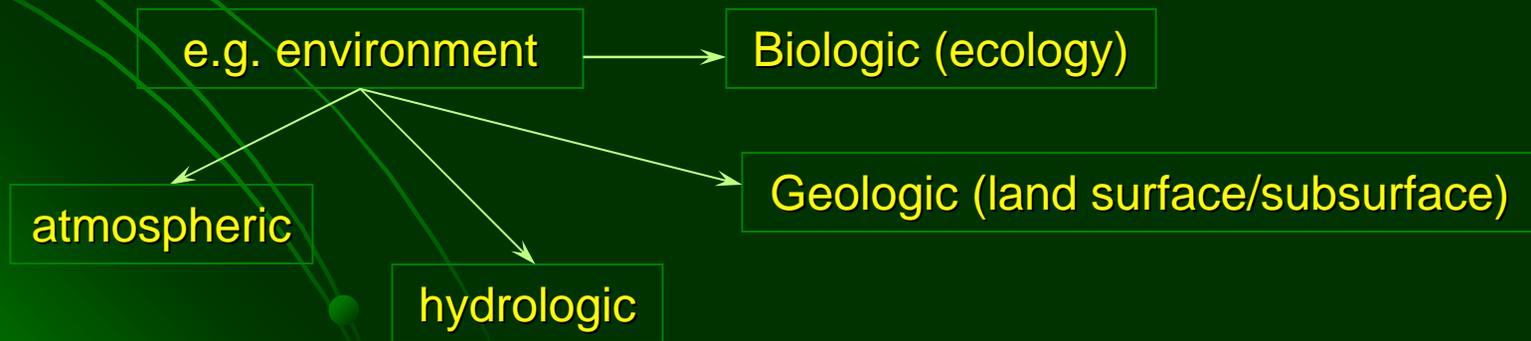


# GIS model & modeling

- Model : a simplified representation of a phenomenon or a system.
- GIS modeling : the use of GIS in the process of building models with spatial data.
- Basic requirement in modeling : modeler's interest & : **Knowledge** of the systems be modeled.



# GIS model & modeling

- GIS Model elements : 1. a set of selected spatial variables  
: 2. functional / mathematical relationship between variables.
- GIS Model can be related to : exploratory data analysis  
: data visualization  
: DB management
- GIS Model can work together with / across GIS software packages & other computer programs. ( e.g. excel )
- GIS Model can be : vector – based  
: raster – based  
: include both in one model / task (using conversion )  
] Depends on nature of model , data source , computing algorithm

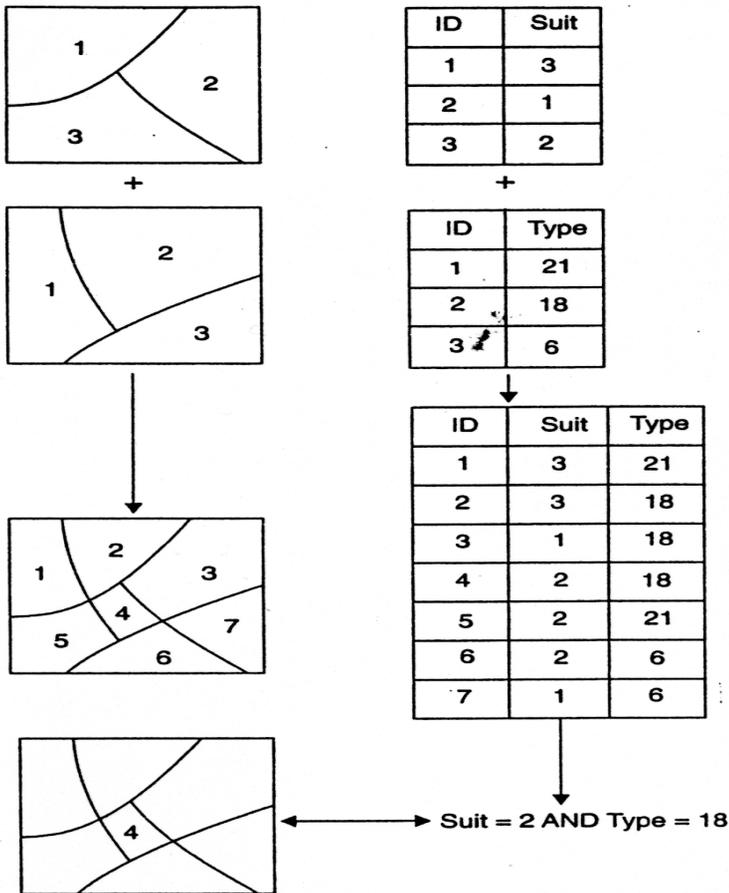
# GIS Types of GIS models

- ❖ Binary models
  - ❖ Index model
  - ❖ Regression models
  - ❖ Process models
- 
- A decorative graphic in the bottom-left corner of the slide. It consists of three curved, parallel lines that sweep from the bottom-left towards the center. Each line has a small, solid black dot placed at its end.

# Binary models

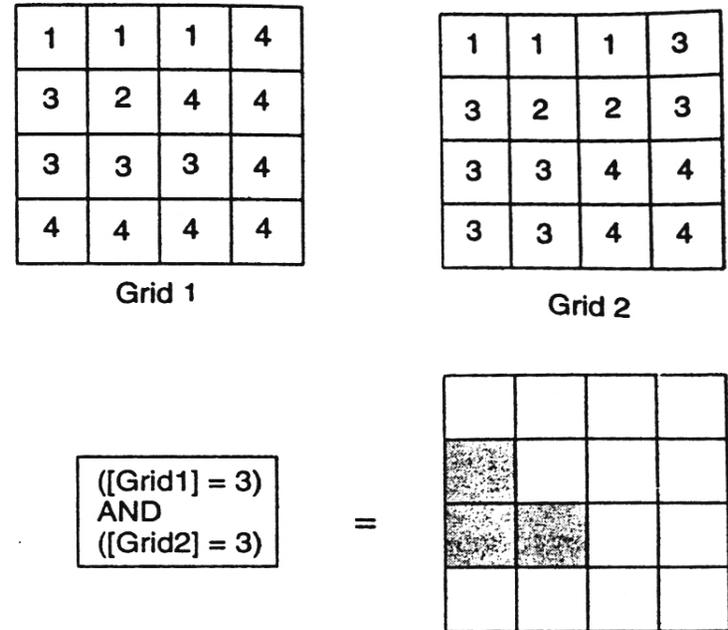
- Logical model (expressions) to select features from composite maps or multiple grids (features: point, line, polygon, cell)
- Output → 1 ( true ) & ∅ ( false)
- Map overlay → combine attributes / variables
- A common example of this model is siting [ point, polygon (potential area) ] analysis. ( Fig. 14.1)
- Spatial query Fig. 14.2
  - compare to local operation of grid →

# Binary models



**Figure 14.1**

An illustration of a vector-based logical model. The two maps at the top are overlaid so that their spatial features and their attributes of Suit and Type are combined. A logical expression, Suite = 2 AND Type = 18, results in the selection of polygon 4 in the output.



**Figure 14.2**

An illustration of a raster-based logical model. A query statement,  $[(\text{Grid1}) = 3] \text{ AND } [(\text{Grid2}) = 3]$ , results in the selection of 3 cells in the output.

# Index Models: Weight-rating Score Models

- Assign & standardize values to spatial elements(features) of each layer.
- Use the index value calculated from a composite map or multiple grids to produce a rank map.
- Index value of a polygon / cell =  $(weight_1 \times score_{A1}) + (weight_2 \times score_{A2})$
- See Fig. 14.3 (vector-based), Fig.14.4 ( raster-based )
- Steps:
  1. assign weight to each variable (w)
  2. assign & standardize scores to each class of each variable(data layer)

# Index Models : Weight-rating Score Models

- Steps:

3. index value calculation

4. ranking index values of each polygon / cell.

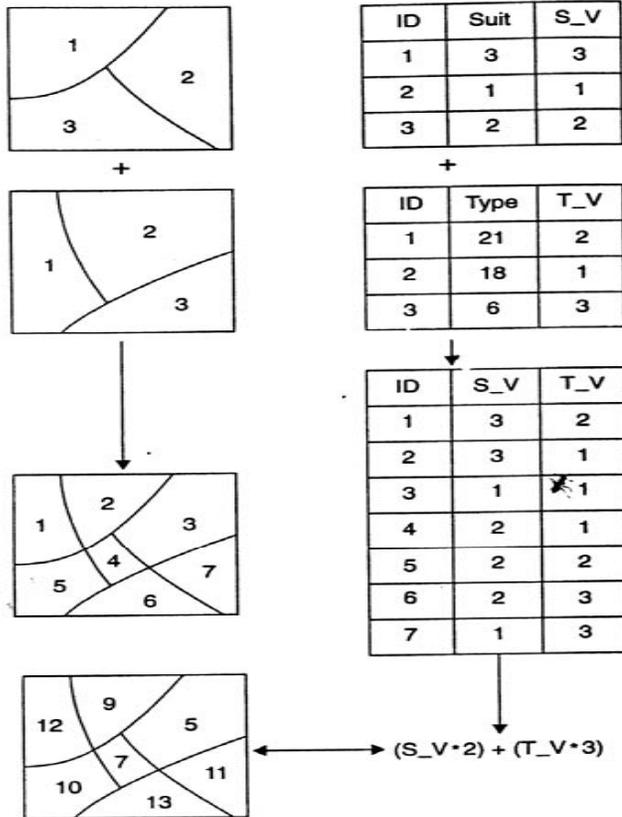
$$\text{Total Score / Index value} = \sum_{i=1}^n W_i S_j$$

$W_i$  = weight of  $i^{th}$  variable

$S_j$  = score of class  $j^{th}$  in the variable  $i^{th}$

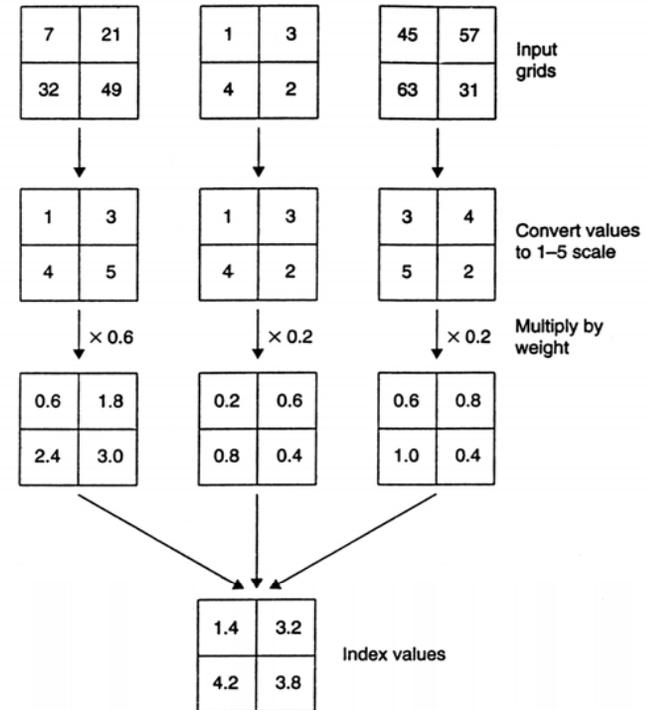
Check !

# Index Models : Weight-rating Score Models



**Figure 14.3**

An illustration of a vector-based index model. First, the observed values of each map are given the numeric scores from 1 to 3. The Suit values of 1, 2, and 3 are given the scores of 1, 2, and 3 respectively. The Type values of 6, 18, and 21 are given the scores of 3, 1, and 2 respectively. Second, the two maps are overlaid. Third, a weight of 2 is assigned to the map with Suit and a weight of 3 to the map with Type. Finally, the index values are calculated for each polygon in the output. For example, Polygon 4 has an index value of 7 ( $2 \times 2 + 1 \times 3$ ).



**Figure 14.4**

An illustration of a raster-based index model. First, the cell values of each input grid are assigned the numeric scores from 1 to 5. Second, the index values in the output grid are calculated by summing the products of each grid multiplied by its assigned weight. For example, the index value of 1.4 is calculated from:  $1 \times 0.6 + 1 \times 0.2 + 3 \times 0.2$ , or  $0.6 + 0.2 + 0.6$ .

# Index Models : Weight-rating Score Models

- $\max-X_i$   
max-min

7	21
32	49

1	0.67
0.40	0

Cost: The less, the better: veg density ↓ index value ↑ LS prob ↑

Rating score

- $X_i$ -min  
max-min

7	21
32	49

0	0.33
0.59	1

Benefit: The more, the better : rain ↑ index value ↑ probability Landslide ↑

Normalized/standardized cell values(scores) to be comparable.

# Regression Model

- Relates a dependent variable to a number of independent variables in an equation - used for prediction / estimation.
  - 2 types of regression model (?? - discuss??)
    - ◆ Linear(?) regression : when variables are all numeric.
    - ◆ Logistic regression : dependent variable is a binary phenomenon(/probability?) & the independent variables are categorical or numeric variables.
- 

# Regression Model

- **Example : Linear (?) regression**

$$\text{SWE} = a + b_1 \text{ Easting} + b_2 \text{ southing} + b_3 \text{ ELEV}$$

When  $a$ ,  $b_1$ ,  $b_2$  and  $b_3$  are regression coefficients

Easting - column no. of a grid cell

Southing – row no. of a cell

ELEV – elevation values of a cell

SWE – snow water equivalent - a dependent variable

# Regression Model

- **Logistic regression**

- $y = 0.002 \text{ ELEV} - 0.228 \text{ slope} + 0.685 \text{ canopy 1} + 0.443 \text{ canopy 2} + 0.481 \text{ canopy 3} + 0.009 \text{ aspect E-W}$
- $y = \text{habitat suitability for red squirrel to be present}$

where canopy 1,2,3 - categories of canopy

then,

Probability ( p ) of squirrel presence for each cell :

$$P = 1 / ( 1 + \exp (-y) )$$

$y \uparrow$        $P \uparrow$

?? # Check relationship of regression models with ( i ) linear equation, 2<sup>nd</sup> order polynomial, 'best fit' least square analysis ??#

In mathematics, especially as applied in statistics,

the **logit** (pronounced with a long "o" and a soft "g", IPA /lɒʊdʒɪt/) of a number  $p$  between 0 and 1 is

- This function is used in logistic regression

# Process Model

- Integrate existing knowledge about envt. process in the real world into a set of relationships and equation for quantifying the process.
- Offer both a predicative capability & explanation processes proposed.

Examples:

USLE

$$A = RKLSCP$$

A- av. soil loss in tons , R- rainfall intensity S – slope gradient , C – cultivation factor

K-soil erodibility , L- slope length P- supporting practice factor.

L & S – estimated from field measurement -

sometimes combined to be a single topographic factor

# Process Model

“AGNPS” (Agricultural nonpoint source)

$$SL = (EI) K LS C P (SSF)$$

- Used to estimate upland erosion for a single storm.

SL – soil loss

EI – product of the storm total kinetic energy and max – 30 minute intensity

K- soil erodibility , LS – topographic factor,

C- cultivation factor, P - supporting practice factor

SSF – a factor to adjust slope shape in a cell.

# Process Model

## “SWAT” (soil & water assessment tool )

a model predicts the impact of land management practices on water Q & Q, sediment, and agricultural chemical yields in large complex watersheds.

Inputs are Land management practice such as :

- ◆ Crop rotation, irrigation, fertilizer use, pesticide application rates, physical characteristics of the basin & subbasin ( precipitation, temperature, soil, vegetation, & topography )

Output :

- ◆ simulated values of surface water flow, GW flow, crop growth, sediment & chemical yields.