



Map Algebra

4

Lesson 4A overview

❑ Introduction to Map Algebra (4A)

- Language components
- Syntax and rules
- Objects
- Operators
- Commands
- Exercise 5A

❑ Map Algebra functions (4B)

- Function syntax
- Local functions
- Focal and Block functions
- Zonal functions
- Global functions
- Exercise 5B

Map Algebra: The language of raster

❑ A data-manipulation language designed for raster

- Math-like expressions

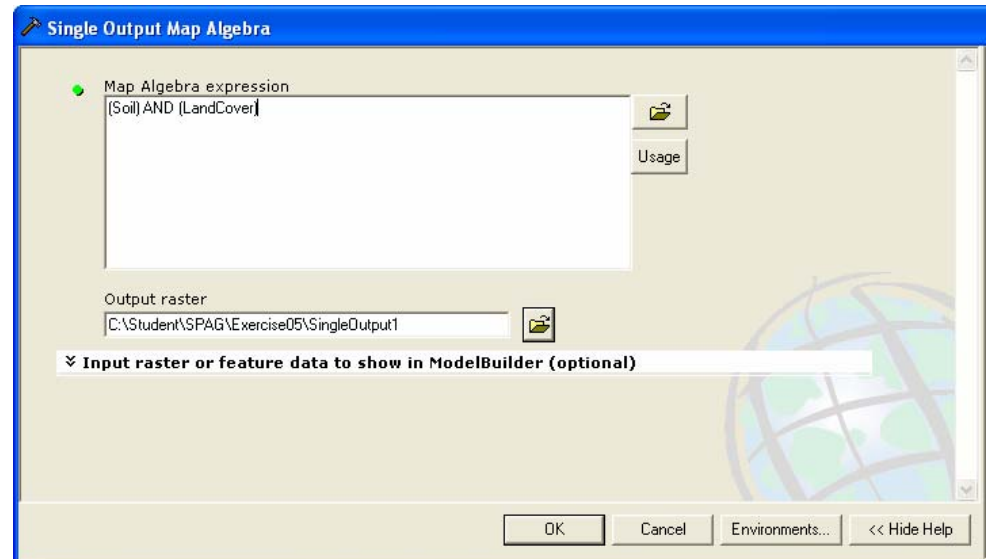
$$\text{AqSuit} = (\text{SoilSuit} * 0.75) \div (\text{SlpSuit} * 0.25)$$

❑ Parts of the language:

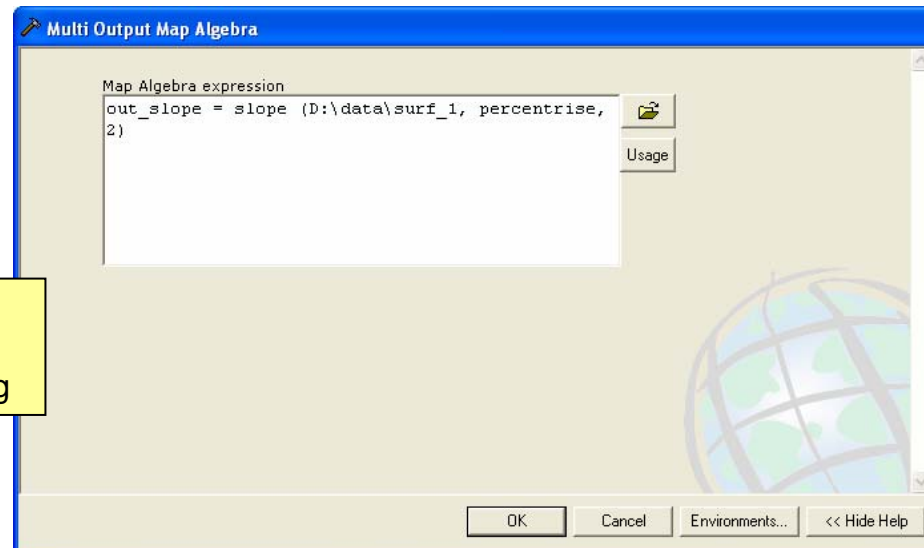
- Objects - Raster, vector, numbers, constants, variables...
- Operators – “+”, “-”, “/”, “GT”, “LE”, “AND”, “OR”
- Functions - SLOPE, FOCALMEAN, SIN,
 - Central part of the language; over a hundred
 - User interface implements some, like SLOPE
- Rules - For building expressions and using functions

Map Algebra geoprocessing tools

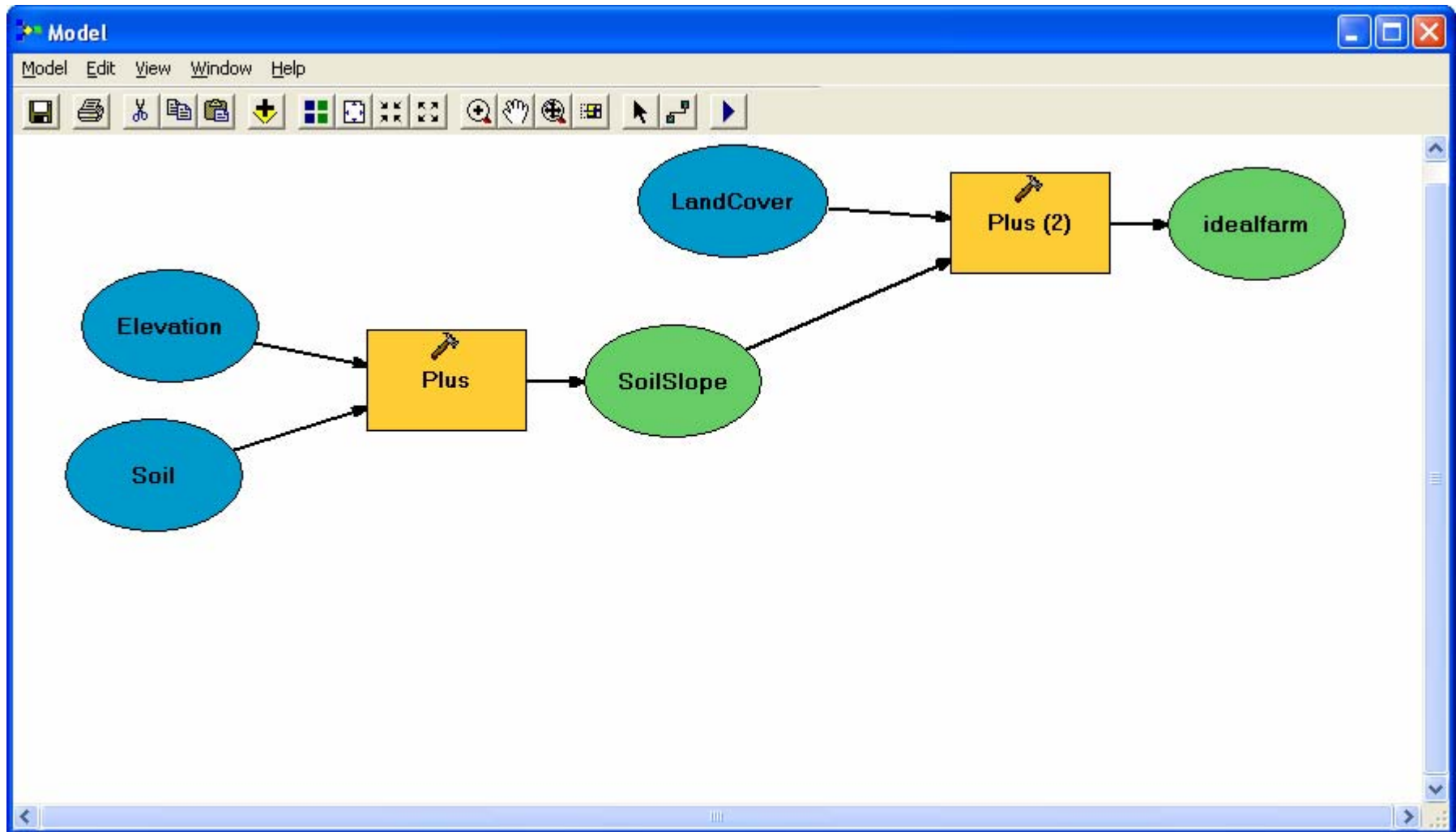
Single Output Map Algebra
Output path:
Appears on the tool



Multi Output Map Algebra
Output path:
Set in Environment Settings dialog



Geoprocessing tools vs Model Builder



Expression syntax rules

❑ Delimit operators and objects with blanks

Wrong: `Layer+Layer2+Layer3`

Right: `Layer1 + Layer2 + Layer3`

❑ Operators are evaluated by precedence level

`Layer1 + Layer2 * Layer3`

❑ Override operator precedence with parentheses

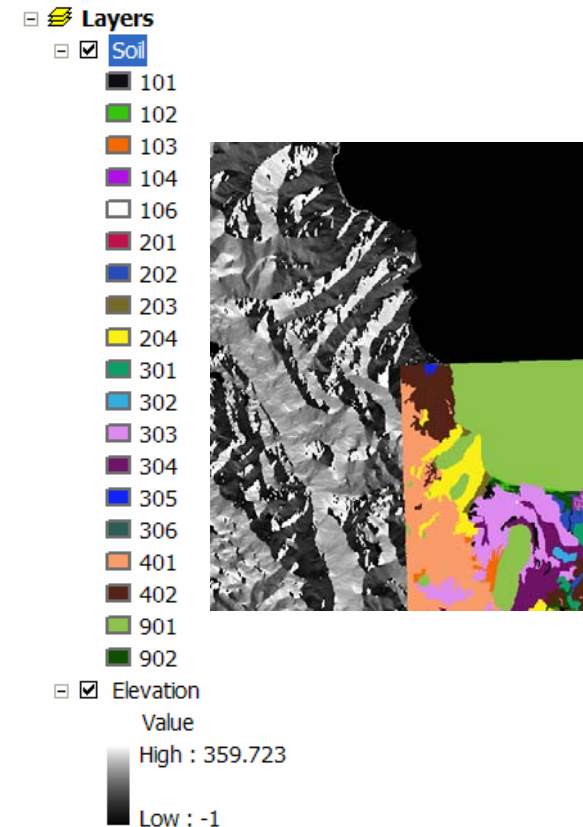
`(Layer1 + Layer2) * Layer3`

❑ Nested parenthetical expressions evaluate first

`(Layer1 + Layer2) / 4 - Layer3`

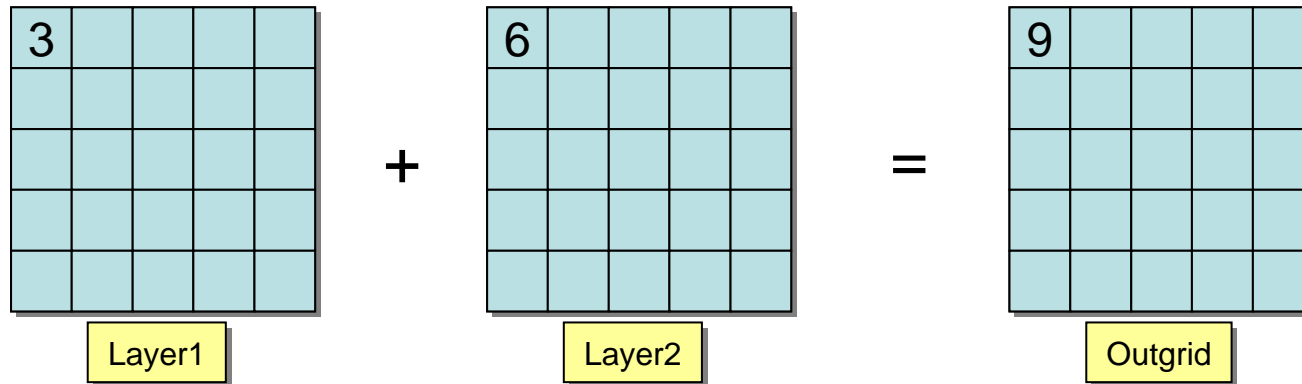
Expression results

- ❑ Expressions return grids, vector data, tables, etc.
 - Depends on functions used
 - Most expressions return grids
- ❑ Tools supply default output names
 - Can rename
- ❑ Layers added to ArcMap
Table of Contents



Expression evaluation

❑ How expressions are processed



- ❑ 1. Define an empty output raster based on the analysis environment
- ❑ 2. Position to the next output cell (start at row 0, column 0)
- ❑ 3. Resample input raster(s) to determine corresponding cell values
- ❑ 4. Evaluate the expression and write the result to the output cell
- ❑ 5. Repeat steps 2—4 for all output cells

Map Algebra objects

❑ Objects used in expressions or as function arguments

- Raster as layers or paths

`SLOPE (Elevation)`

`SLOPE (a:\student\database\arelev)`

- Vector as paths

`SHAPEGRID (a:\student\database\avroad.slip)`

- Tables - Output by a few functions
- Numbers - Integer or decimal
- Scientific notation okay (1.234e² is the same as 123.4)
- Constants and variables (P1, DEG, \$\$ROWMAP, \$\$NROWS, etc.)
 - Built in for your convenience

User attributes in expressions

- ❑ You may use numeric VAT fields in expressions
- ❑ Reference with *Layer.field* notation

Vegetation.vat			
Value	Count	Desc	Suit
101	2450	Grass	1
201	65780	Mixed	3
301	32187	Pine	2
401	5433	Oak	5

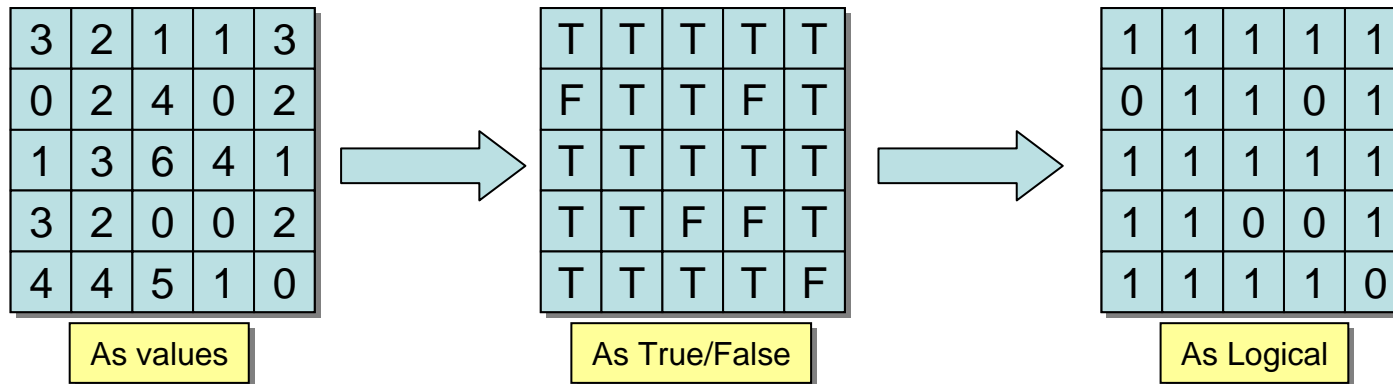
Soil.vat			
Value	Count	Desc	Suit
23	2450	Sand	2
46	65780	Loam	1
87	32187	Clay	6
99	5433	Rock	9

Vegetation.suit + soil.suit

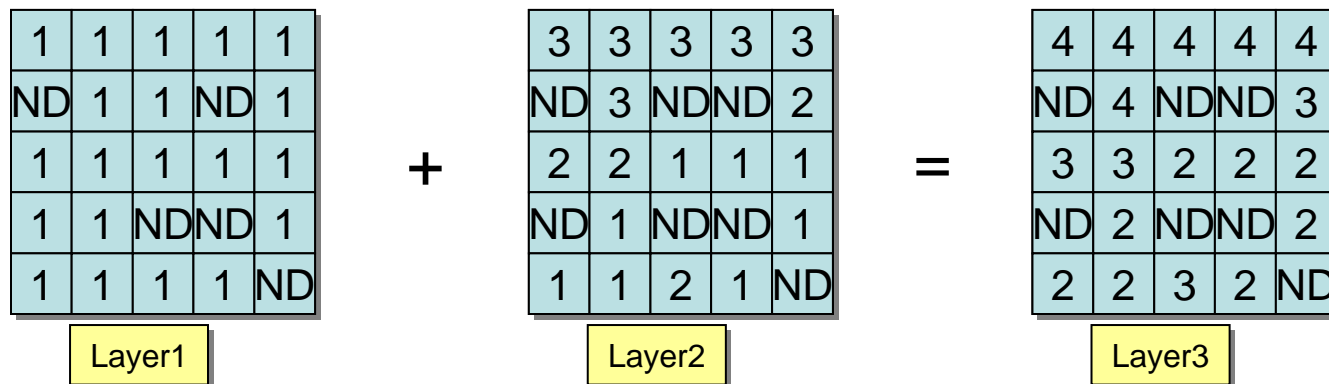
- *Layer alone* is assumed to be Layer.Value
- ❑ You may join tables to raster VAT file
 - Use joined fields for symbology, selection
 - Cannot use in Map Algebra expressions

Special cell values in Map Algebra

- **Logical** - Non-zero values are *True*, zero is *False*



- **NoData** - If any input is *NoData*, the output is *NoData*



Map Algebra operators

- ❑ Work with two inputs, like **Slope GE 10**

Boolean

^, NOT	Logical complement
&, AND	Logical And
I, OR	Logical Or
!, XOR	Logical Xor

Relational

=, EQ	Equal
^=, <>, NE	Not Equal
<, LT	Less than
<=, LE	Less than or equal
>, GT	Greater than
>=, GE	Greater than or equal

Arithmetic

+	Addition
-	Subtraction
*	Multiplication
/, DIV	Division
MOD	Modulus
-	Unary minus

Combinatorial

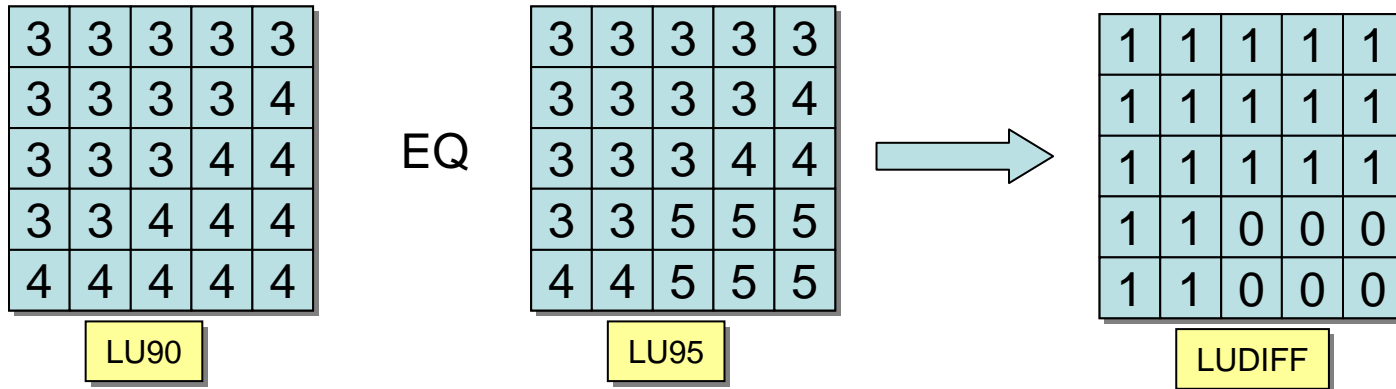
COR	Combinatorial Or
CAND	Combinatorial And
CXOR	Combinatorial XOR

Logical

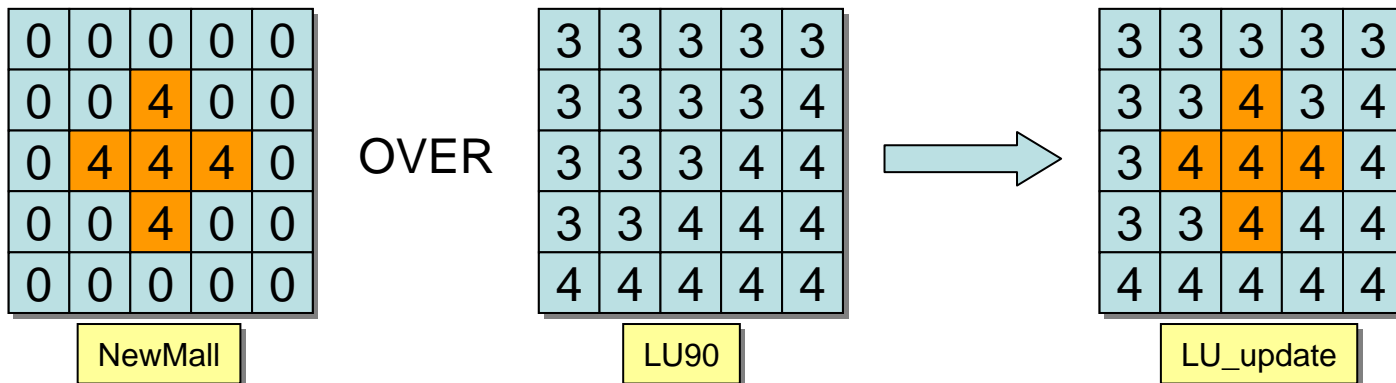
DIFF	Logical difference
IN {list}	Contained in list
OVER	Replace

Examples of operators

❑ Using EQ to find changes in lad use

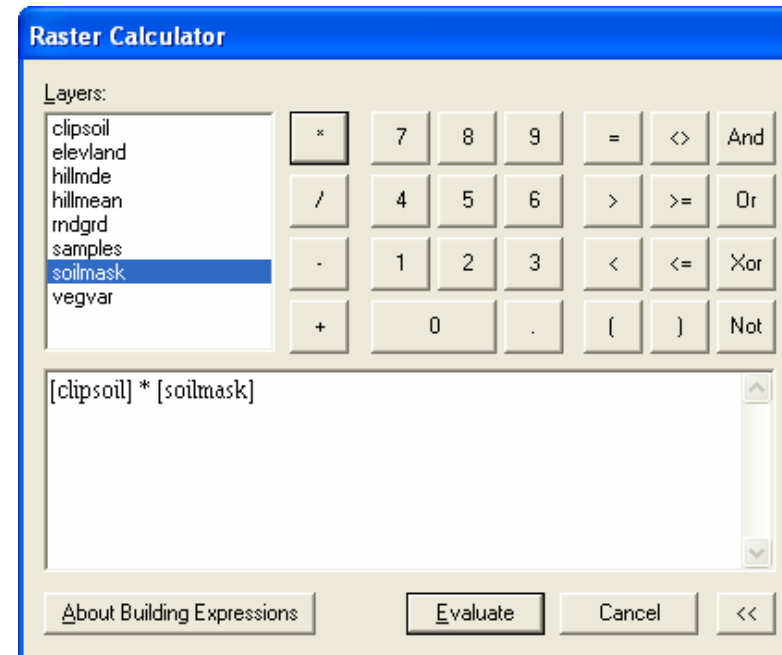


❑ Using over to update land use



ArcGIS Spatial Analyst command

- ❑ There are a few commands
 - Tasks not suited to functions
 - Enter in Raster Calculator
- ❑ Not part of Map Algebra
 - Cannot use in expressions
- ❑ Mostly data management
 - Build attribute tables
 - Create, manage grid stacks
 - Others



Exercise 4A overview

- ☐ **Work with Map Algebra**
- ☐ **Operators**
- ☐ **Objects**
- ☐ **Commands**

Lesson 4B overview

❑ Introduction to Map Algebra (4A)

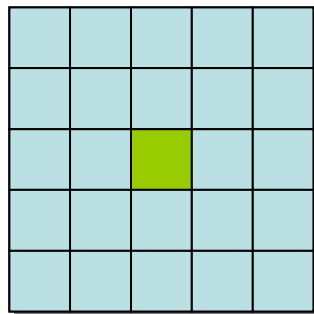
- Language components
- Syntax and rules
- Objects
- Operators
- Commands
- Exercise 4A

❑ Map Algebra functions (4B)

- Function syntax
- Local functions
- Focal and Block functions
- Zonal functions
- Global functions
- Exercise 5B

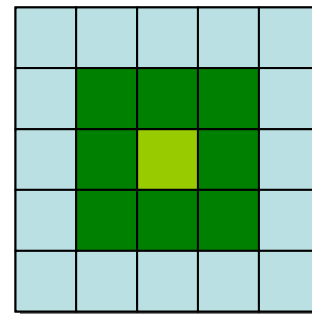
Map Algebra functions

- ❑ Do most of the work in Map Algebra
 - About 168 functions
- ❑ Can classify functions by processing method



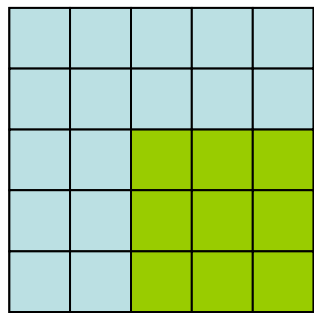
Local

By Cell



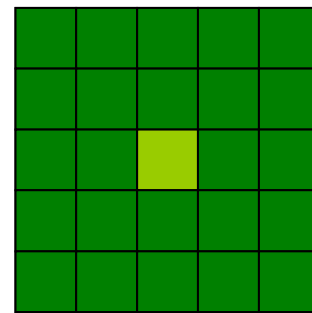
Focal

By neighborhood



Zonal

By zone



Global

By raster

Function syntax rules

- ❑ Functions return values
- ❑ Use as “objects” in expressions

```
Farmsoils + CON(Slope LE 15, 1, 0)
```

- ❑ Arguments in parentheses and comma-delimited

```
SLOPE(Elevation, DEGRE)
```

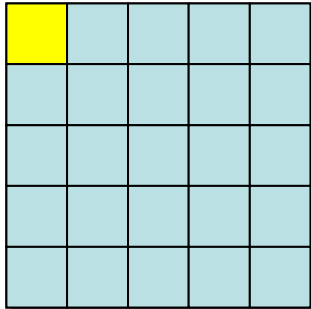
- ❑ Arguments may be other functions or expressions*

```
SLOPE (IDW(c:\data\elevpoints, spot), DEGREE)
```

- ❑ * If they return the data expected by the argument
- ❑ * If the function allows it

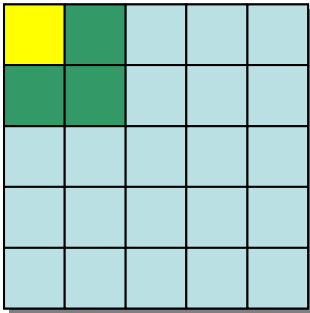
Local functions

- ❑ **Compute values based on the current output cell**
 - Most functions are local
- ❑ **Each cell is processed, starting at top left**



Focal functions

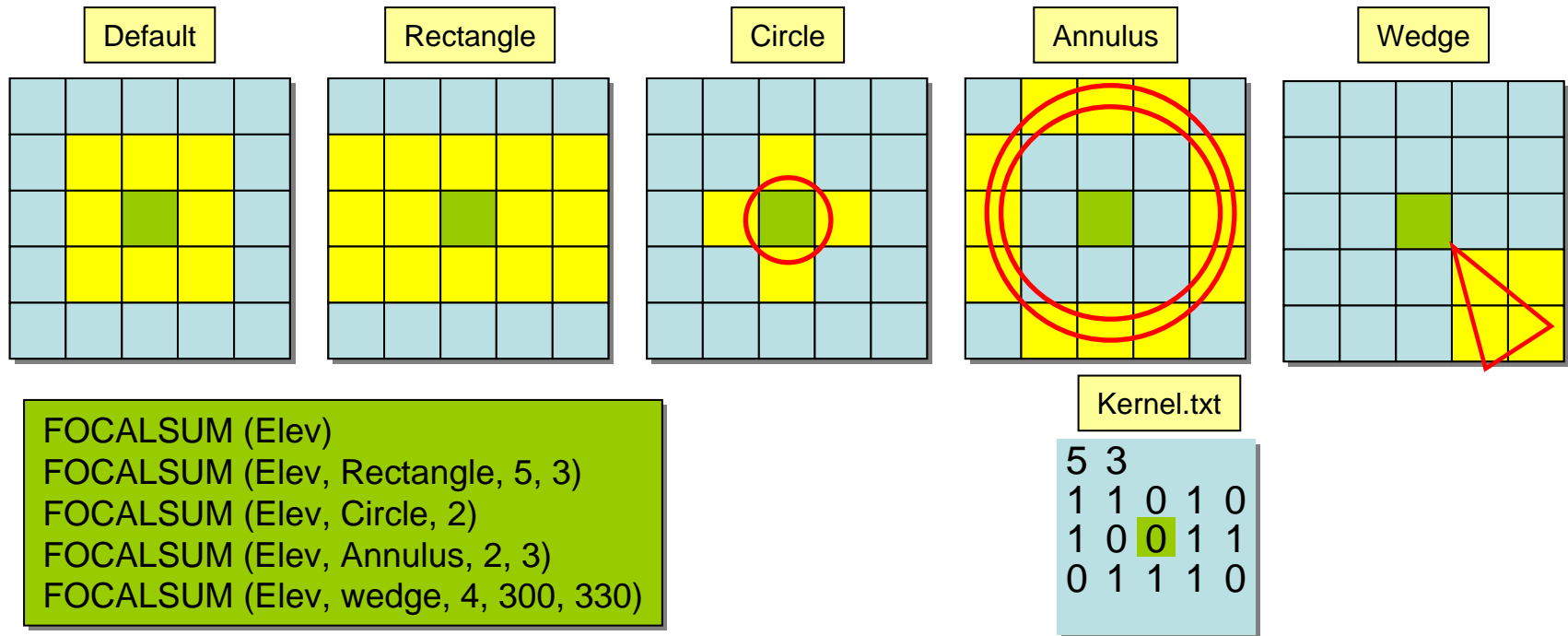
- ❑ **Compute values by cell neighborhoods**
 - Writes result to current cell in the output grid
- ❑ **Neighborhood is a moving window over input**



- ❑ **General syntax:**
`FOCALxxx(InLayer, neighborhood, (DATA | NODATA))`

Focal neighborhoods

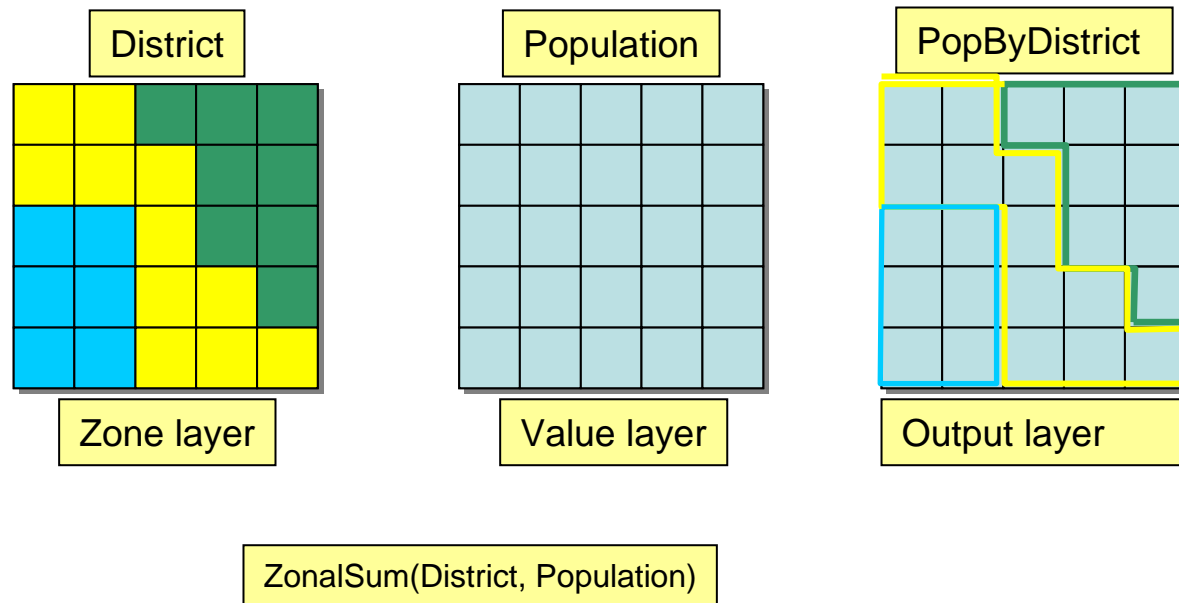
- ❑ You may define the neighborhood geometry



- ❑ Create a custom neighborhood with a kernel file

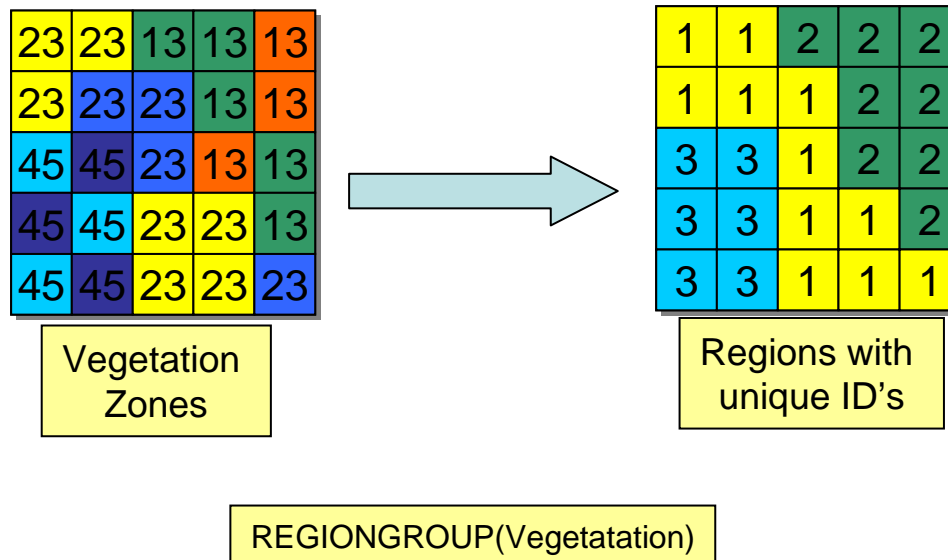
Zonal functions

- ❑ Most summarize values in a layer by zones in another
 - Require two input rasters: Zone and Value



Global functions

- ❑ May access all input cells to compute output cell value
 - Mostly do distance
- ❑ **REGIONGROUP** assigns unique ID's



The CON function

❑ IF-THEN-ELSE function for Map Algebra

`CON(<condition>, <true_expression>, {false_expression})`

`IF TEST THEN(TEST= 1) ELSE(TEST=0)`

❑ May be a simple IF-THEN-ELSE

`CON(Slope <20, 1, 0)`

❑ Or nest CONs for an ELSE-IF

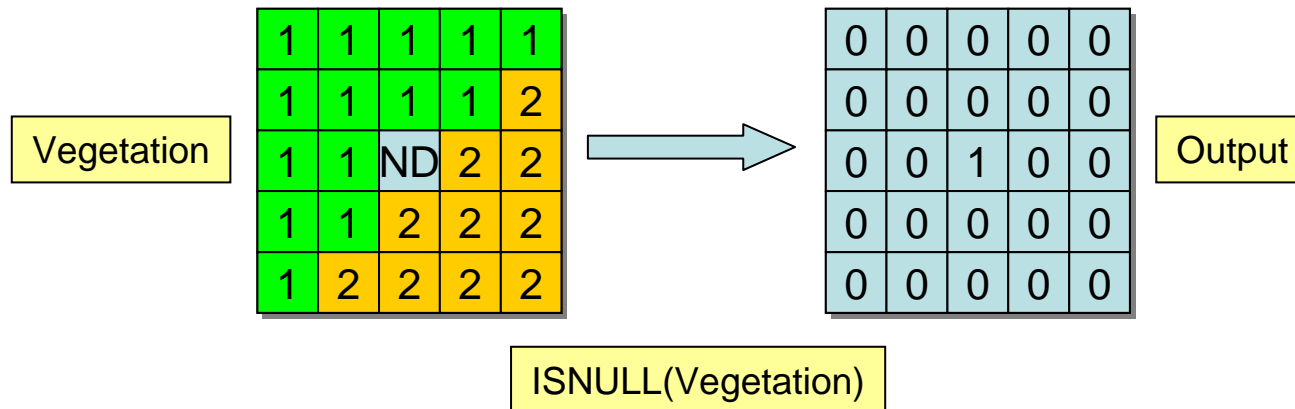
`CON(Slope < 20, 1,`

`CON(Slope < 40, 2, ← First CON {false expression}`

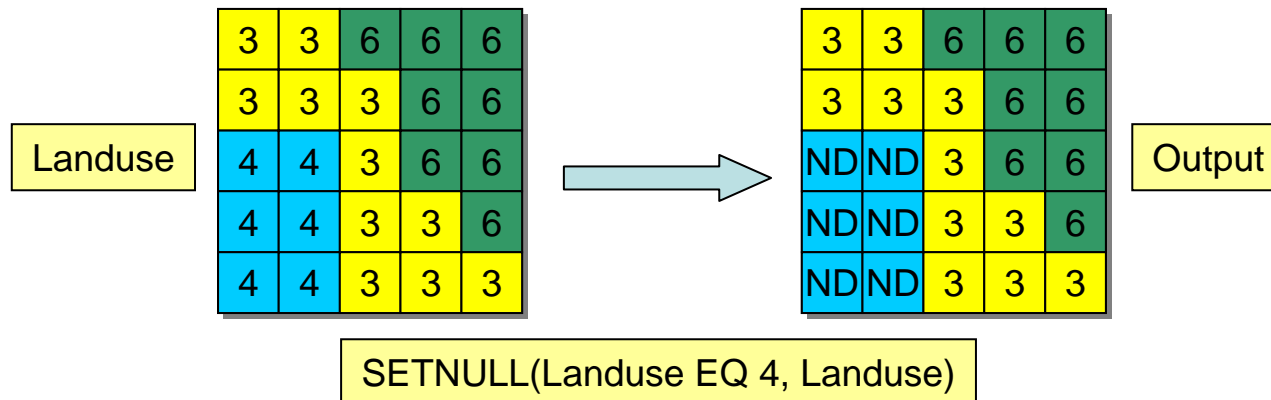
`CON(Slope < 90, 3, 5))) ← Second CON {false_expression}`

Working with NoData

- ❑ **ISNULL** tests for NoData: Returns *true* or *false*



- ❑ **SETNULL** assigns NoData to cells that pass a test



Exercise 4B overview

- ☐ Work with Map Algebra functions
- ☐ Work with local functions
- ☐ Work with focal functions
- ☐ Work with zonal functions
- ☐ Work with global functions