Geog 464 Learning Objective Outline

LOO 09 Making choices about GIS data analysis
09.1 In what way do information needs motivate GIS-based data analysis?
09.2 How does combining spatial data transformations with spatial relationships lead to a framework for understanding GIS data operations?
09.3 What is the advantage of using a Steinitz landscape modeling approach to functional planning data analysis?

09.1 In what way do information needs motivate GIS-based data analysis?
RUGIS Chapter 6. Section 6.1

Decision support is enabled by data content and structure as scoped in a database model design. A database model design is enabled and constrained by choice (use) of a data model.

Informational needs for decision processes in planning, programming, and implementation are addressed by transforming data into information through the use of data processing techniques. The relationship presented in Figure 6.1, in which information needs guide the selection of geographical data and in turn the selection of data transformation (input to output) using operations is the basis of a *data analysis framework* for decision support.

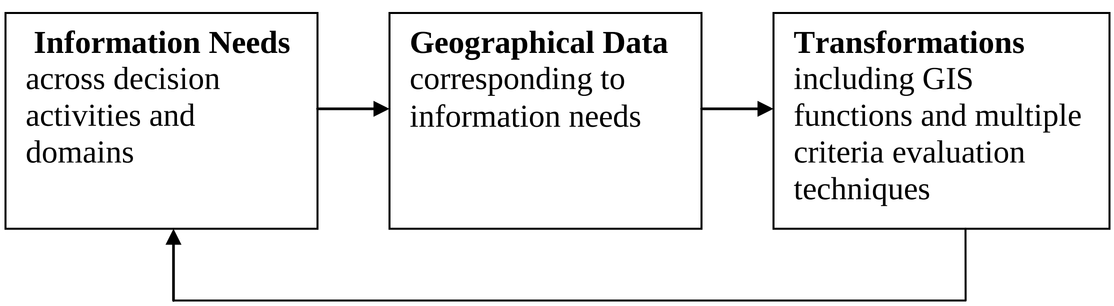

Figure 6.1 Making choices about data analysis relies on a relationship among information needs, geographical databases, and data transformations

09.2 How does combining spatial data transformations with spatial relationships lead to a framework for understanding GIS data operations?
RUGIS Chapter 6 Section 6.2

It is a challenge to identify what kinds of GIS data analysis is needed to derive information.
A data analysis framework aims at making the transition from formulating information needs to selecting appropriate GIS data analysis operations somewhat more understandable.

Albrecht (1999) argues for a minimal and sufficient set of universal analytical GIS operations that includes twenty task-oriented analytical operations including search, locational analysis, terrain analysis, distribution/neighborhood, and spatial analysis operations, sufficient to solve many common analytical tasks. The missing link in Albrecht's framework is the lack of conceptual bridge to transition from users' information needs to analytical operations.

Chrisman (2002) offers a framework based on measurement of spatial entities and processes, representation of measurements in a database, operations aimed at producing more measurements and discovering relationships among the data, and transformations of relationships. The framework includes a potential transition from data to information based on operations, but it does not include *conventional spatial relationships* associated with operations.

Tobler (1979) presents a transformational view of cartography, which he later extended to GIS (Tobler 2006) by cross-tabulating possible transformations among four common spatial data construct types: points, lines, polygons, and fields (see Table 6.1).

Table 6.1. Spatial data transformations by spatial data construct types.

TO: **FROM:**	**Points**	**Lines**	**Polygons**	**Fields**
Points	Points->Points	Points->Lines	Points->Polygons	Points->Fields
Lines	Lines->Points	Lines->Lines	Lines->Polygons	Lines->Fields
Polygons	Polygons->Points	Polygons->Lines	Polygons->Polygons	Polygons->Fields
Fields	Fields->Points	Fields->Lines	Fields->Polygons	Fields->Fields

Table 6.1 lists all sixteen possible combinations of transformations among four spatial data construct types associated with vector and raster data models. It is important to point out that transformations in Table 6.1 have a broader meaning than merely a change from one data construct type into another data construct type as they also include feature relationships. So, the "->" symbol should be read "transformation" and "relationship". For example a ground water well, represented by a point feature possibly has a "flow relationship" with an adjacent stream represented by a line feature (as in the Points->Lines entry for Points row & Lines column).

Although the transformations among the spatial data types in Table 6.1 are straightforward, it is still difficult to relate them to user information needs without understanding what the arrow "relationship" means. Egenhofer and Franzosa (1991) identified nine such relationships for two spatial regions - disjoint, touching, equal, containing, contained by, covering, covered by, overlapping with disjoint boundaries, and overlapping with intersecting boundaries.

Below we list some of those relationships, as part of a basic set of relationships important for many GIS operations and provide definitions of these relationships drawn from the American Heritage Dictionary of the English Language (American Heritage Dictionary 2006):

- Connectedness - Having a continuous path between any two points (nodes)
- Adjacency – contiguity or next to
- Containment – inside or within
- Proximity – nearness, closeness
- Overlap – lie over and covering
- Pattern – a sequence of systematic spatial occurrences
- Flow – movement through space or within a channel.

Table 6.1 *combines transformation of spatial data construct types with spatial relationships*, and thus we address information needs arising from those generic relationships in a decision situation focusing on GIS data analysis operations. *For example, the question whether a specific wastewater facility footprint encroaches on the area designated as the habitat of a protected species can be answered by evaluating whether both areas overlap.*
To help in the task of finding the appropriate GIS data analysis operations we enumerate all combinations of spatial relationships with spatial data transformations. They are listed by spatial data types (points, lines, polygons, and fields) in tables 6.2 - 6.5.
- GIS data analysis operations addressing the combinations are given in table cells.
- Operation names are implemented in ArcGIS software.

Table 6.2. GIS data analysis operations for computing point-based spatial relationships (expanding the points row in Table 6.1 and introducing relationships as columns)
Table 6.3. GIS data analysis operations for computing line-based spatial relationships. (expanding the lines row in Table 6.1 and introducing relationships as columns)
Table 6.4. GIS data analysis operations for computing polygon-based spatial relationships (expanding the polygons row in Table 6.1 and introducing relationships as columns)
Table 6.5. GIS data analysis operations for computing field-based spatial relationships (expanding the fields row in Table 6.1 and introducing relationships as columns)

Empty cells - GIS data analysis tools do not exist for every combination of spatial relationship and transformation. The many empty cells in the Tables 6.2 - 6.5 underscore the need for abstraction and generalization of spatial data. The reader may notice the conspicuous absence of GIS operations in many of the cells in Table 6.5. These cells correspond to field->vector transformations combined with spatial relationships.

Some tasks (addressing user information needs) may require spatial transformations before one can combine them with spatial relationships for a simple reason that there are no GIS data analysis operations addressing a given combination of data transformation and relationship.

Take for example the combination “Points->Fields AND Proximity” in Table 6.2. Such a combination may be useful for computing the distance **relationship** between watershed and the nearest rainfall gauge measuring the amount of precipitation. Unfortunately, there is no specific GIS data analysis operation for computing the distance between a point location and a zone of raster cells. We can, however, **transform** zonal fields to polygons and then represent polygons by their centroids. We can then use “Points->Points AND Proximity” combination and use *Point Distance* operation (Table 6.2). We then **transform** to centroids as A “work around” solution.

09.3 What is the advantage of using a Steinitz landscape modeling approach to functional planning data analysis? *RUGIS* Chapter 6 Section 6.3 – 6.5

In section 3.2.2 we introduced several questions that can be posed to guide GIS work at each of the stages. We take advantage of those questions below when framing the information needs for each of the six phases of the landscape modeling process for a wastewater facility siting problem (Tables 6.6 – 6.11). However, let’s focus on the current labs in this course that are meant to take us through a “light-weight” version of geodesign modeling for planning (labs 1 & 2) and improvement programming (labs 3 & 4), respectively.

Scenario Representation model – a description of the water conditions in the world
Do we have the data in the appropriate form or are data conversions necessary?

Scenario Process model – how water changes states for the conditions in the representation model
What are the relationships among the spatio-temporal elements so that we have a better understanding of urban-regional process, i.e., what (who) influences what (who)?

Scenario evaluation model – aspects of a world to consider; conditions to address in processes
How well is the world working given the current state of the urban-regional environment?

Scenario Change model – a before and after description of intentionally changed conditions. There are at least two important types of change that should be considered.

1) **How might the landscape be changed by current trends?** Modeling trends leads us to develop projection (e.g., population, employment, etc.) models that act as the basis of landscape change, even when dealing with a small area of a community. This is what the process model is supposed to answer.
2) **How might communities change by implementing design actions?** A design action is an intervention, an activity that pro-actively changes a place, rather than accepting change as “inevitable”. That is, the change is directed by design which is to be addressed by the change model.

Scenario impact model – the results/implications of that change on conditions create an impact.
What are the predictable impacts, i.e., the outcomes based on the changes put forward in the change model?
There are at least four questions one needs to answer to address impacts:

- what (quality impact level)
- where (location of impact), and
- when (temporal distribution of impact)
- how much (magnitude of the impact)

Scenario decision model – what choice of impacts (good and bad) are you minimizing or maximizing
How are we to treat impacts in an equitable manner, considering there are different types of equity?

Resolving trade-offs requires a systematic evaluation of alternative model solutions, on the bases of measurable attributes called *criteria* when used in the decision model and standardized measurements for outcomes for each decision option.

The methodology developed specifically for the purpose of evaluating decision options on the basis of evaluation criteria is called multiple criteria evaluation (MCE) (Voogd, 1983).