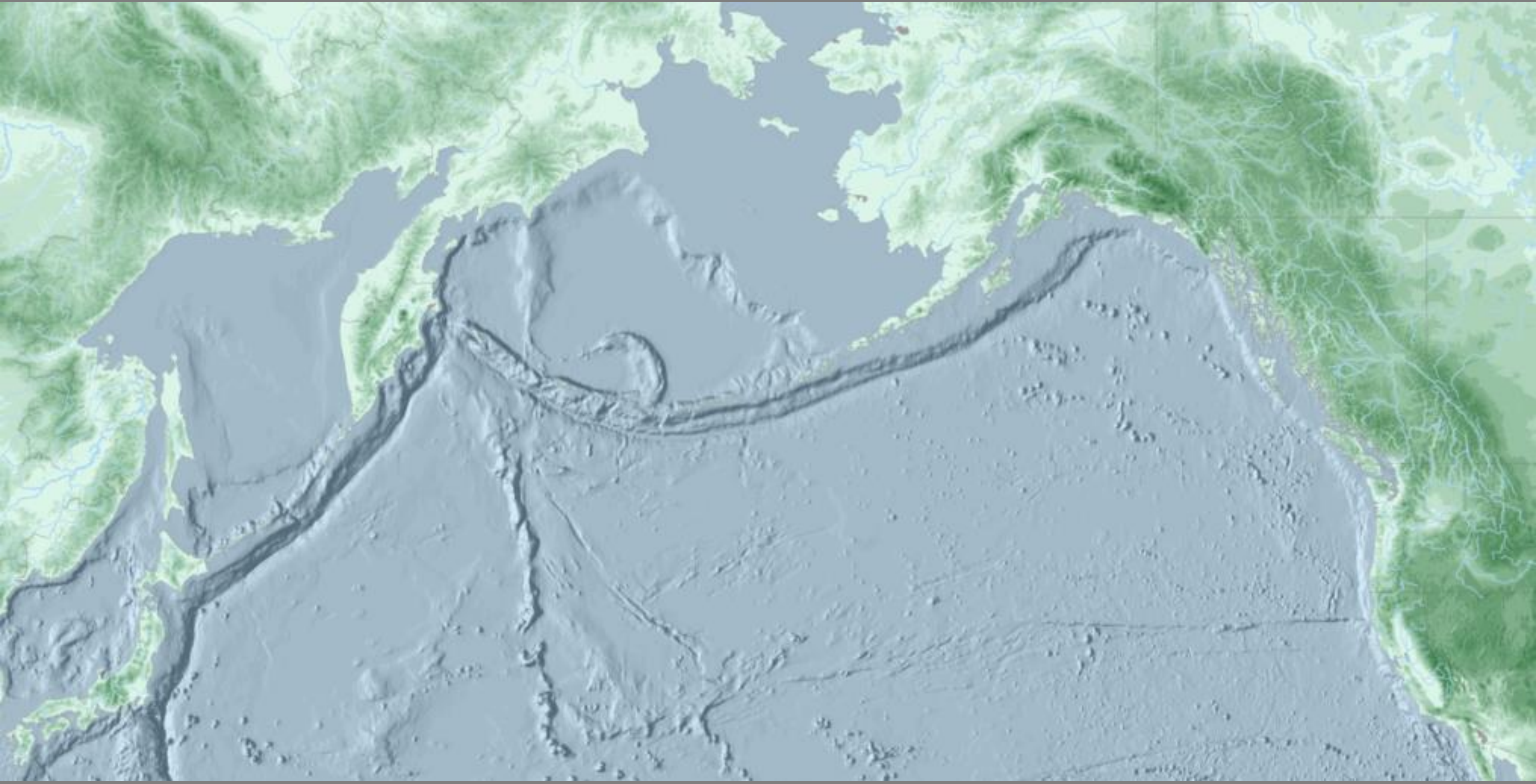


SPATIAL MODELING

GIS Analysis | Winter 2016

Spatial Models

Spatial Modeling attempts to represent how the world works…

"All models are wrong, but some are useful"

(G.E. Box, quoted in course textbook pg. 379)

Spatial Models

- Represents how data is manipulated at a single point in time (*static*) or over time (*dynamic*)
- Allows you to…
  - Search for data *patterns* or *anomalies*
  - Identify data *indicators* or *predictors*
  - Experiment with different data *scenarios*

Types of Spatial Models

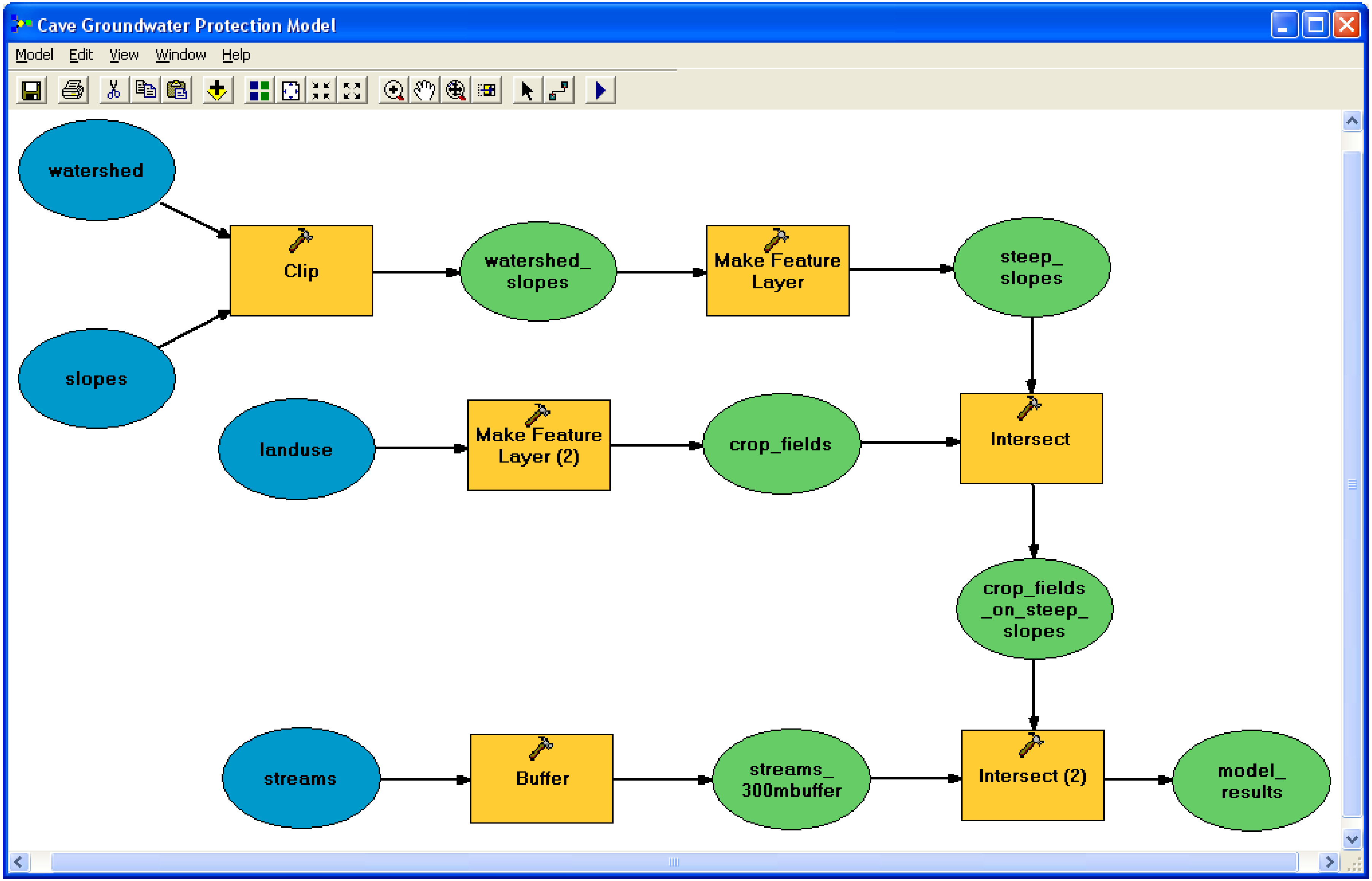
- **Cartographic**
  - Automating map analysis & processing for a given geographic area & point in time
- Simple Spatial
  - Apply a set of equations from a sample area to predict specific variable(s) to a larger geographic area
- Spatio-temporal
  - Dynamic in both time & space; time passes explicitly in the model and changes in time causes changes in spatial variables

Why Build/Use Spatial Models?

- *Conceptual overview* of geoprocessing steps
- Forces you to specify and explain your *logical thought processes*
- Great way to *document your work*
  - e.g. Diagrams/Flowcharts

Cartographic Model Flowchart

- *Visual illustration of spatial analysis*
- Shows combination of datasets, operations, parameters, and outputs of your analyses
- Popular spatial flowcharting applications:
  - ERDAS Imagine Model Maker
  - ESRI ArcGIS ModelBuilder
- Flowchart symbology can vary


Cave Groundwater Protection Model
Model Edit View Window Help
watershed
slopes
Clip
watershed_ slopes
Make Feature Layer
steep_ slopes
landuse
Make Feature Layer (2)
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Intersect
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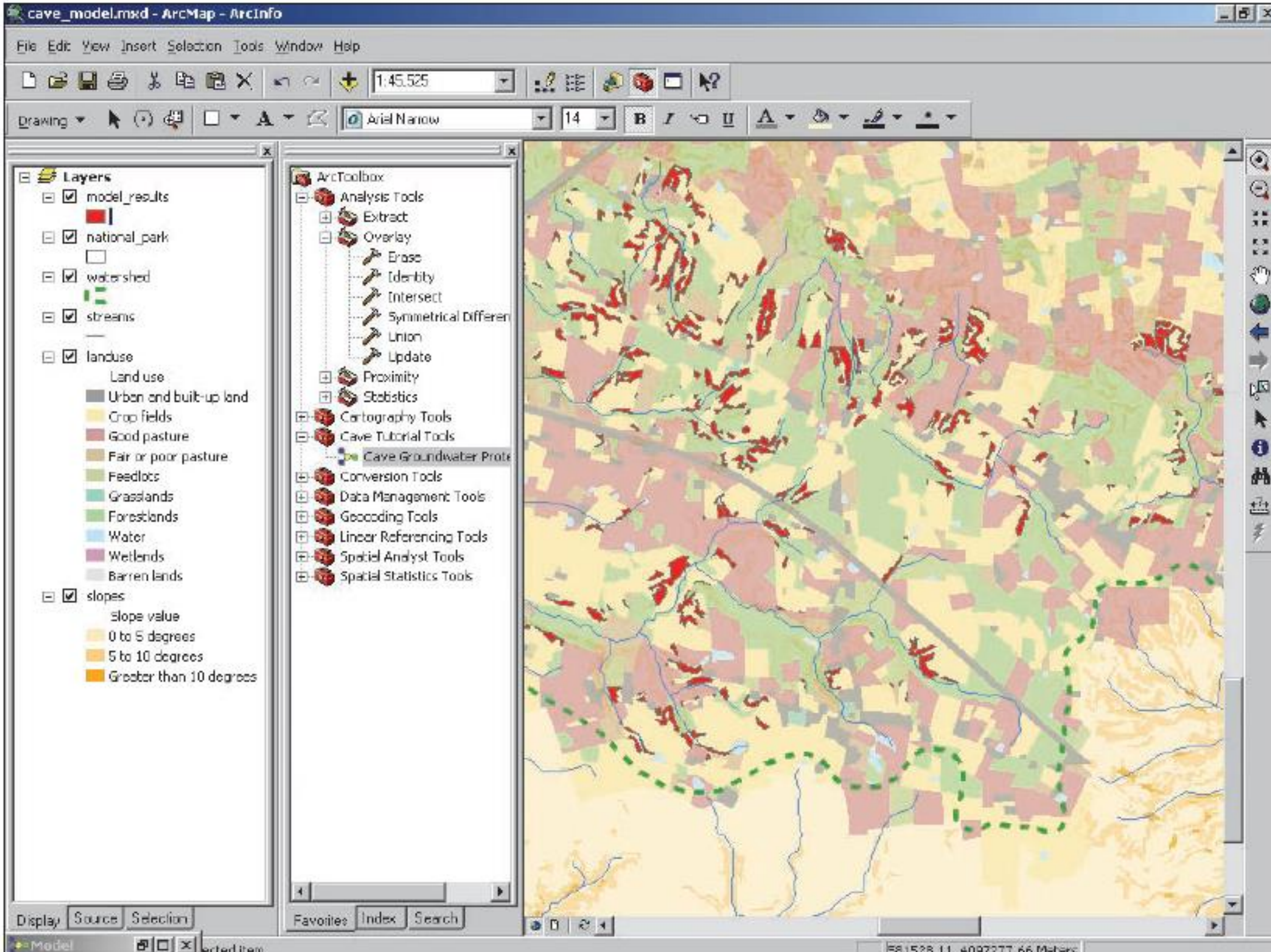
Intersect (2)
model_ results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streams
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Land use
Urban and built-up land
Crop fields
Good pasture
Fair or poor pasture
Feedlots
Grasslands
Forestlands
Water
Wetlands
Barren lands
slopes
Slope value
0 to 5 degrees
5 to 10 degrees
Greater than 10 degrees
ArcToolbox
Analysis Tools
Extract
Overlay
Erase
Identity
Intersect
Symmetrical Differen
Union
Update
Proximity
Statistics
Cartography Tools
Cave Tutorial Tools
Cave Groundwater Prote
Conversion Tools
Data Management Tools
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Linear Referencing Tools
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Model Logic

Model Logic

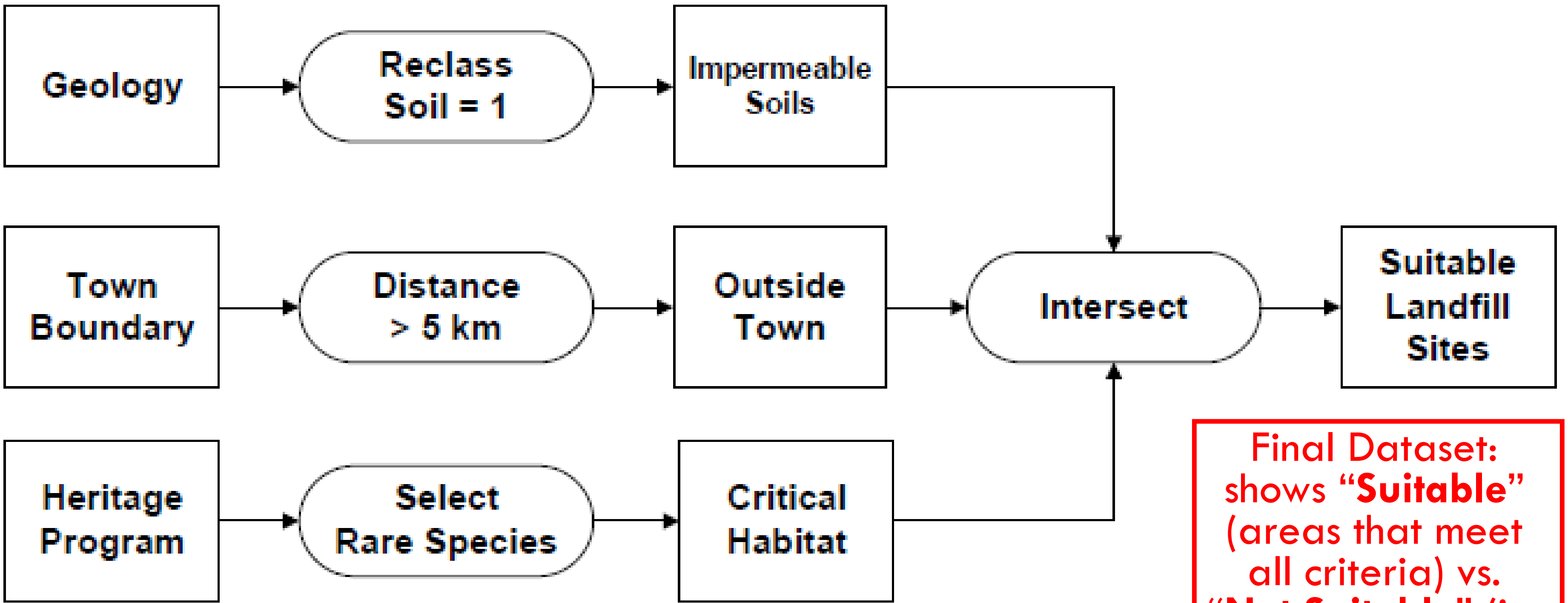
- Infinite variety of ways that logical flow of models can be put together
- Some of the most common include…
  - **Boolean**
  - **Arithmetic**
  - **Weighted Arithmetic**

Boolean Model

- Each factor dataset is mapped with the values of "*yes/1*" (*meets criteria*) or "*no/0*" (*everything else*)
- All factors are multiplied together
- Often used with *Suitability Models*
- Final dataset: locations that satisfy *all factors*
- Popular with raster data, but also works with vector data

Boolean Model – Landfill Site Suitability

Each input factor is mapped as **“yes”(1) or “no” (0)**; all inputs multiplied together



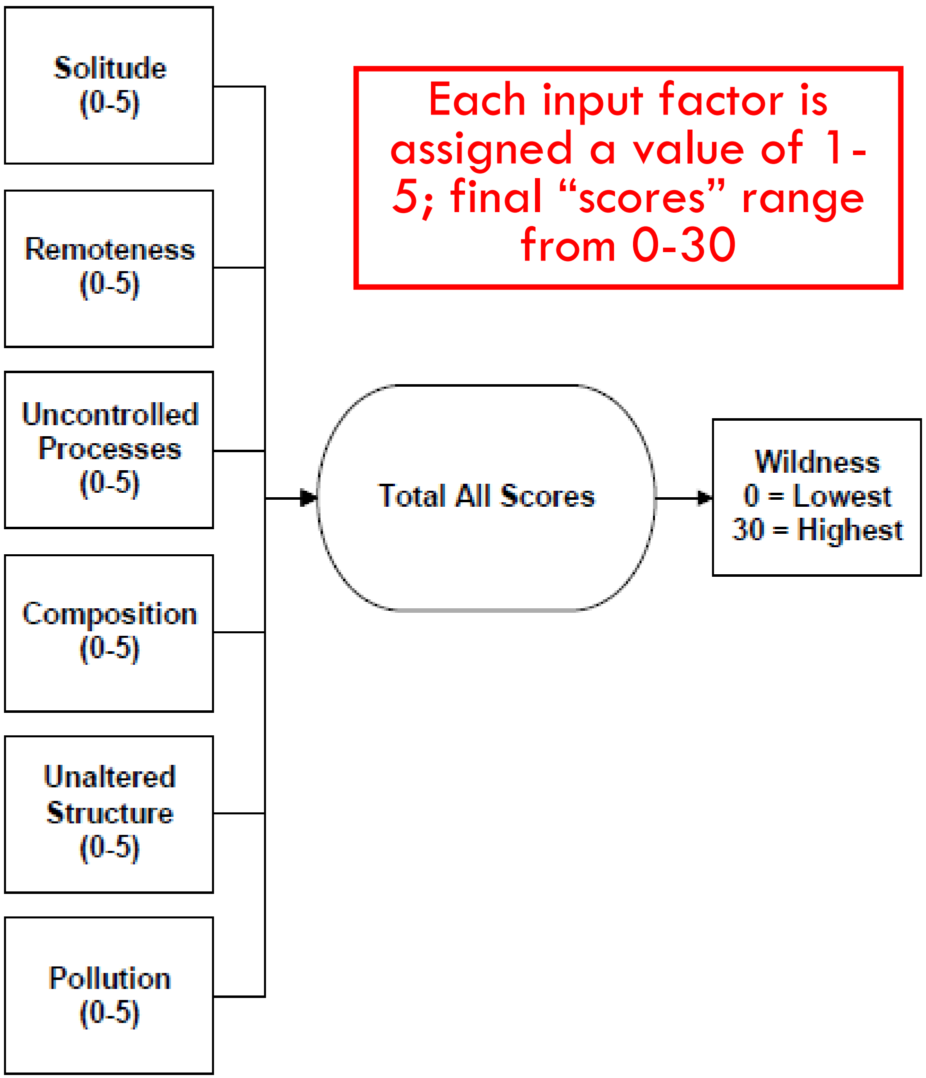
Final Dataset: shows “**Suitable**” (areas that meet all criteria) vs. “**Not Suitable**” (i.e. all other areas)

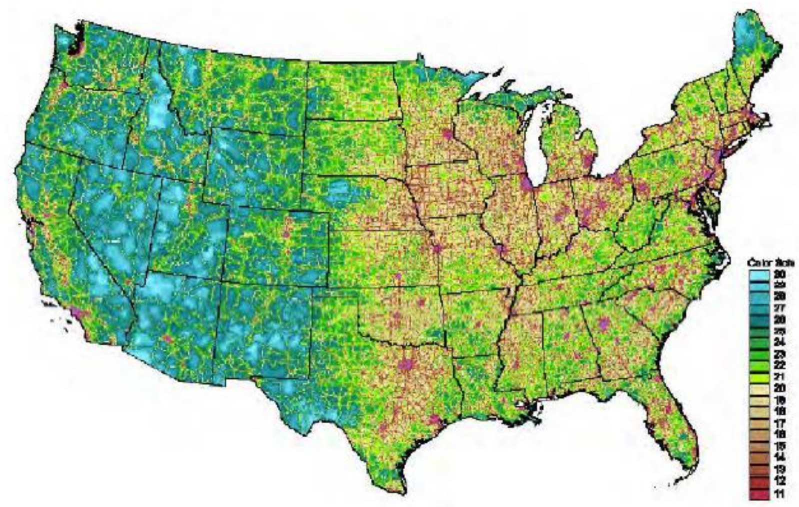
Arithmetic Model

- Combine variety of input factors
- Each factor assigned an individual "*score*"
- All scores combined into a "*final score*"
- Final scores show range of ordinal/ranked values
  - e.g. Highest score = "most"
  - e.g. Lowest score = "least"

Arithmetic Model – Wildness Score

Each input factor is assigned a value of 1-5; final "scores" range from 0-30

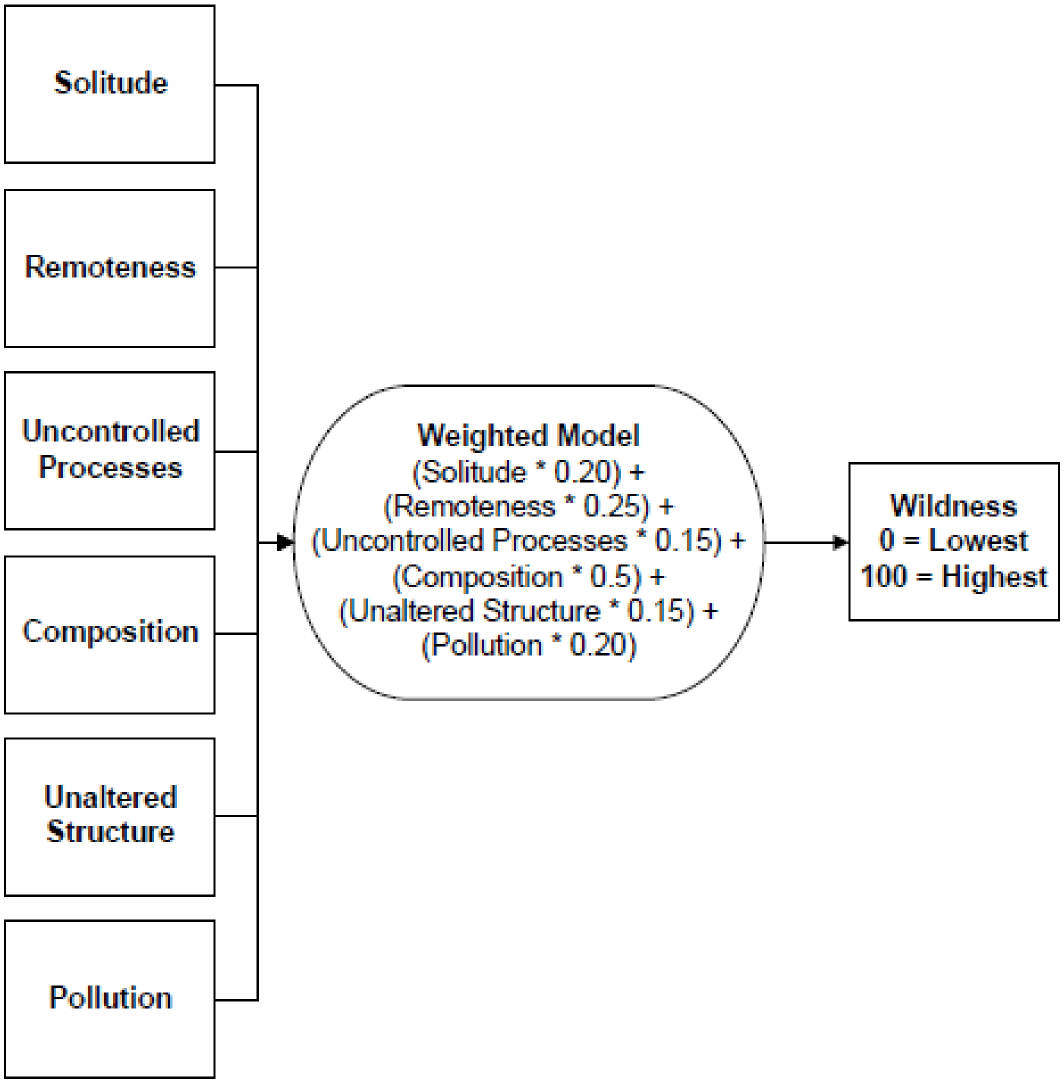




Weighted Arithmetic Model

- *Weighted scores* – apply different weights to each factor, based on their *relative importance*

Weighted Arithmetic Model



Each input factor is assigned a value of 0-100; factors multiplied by weights; final rankings values are between 0-100

Cartographic Model

Model Development

1. Planning
    a) Set general criteria
    b) Convert general criteria to specific criteria (including weighted factors if necessary)
    c) Evaluate input datasets (available? quality?)
    d) Determine derived/output datasets
    e) Select appropriate analytical tools
2. Implementation – create in ArcGIS

Model Development

3. Testing and Refinement
    a) <u>Iterative</u> process
    b) "*Sensitivity Analysis*"
4. Use
5. [Distribution]

Example - New Home Site Selection

- *Research question*: Where are the best locations within my study area for building a new home?
- Use a *Boolean Model*

General to Specific Criteria

General criteria	Specific Criteria
Slopes not too steep	Slopes<30 degree
Southern aspect	Aspect 90-270 degrees
Soils suitable for septic system	List of septic-suitable soil units
Far enough from road for privacy (but not too far!)	Distance to road, 300-2000 meters

Input Datasets

- Slope – *Elevation* dataset (raster)
- Aspect – same *Elevation* dataset (raster)
- Soil type - *Soils* dataset (vector polygons)
- Distance from roads - *Roads* dataset (vector lines)

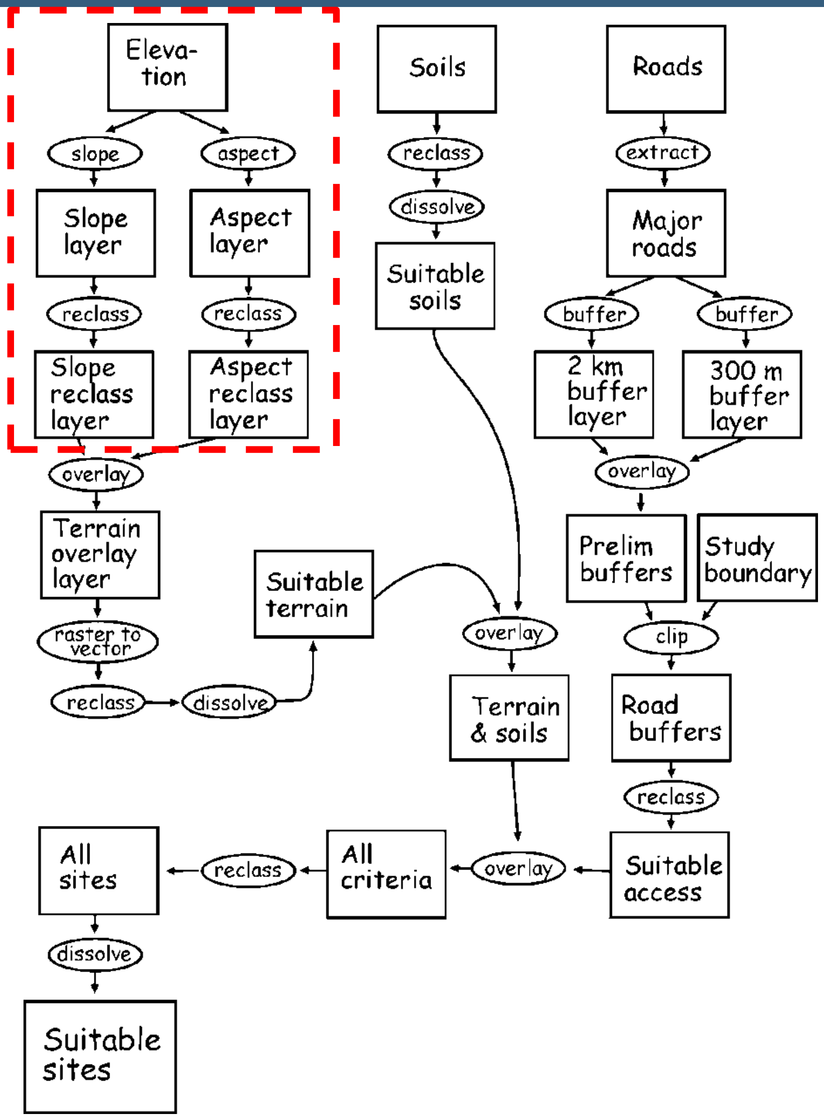
Derived/Output Variables

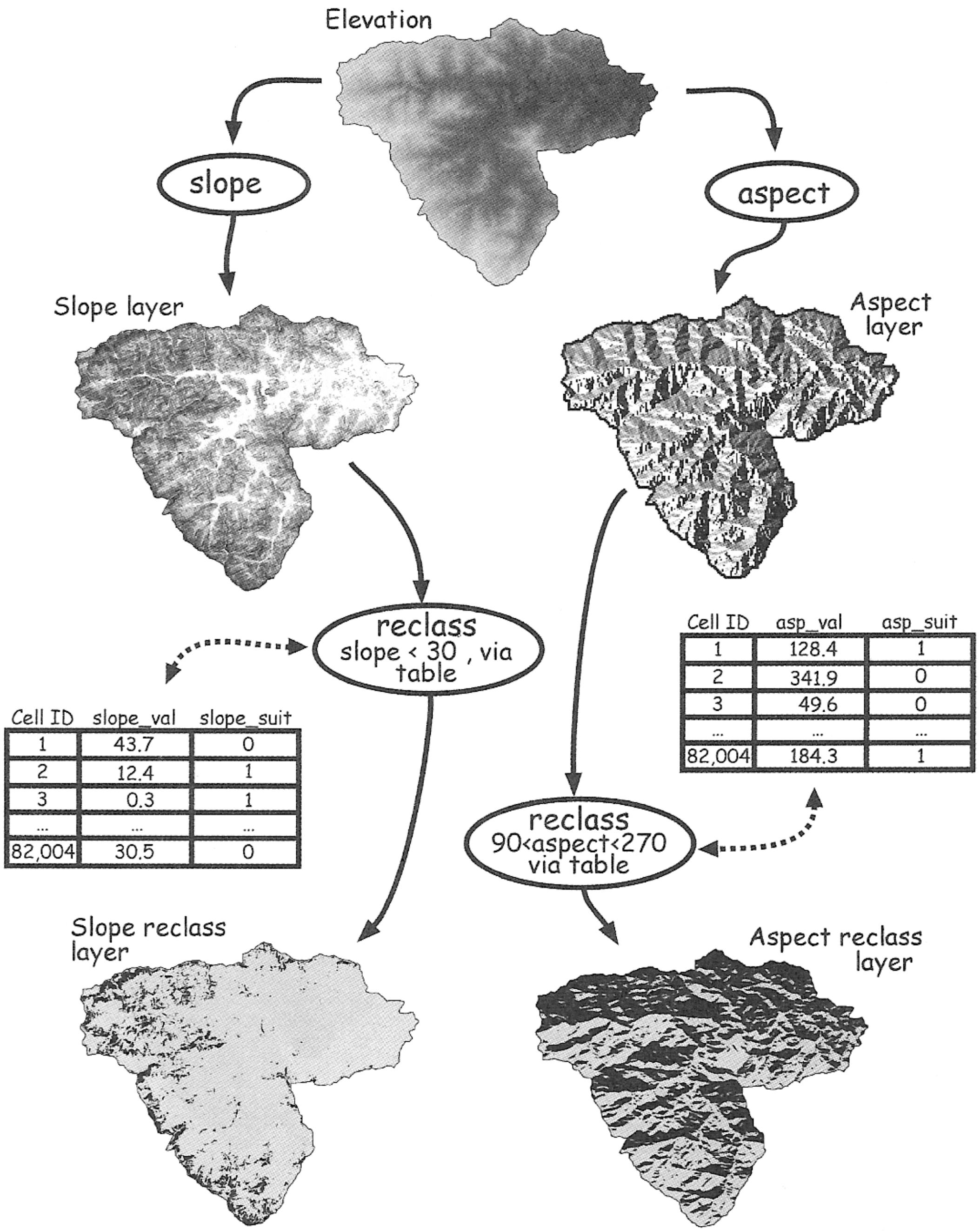
- Elevation dataset => find *Suitable Terrain*
- Soils dataset => find *Suitable Soils*
- Roads dataset => find *Suitable Access*
- **Final output: A + B + C = *Suitable Sites***

Which tools to use?

- Calculate Slope
- Calculate Aspect
- Reclassify
- Overlay
- Raster to Vector
- Dissolve
- Extract
- Buffer
- Clip

Construct Model – Slope, Aspect, Reclassify

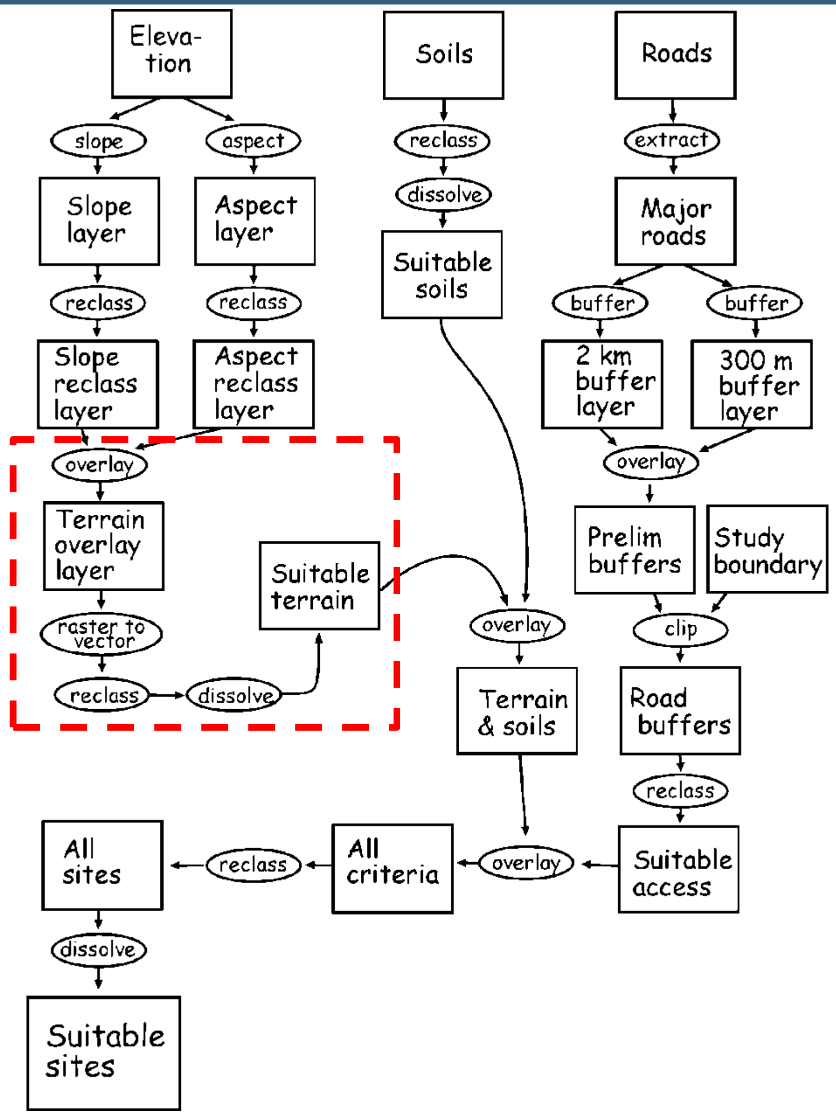


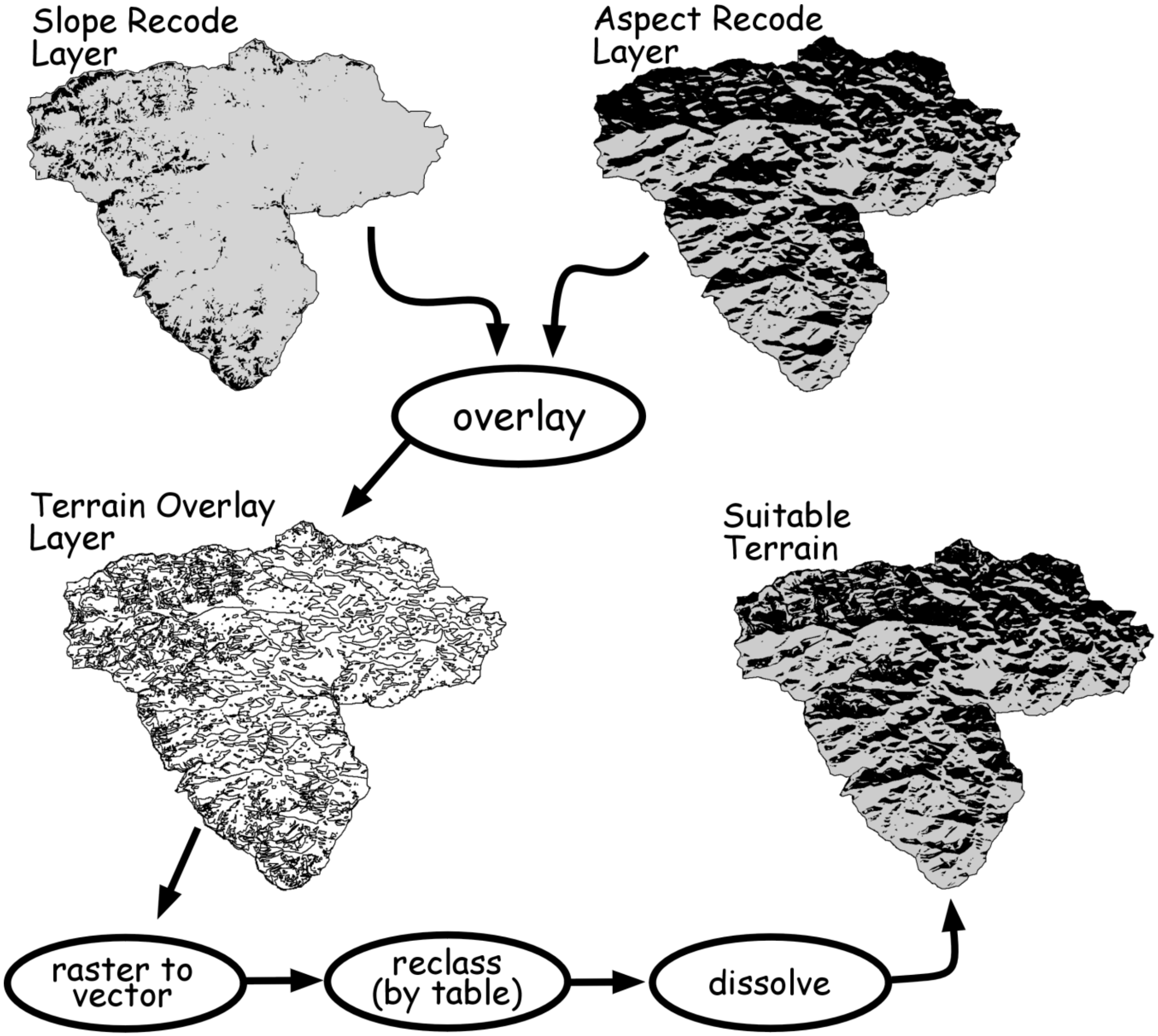


Cell ID	slope_val	slope_suit
1	43.7	0
2	12.4	1
3	0.3	1
...	...	...
82,004	30.5	0

Cell ID	asp_val	asp_suit
1	128.4	1
2	341.9	0
3	49.6	0
...	...	...
82,004	184.3	1

Construct Model – Suitable Terrain

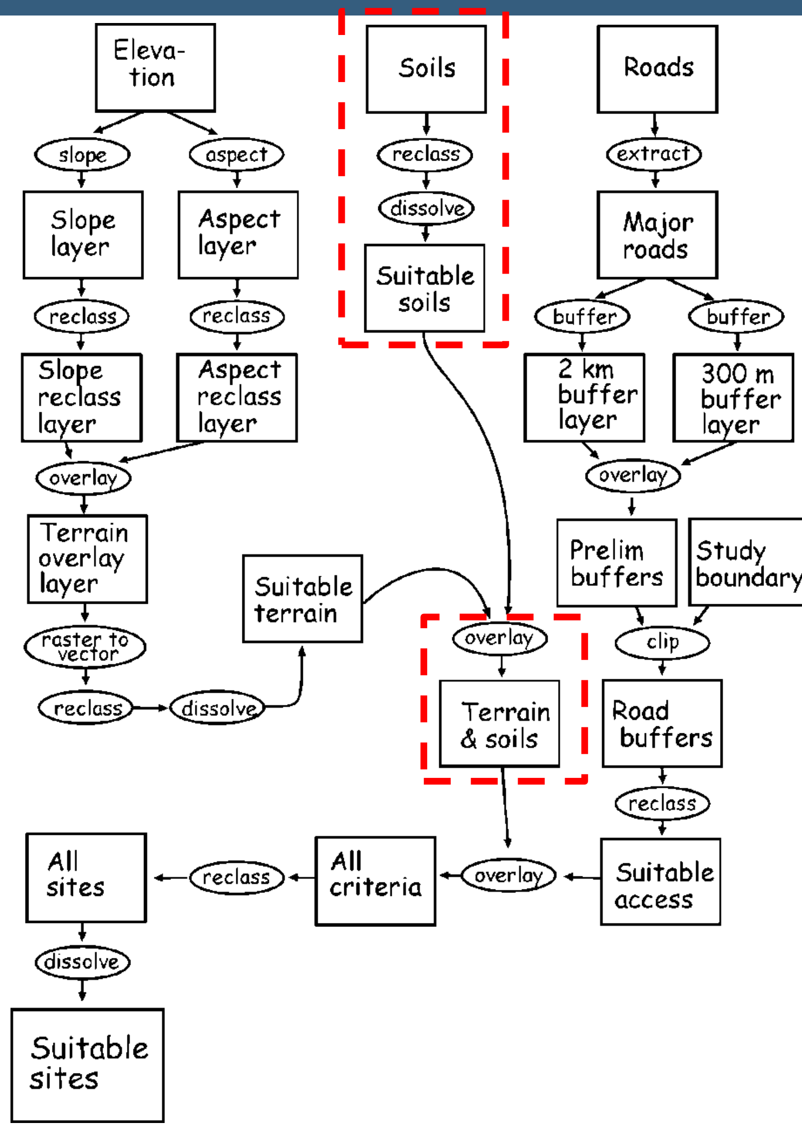




slope_suit	asp_suit	terrain_suit
0	0	0
0	1	0
1	0	0
1	1	1

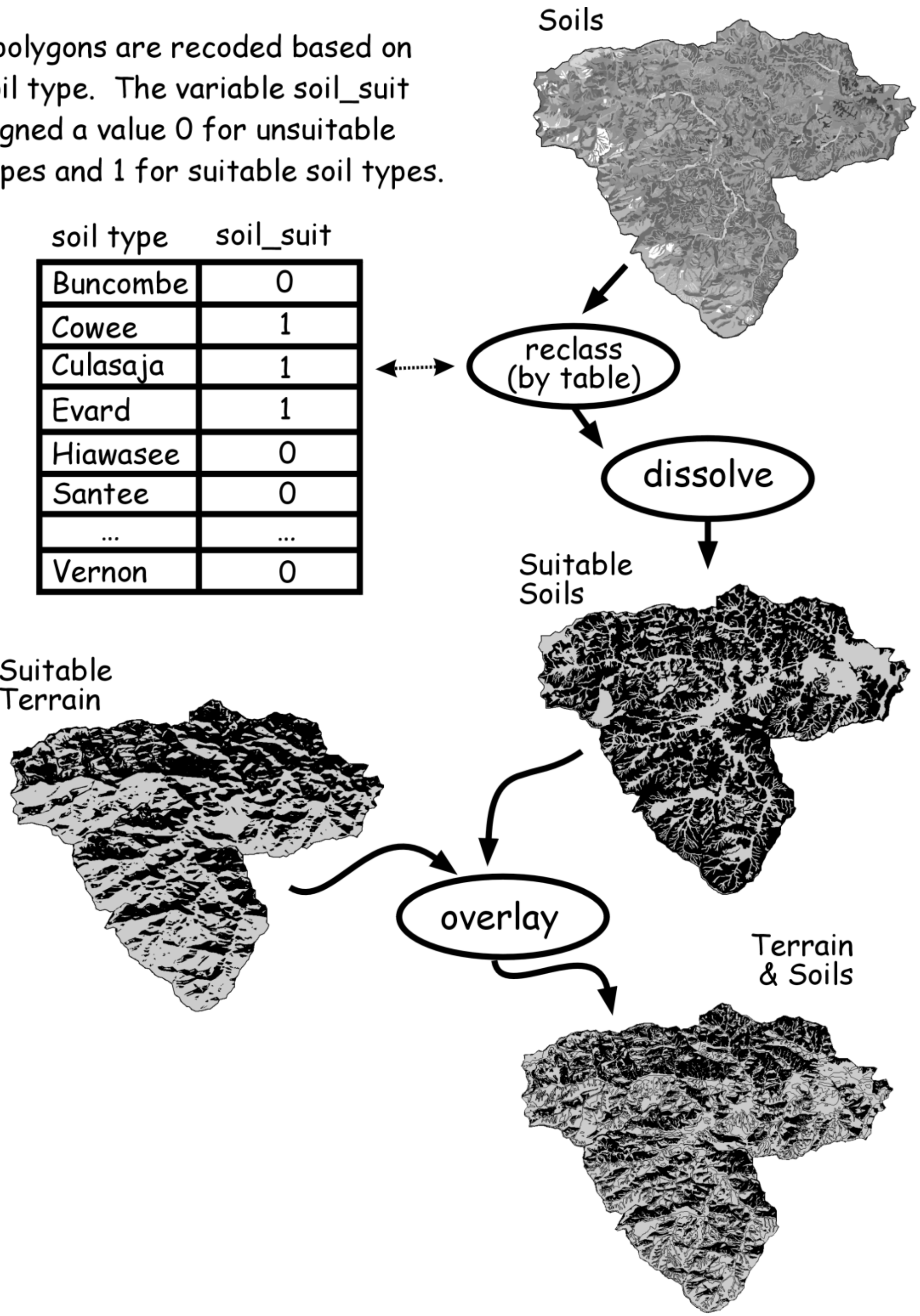
The terrain suitability code is assigned based on this reclass table. Only those polygons with suitable slope <u>and</u> aspect are assigned a terrain_suit value of 1.

Construct Model - Soils

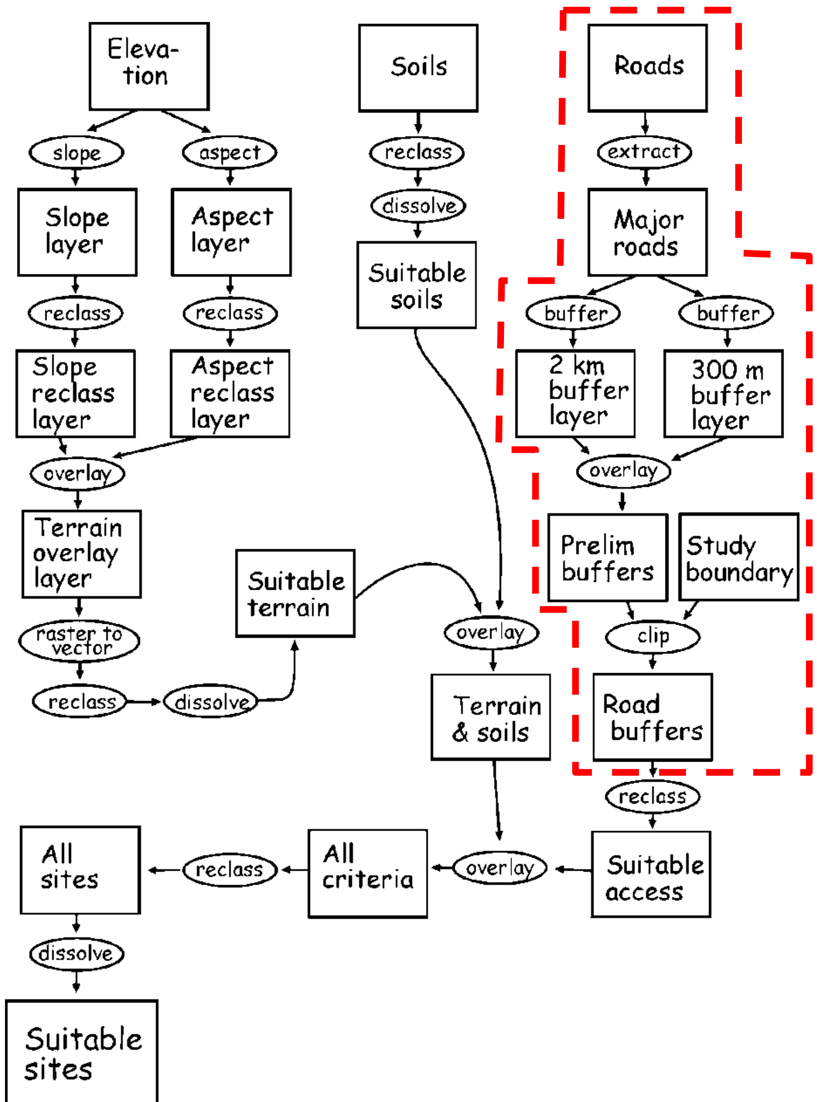


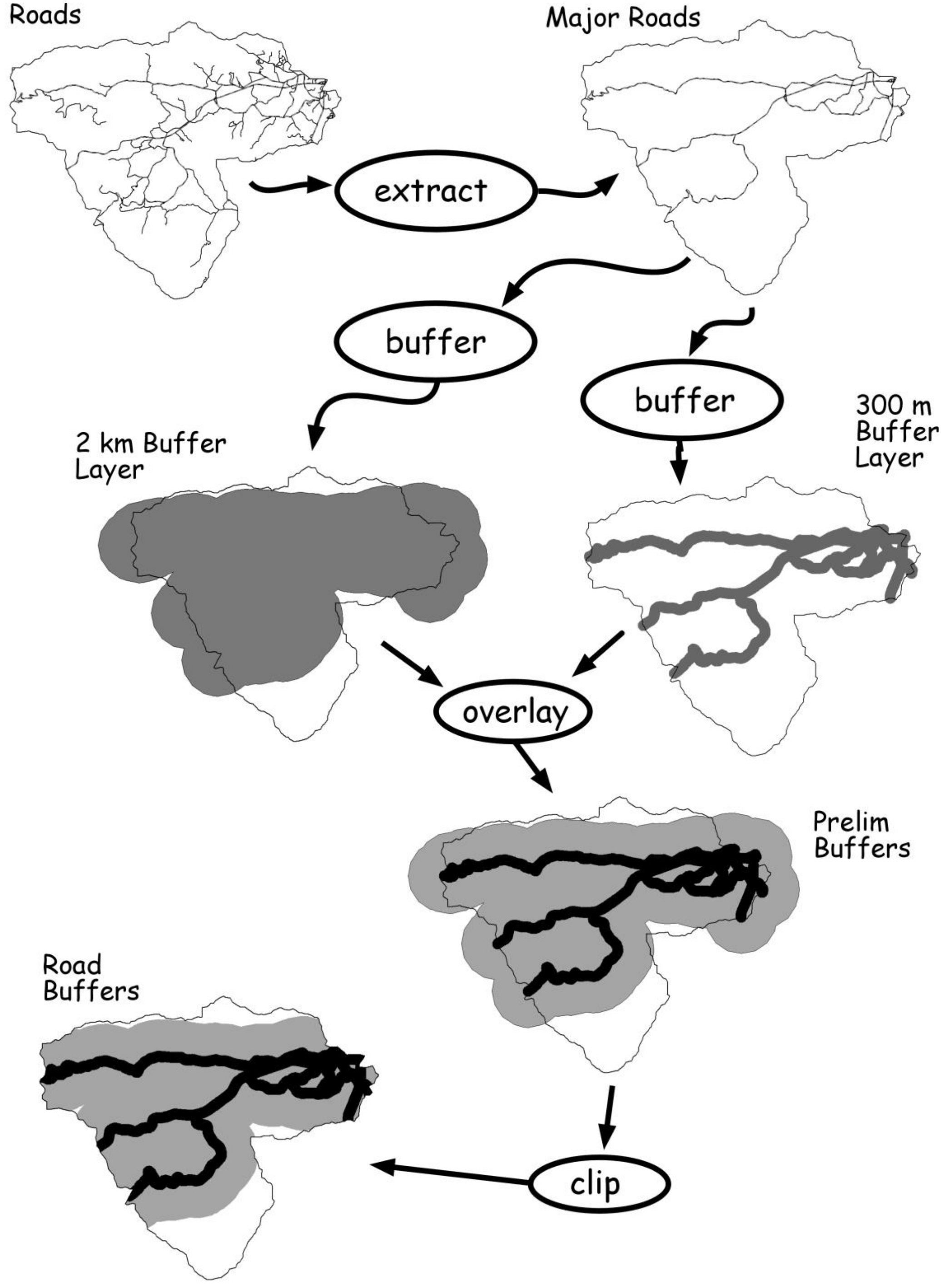
Soils polygons are recoded based on the soil type. The variable soil_suit is assigned a value 0 for unsuitable soil types and 1 for suitable soil types.

soil type	soil_suit
Buncombe	0
Cowee	1
Culasaja	1
Evard	1
Hiawasee	0
Santee	0
...	...
Vernon	0

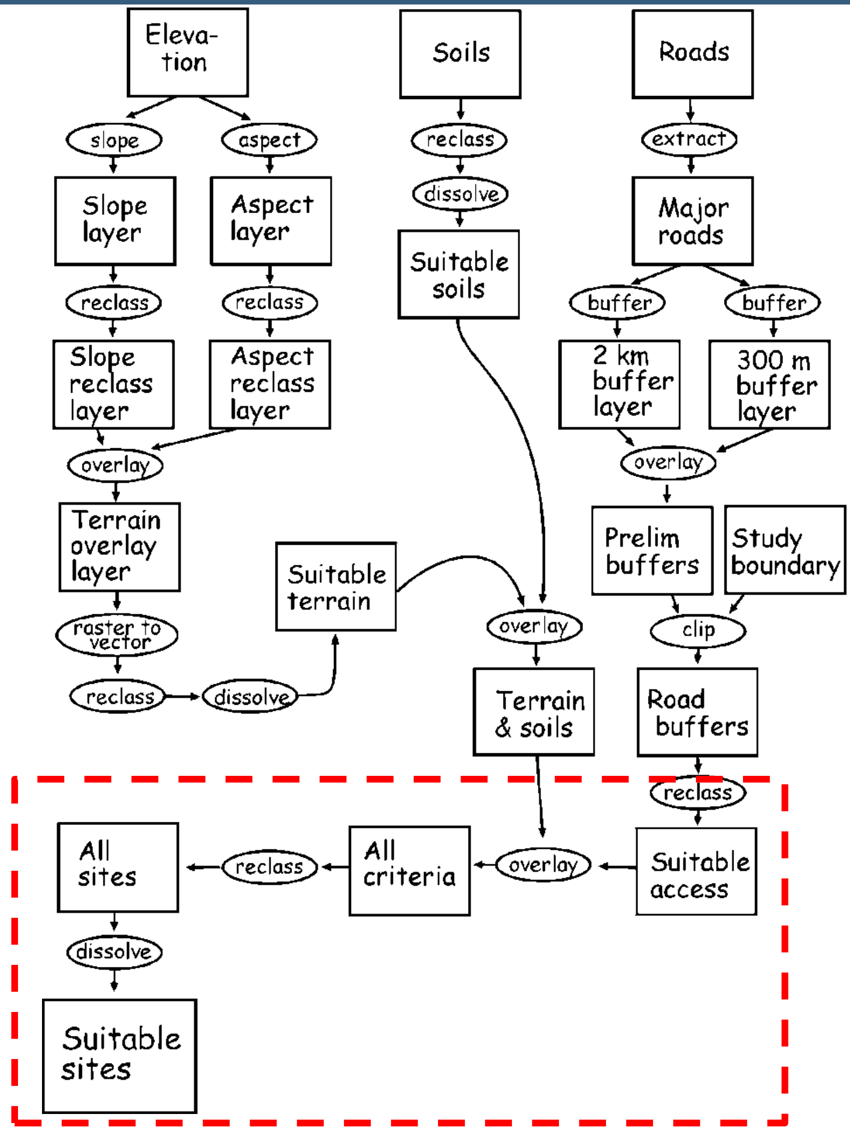


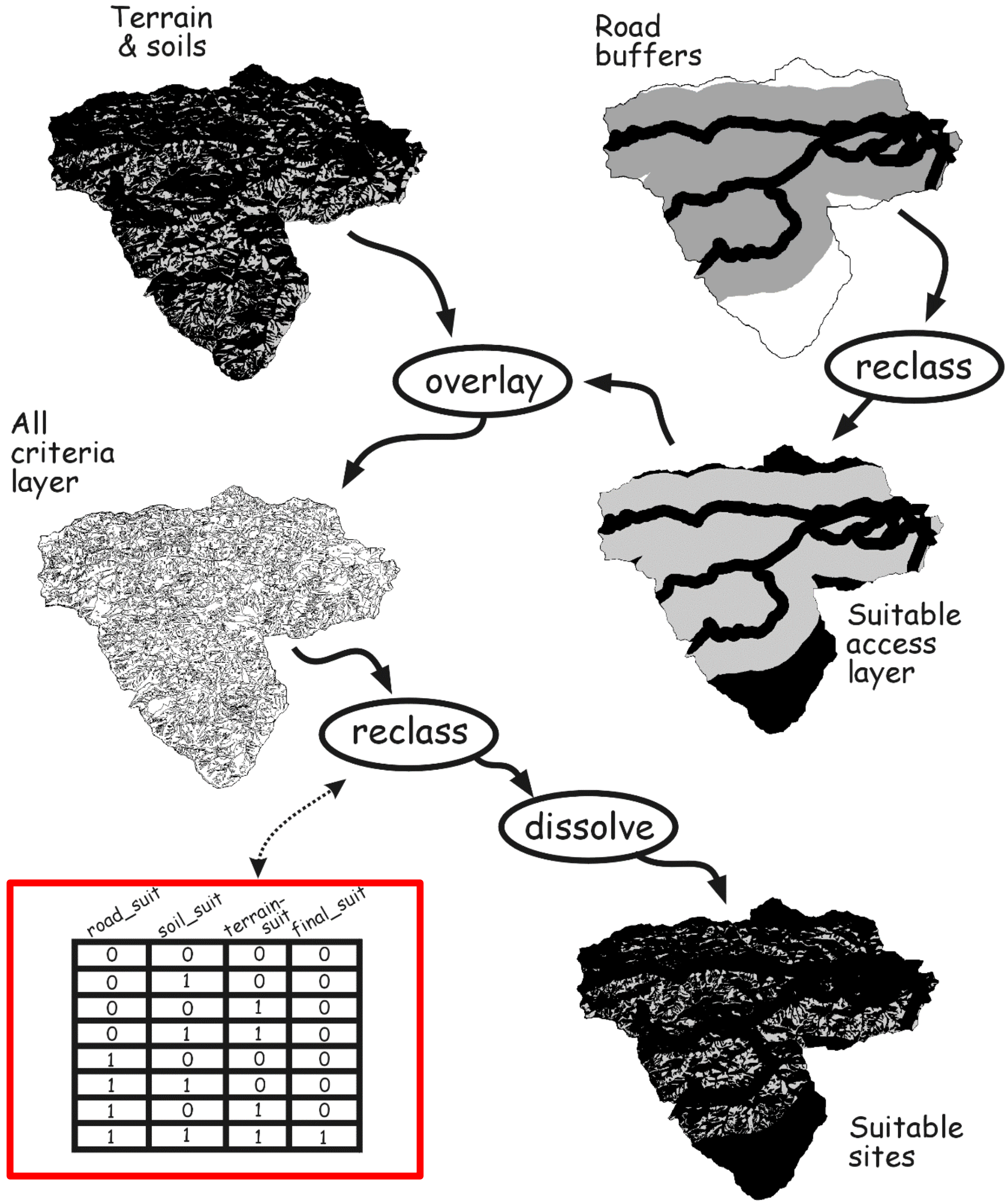
Construct Model - Roads




Roads
Major Roads
extract
buffer
buffer
2 km Buffer Layer
300 m Buffer Layer
overlay
Prelim Buffers
Road Buffers
clip

Construct Model – Combine all criteria





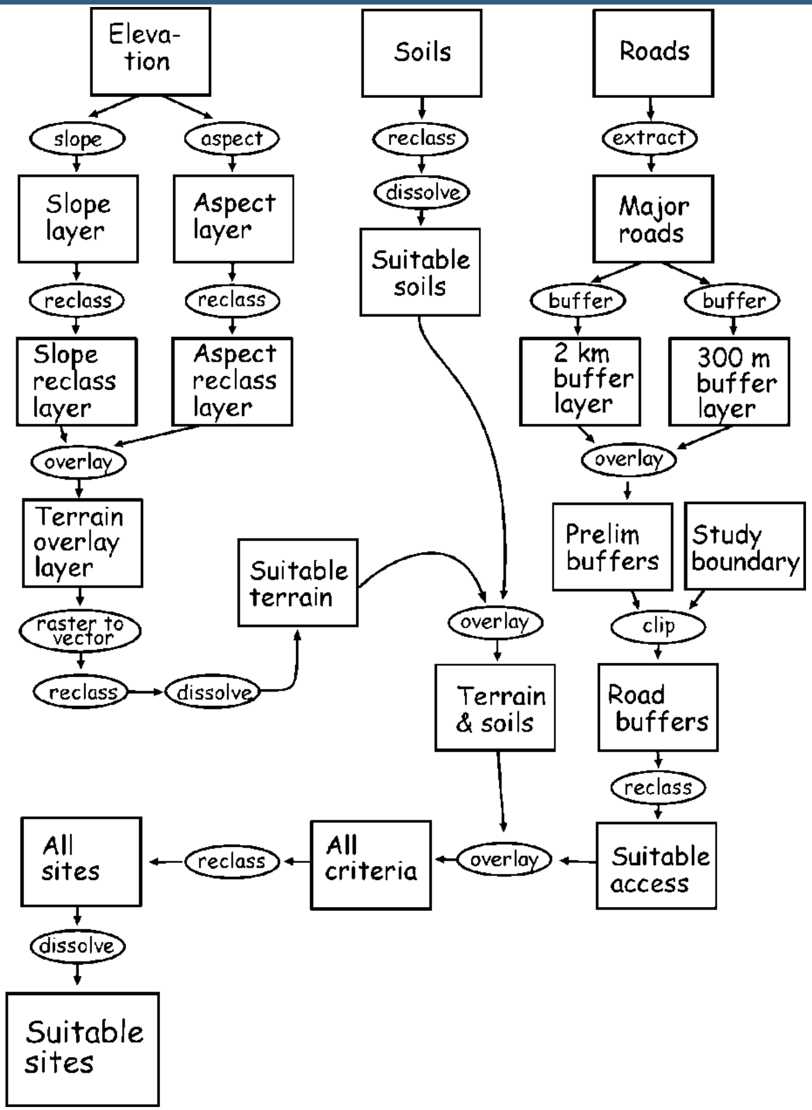
road_suit	soil_suit	terrain-suit	final_suit
0	0	0	0
0	1	0	0
0	0	1	0
0	1	1	0
1	0	0	0
1	1	0	0
1	0	1	0
1	1	1	1

Suitable Sites – Final output table

road_suit	soil_suit	terrain-suit	final_suit
0	0	0	0
0	1	0	0
0	0	1	0
0	1	1	0
1	0	0	0
1	1	0	0
1	0	1	0
1	1	1	1

Boolean Model: only cells that meet <u>all</u> criteria are considered to be "suitable"

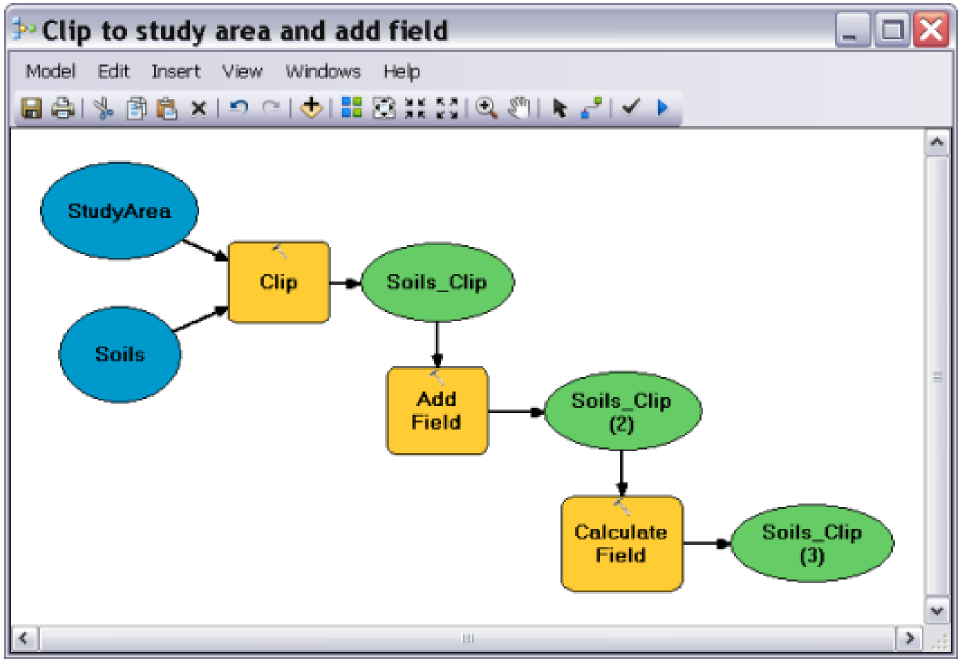
Final Cartographic Model



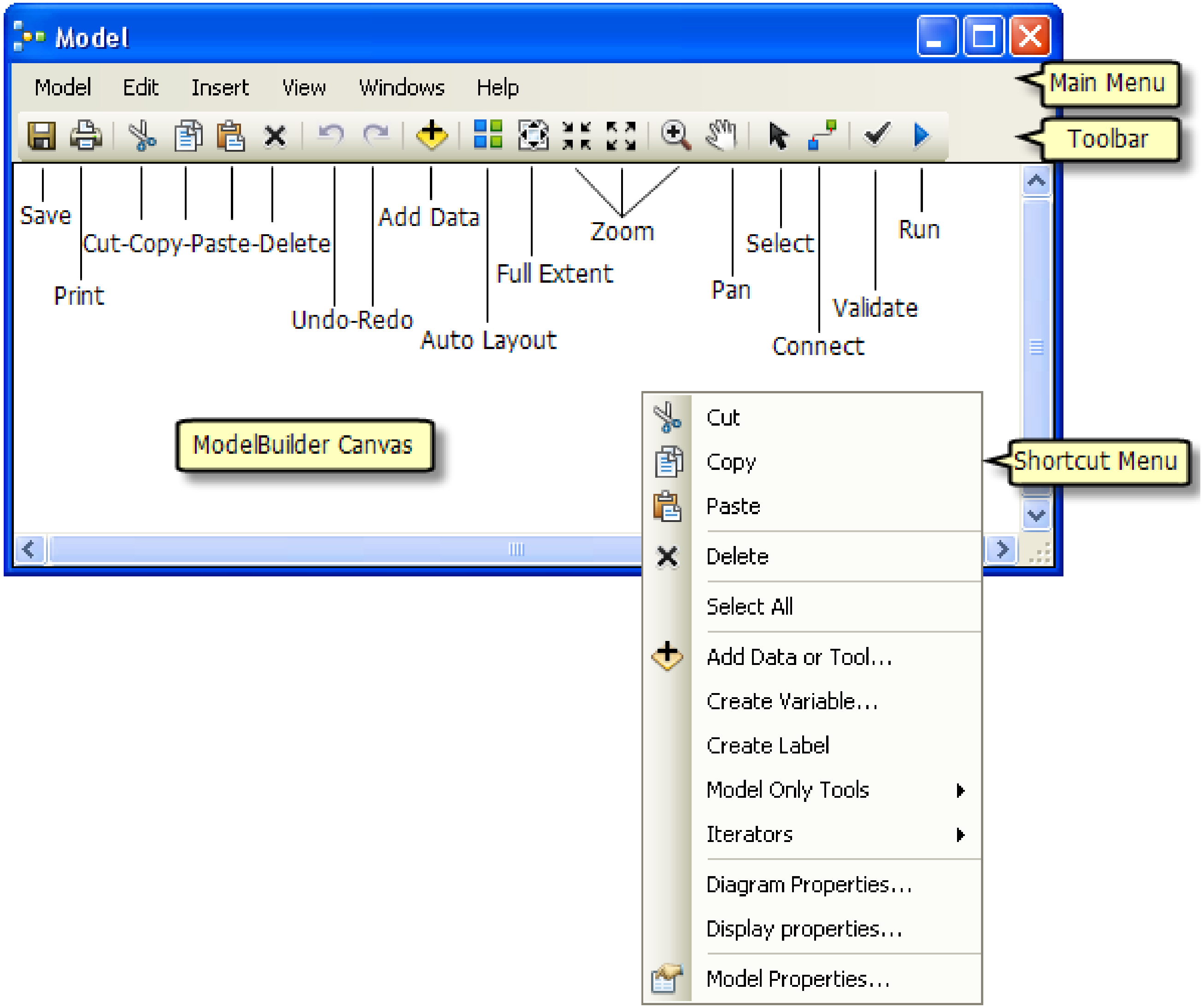
ArcGIS Model Builder

What is ModelBuilder?

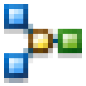
- ArcGIS Application
- Used to create, edit, and manage models
- "Visual programming language" for building workflows



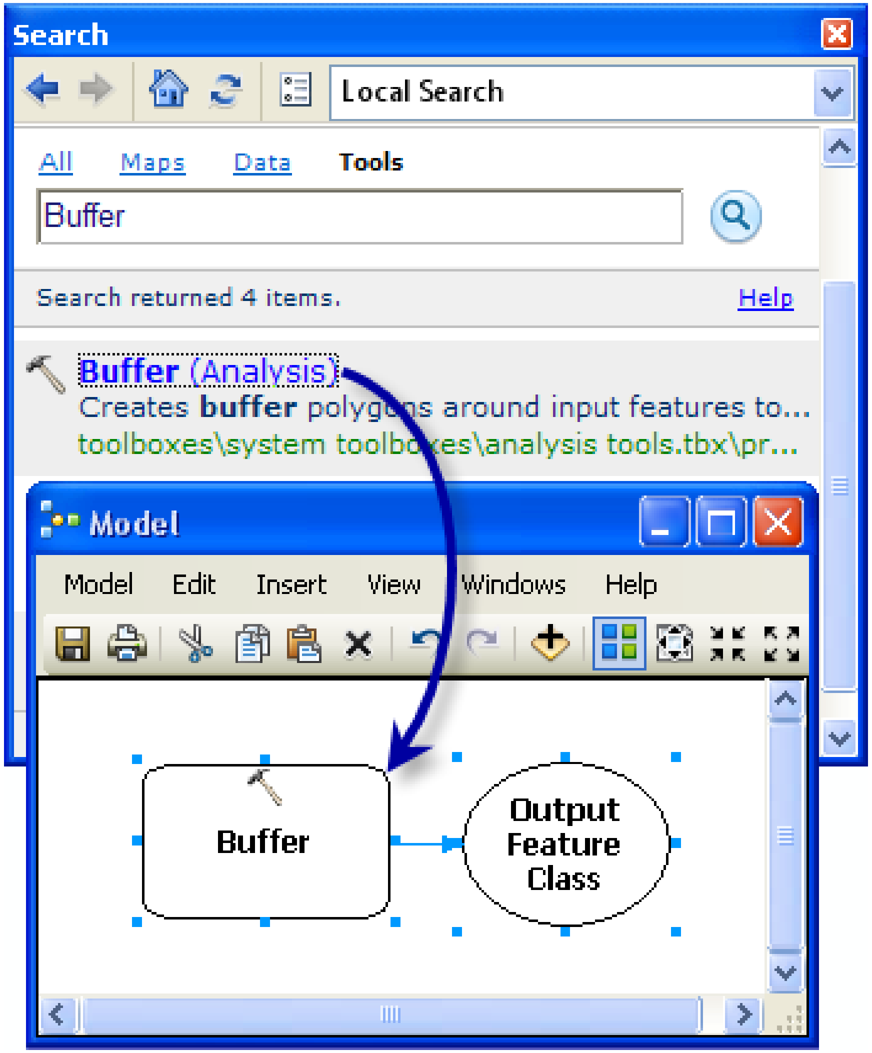
ModelBuilder Interface

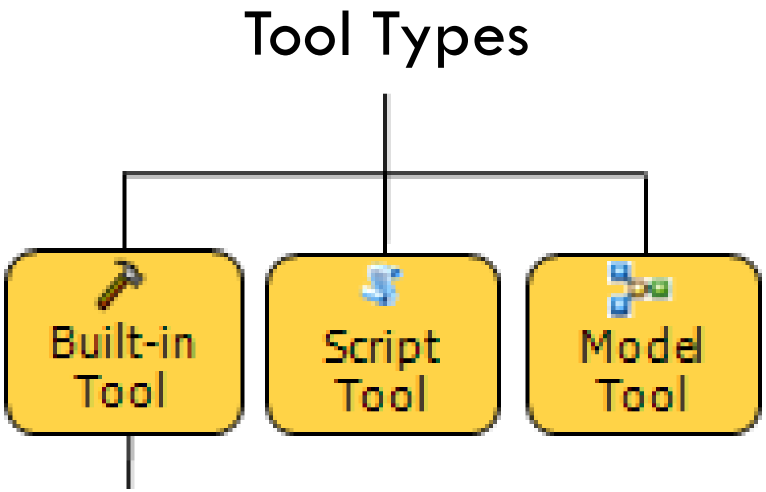


Model Builder Steps

1. Create a new, empty model
    a) ArcMap Standard toolbar > ModelBuilder tool 
    b) or ArcToolbox > New Toolbox > New Model
2. Add Model Elements:
    a) Tools
    b) Variables
    c) Connectors
3. Save and Run the Model

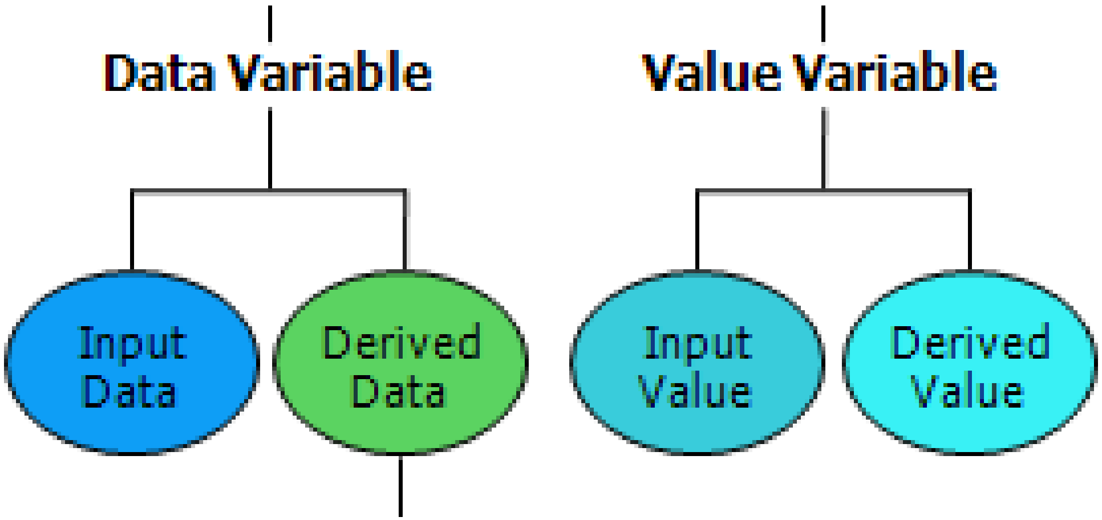
Model Elements – Adding Tools



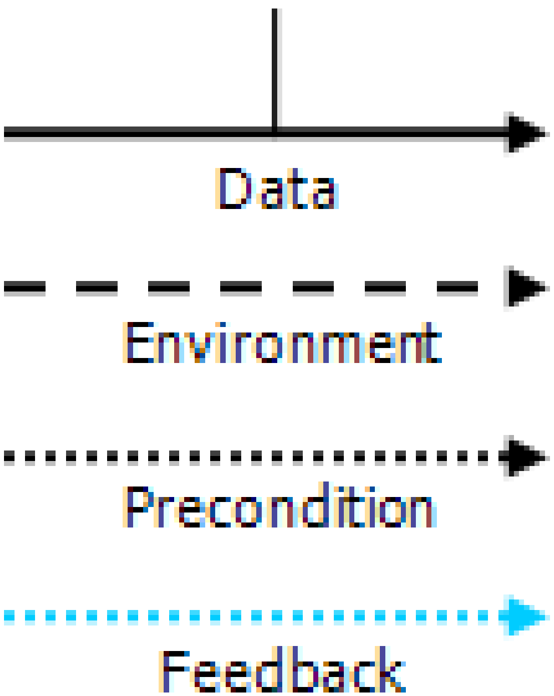


Model Elements – Adding Variables

- ***Data***: input (existing) or derived (created by model)
  - "Add Data" button  or Drag-and-Drop to model
- ***Values***: strings, numbers, booleans, linear units or extents. Input or derived.



Model Elements – Connector Types



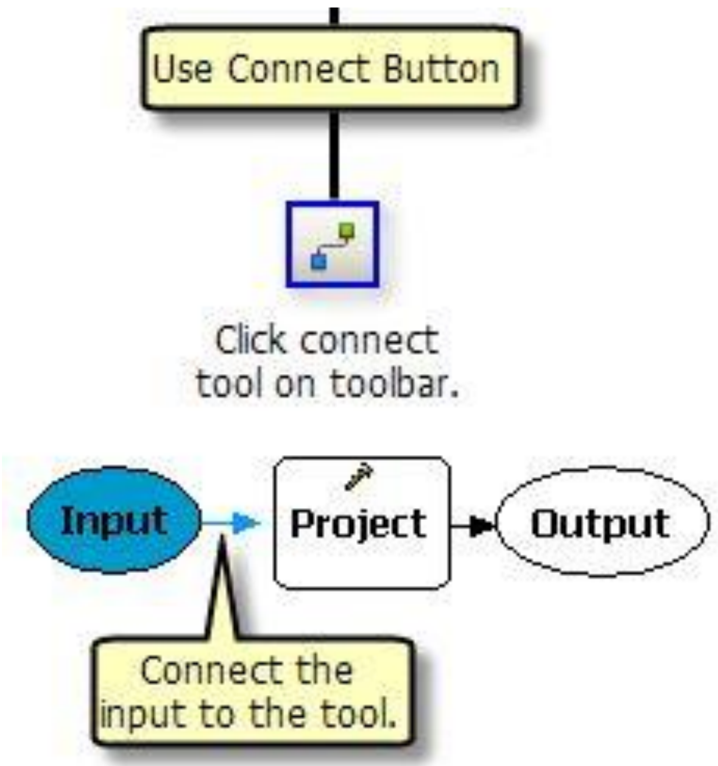
Data: connect data/variables to tools

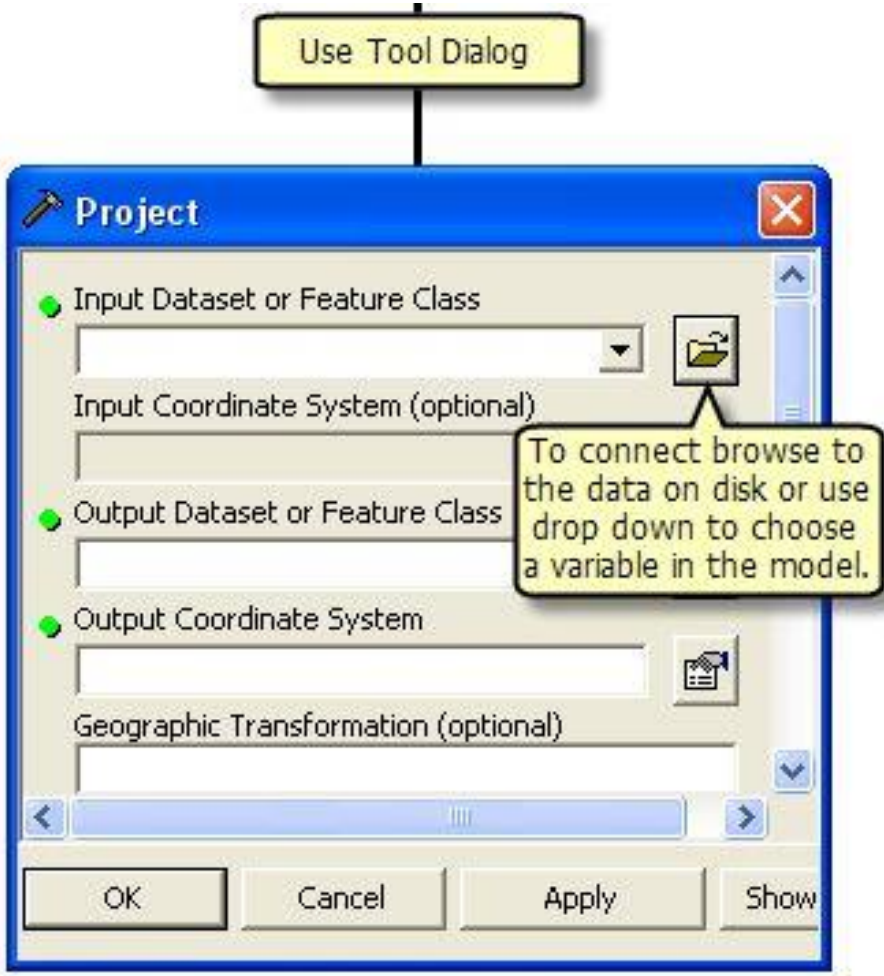
Environment: connect a variable containing an environment setting (data or value) to a tool

Precondition: connect a variable to a tool – tool will not execute until the precondition is met

Feedback: connect the output of a tool into the same tool as the input

Model Elements – Adding Connectors

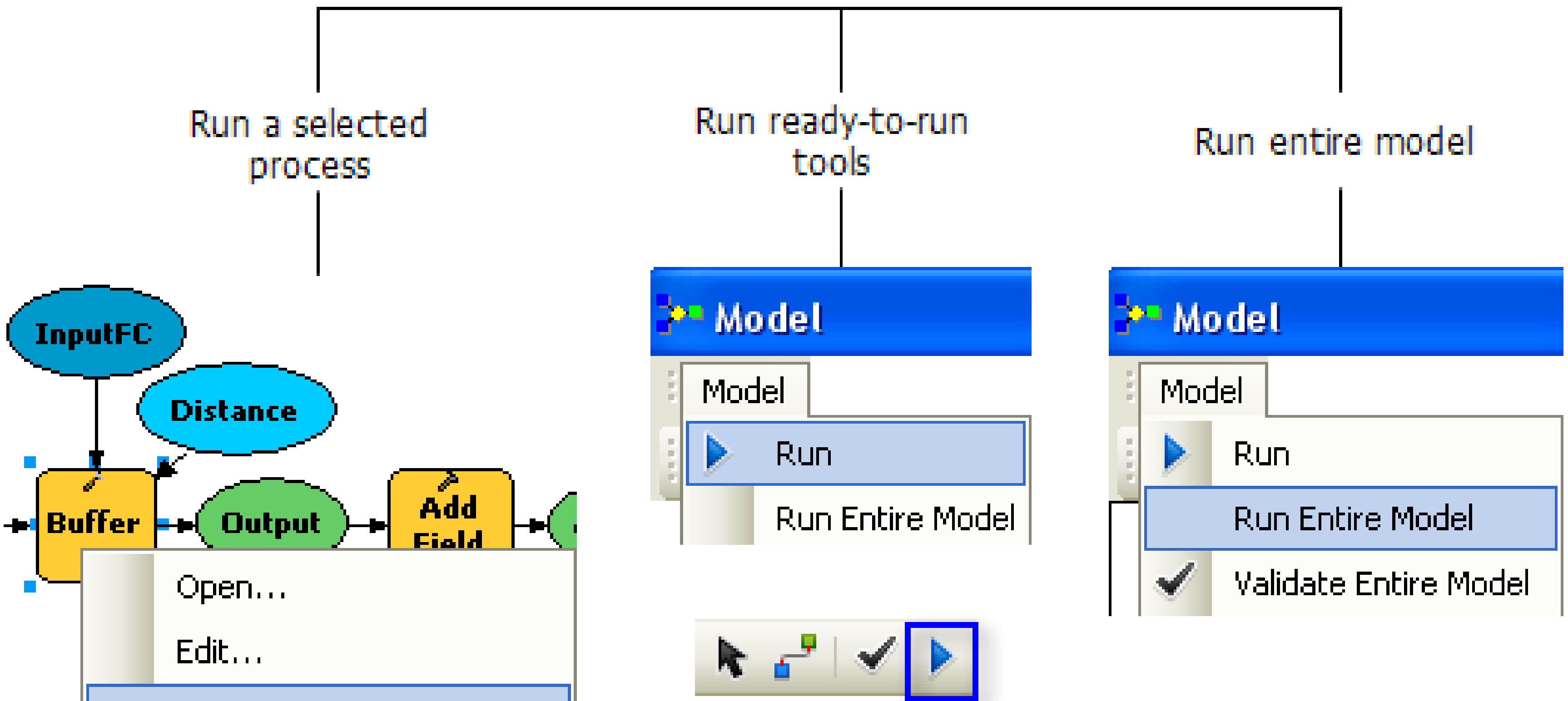




Running the Model

- **Run Single tool** - Select a tool > right-click > **Run**
- **Run Ready-to-run tools**
  - Model menu > **Run** tool 
  - ModelBuilder toolbar > **Run** tool
- **Run Entire model** – Model menu > **Run Entire Model**

Running a Model in ModelBuilder



Model toolbar run tool.