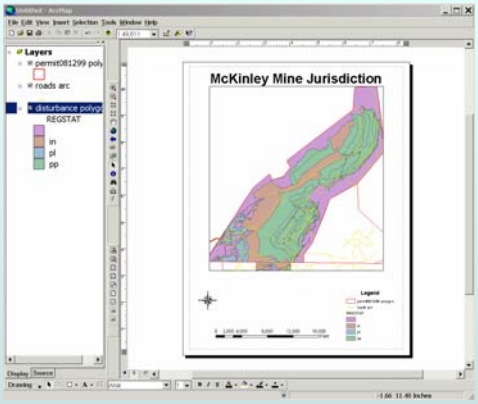
ARCPLOT - The graphic module for map display and query

ARCEDIT - The interactive graphics editor. Used to create and/or edit geographic data.

ARC INFO extensions - Add-on extensions designed for more specialized GIS tasks.

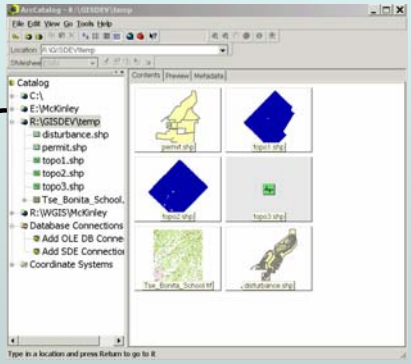
Desktop Applications

ArcMap



ArcToolbox

ArcInfo Desktop applications



ArcCatalog

ArcCatalog - Tool for browsing, organizing, distributing , and documenting you GIS data.

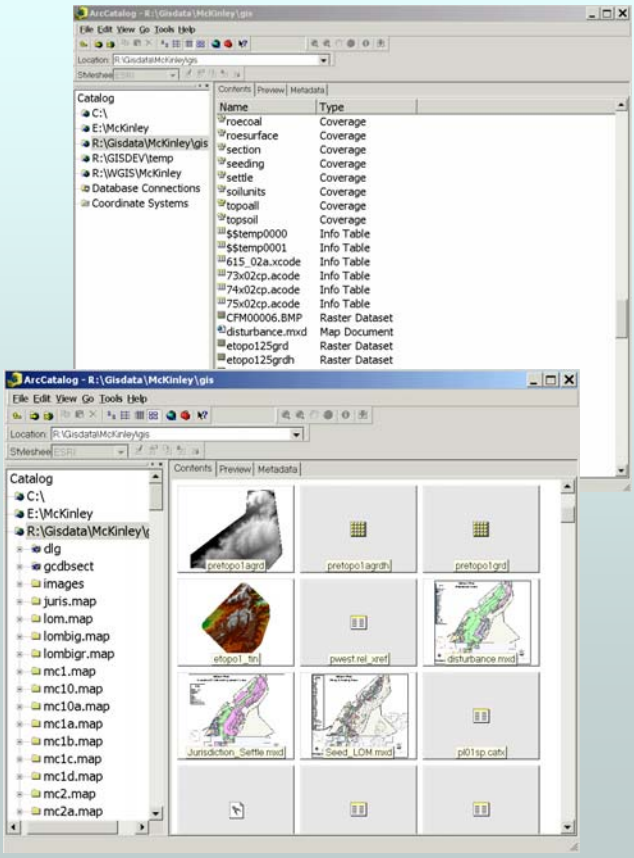
ArcMap - Tool for creating, viewing, querying, editing, composing, and publishing maps.

ArcToolbox - Tool for geographic data processing.

ArcCatalog

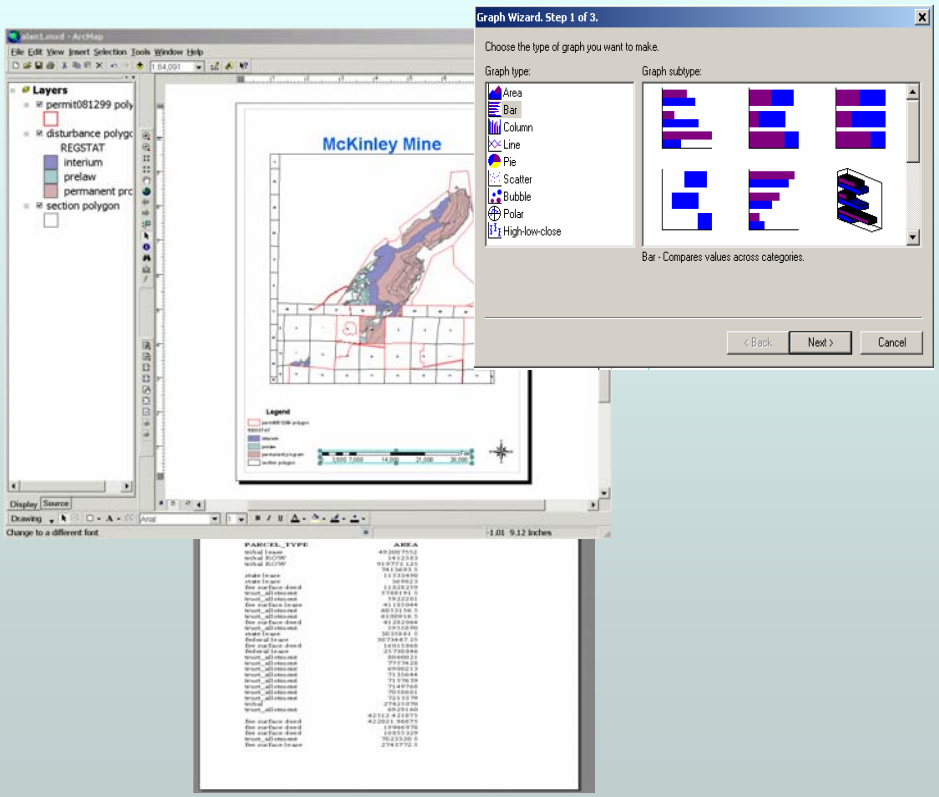
- **Browse your data**
  - **Graphical**
  - **Textual**
- **Manage your data**
- **Create, view data documentation**

  (metadata)



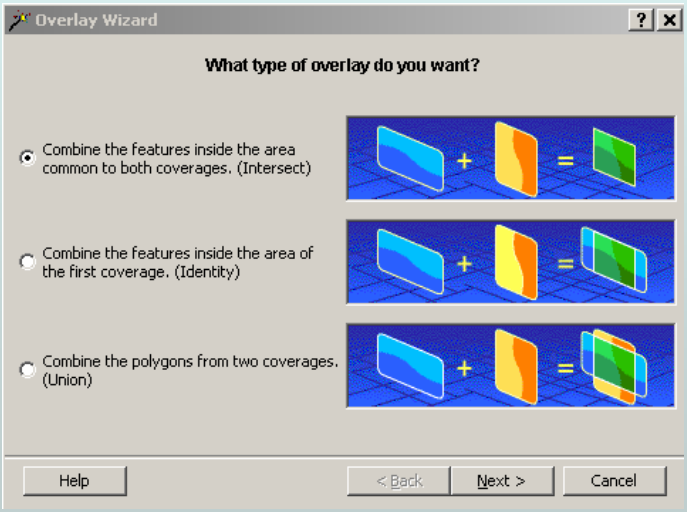
ArcMap

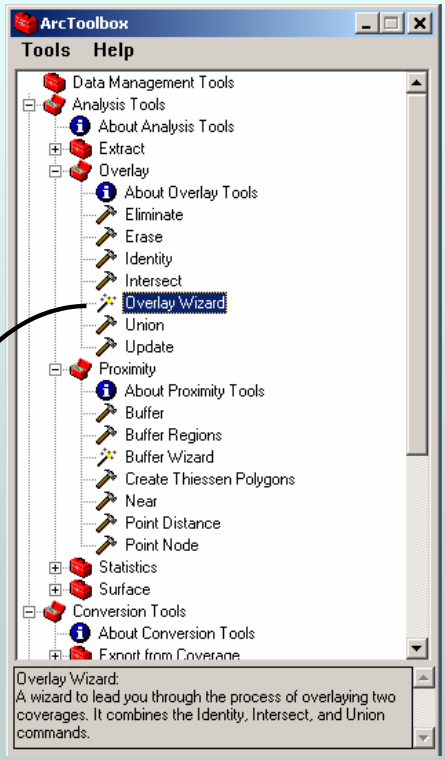
- **Perform map-based tasks**
  - **Mapping**
  - **Editing**
  - **Querying**
  - **Analyzing**
  - **Charting**
  - **Reporting**



ArcToolbox

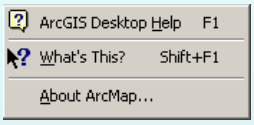
- **Tool tips**
- **Context sensitive help**
- **Documentation**

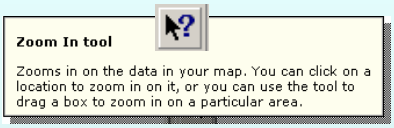


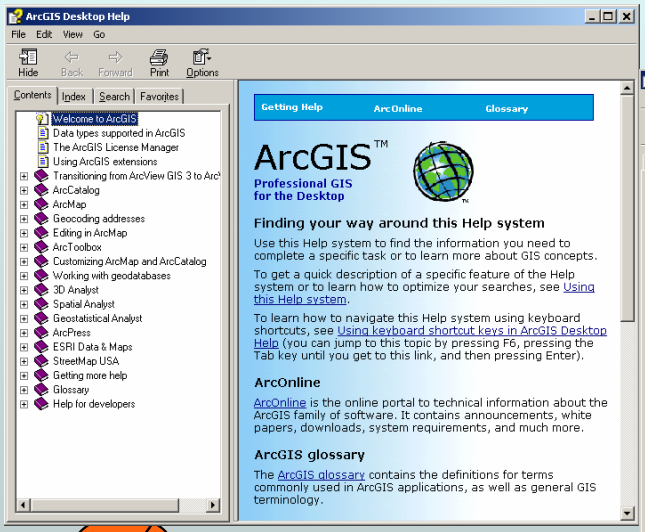


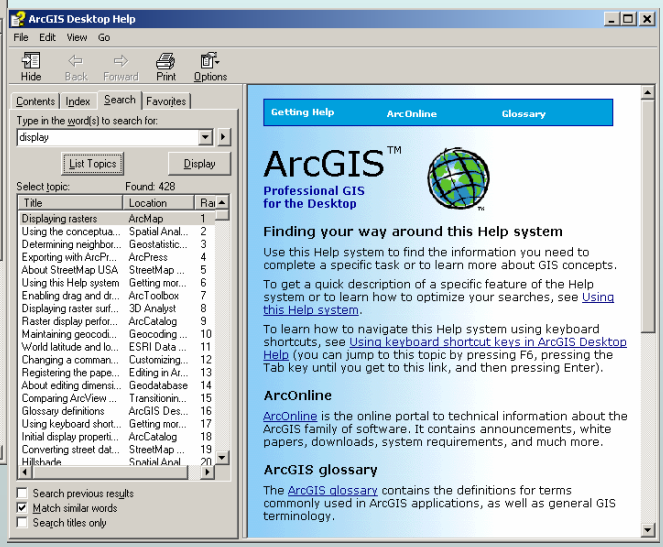
Getting Help

- **Tool Tips**
- **Context sensitive help (What's this?)**
- **Documentation**



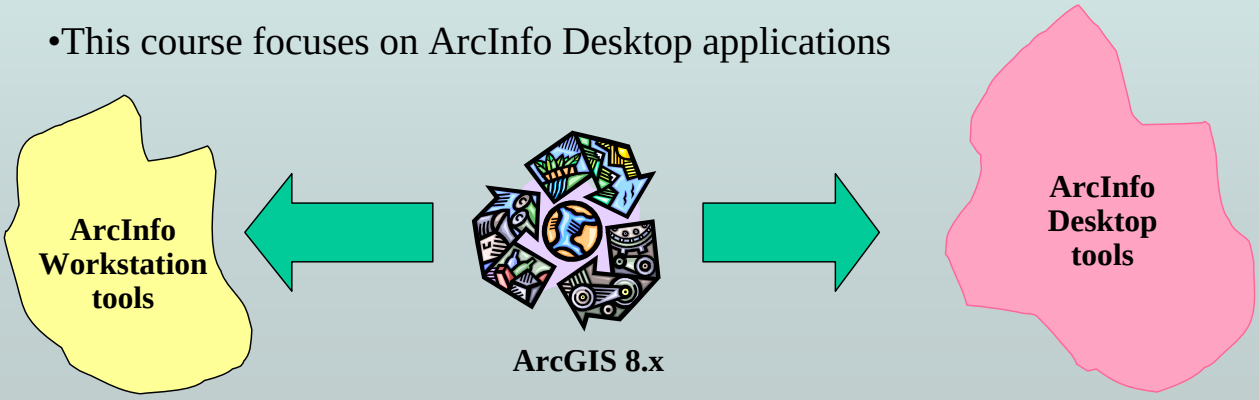






Summary

- Includes two toolkits: Workstation and Desktop
  - Both support data creation, management, analysis, and storage
  - Both can work with the same data, Desktop can handle additional data format types
  - Each has different operational interface
  - Each is customizable
- This course focuses on ArcInfo Desktop applications

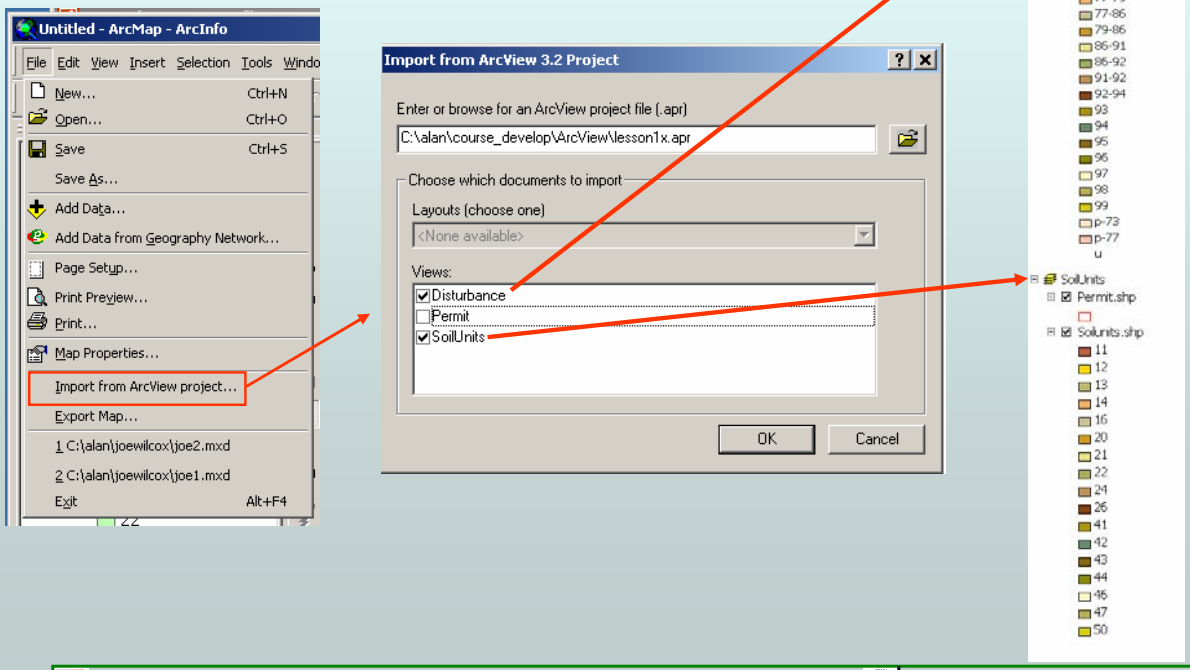


Importing ArcView GIS 3.2 Projects and Symbology

- **Importing an ArcView GIS 3.2 project into ArcInfo 8.x - no layouts**
- **Importing an ArcView GIS 3.2 project into ArcInfo 8.x - with layouts**

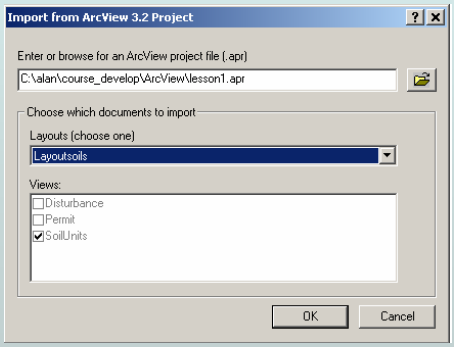
Method 1: Importing ArcView 3.2 Projects

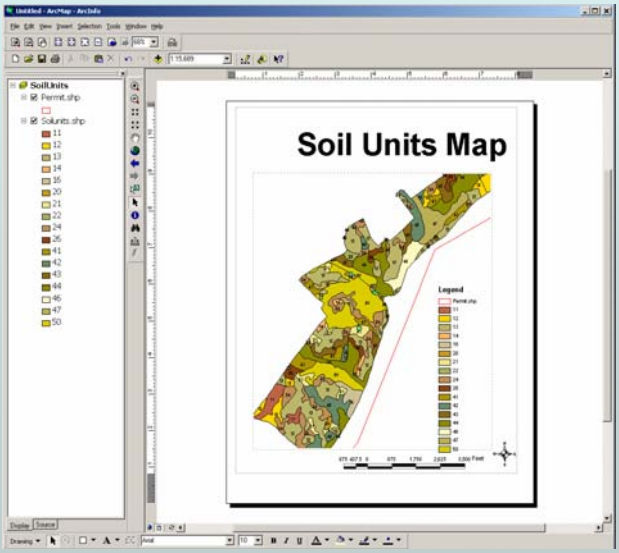
- **No Layouts**
  - **Each selected view becomes a data frame**
  - **Themes become layers**



Method 2: Importing ArcView 3.2 Projects

- **With Layouts**
- **Choose one layout at a time**
- **Legend will come in as graphic elements**
- **North arrows and scalebars will import but may look different**
- **Inset maps will import as data frames**
- **Chart, table and picture frames will not import to ArcInfo 8.x**
- **Each layout you import can be saved to a separate map (.mxd) document**





Results of Importing Projects

- **Imports most project elements**
- **Will not import**
  - **Avenue scripts or customization**
  - **Charts**
  - **Joins and links**
  - **Table documents**
- **Will need to re-create some objects in ArcMap**
  - **Such as**
    - **Event themes**
    - **Joins and links**
    - **Charts**

Instructor Demonstration

- Observe Workstation Interface
- Observe ArcCatalog
  - Directory structure and navigation
  - Thumbnails
  - Documentation (Help)
  - Different Icons
- Observe ArcMap
  - Display and Query data
- Observe ArcToolbox
  - Tool kits
- Importing an ArcView 3.2 project into ArcInfo 8.x

Exercise 1
Introduction to ArcCatalog, ArcMap, and ArcToolbox

- **Start ArcCatalog, ArcMap & ArcToolbox**
- **Connect to folder**
- **Preview & Display folder**
- **Drag & Drop**
- **Toolbars**
- **Customize the display**
- **Layout**
- **Exploring ArcToolbox**
- **Wizards**