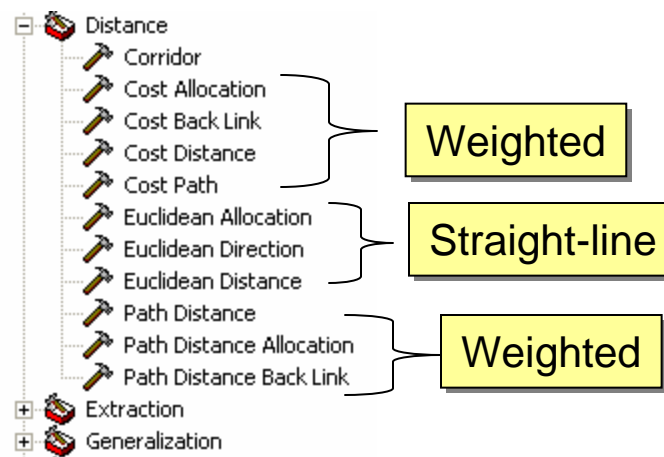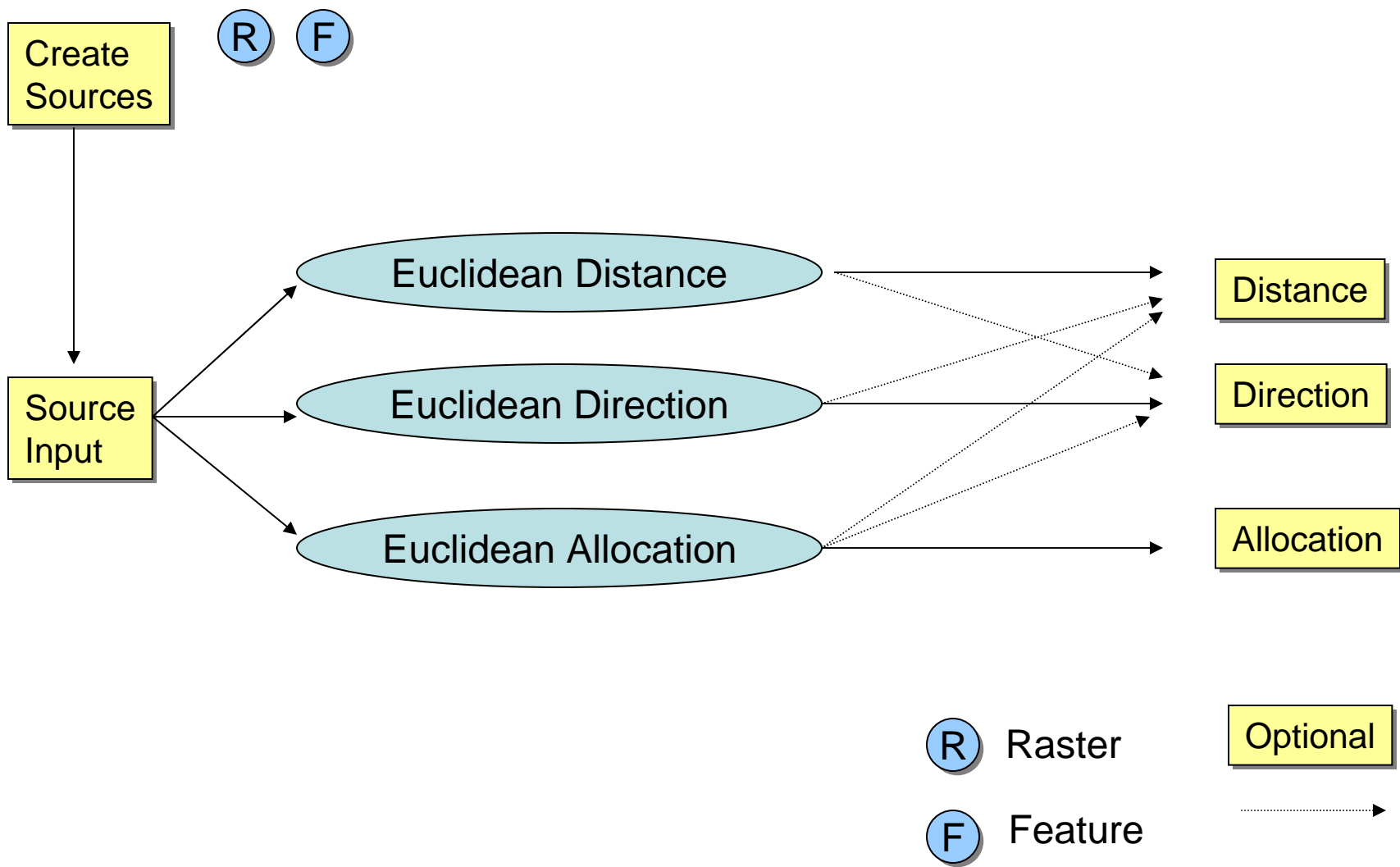# Distance Tools

6

Lesson 6 overview

- ❑ **Straight-line distance**
- ❑ **Euclidean distance: Distance to closest store**
- ❑ **Euclidean allocation: ID of closest store**
- ❑ **Euclidean direction: Compass heading to closest store**
- ❑ **Weighted distance**
- ❑ **Inputs: Cost surface and sources**
- ❑ **Cost distance: How long to drive to closest store?**
- ❑ **Cost path: Best path to the closest store**
- ❑ **Corridor: Probability of travel between stores**
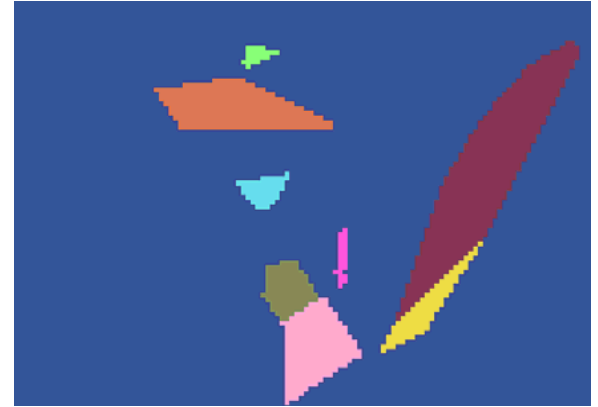- ❑ **Exercise**

Distance tools

Distance
- Corridor
- Cost Allocation
- Cost Back Link
- Cost Distance
- Cost Path

Weighted

- Euclidean Allocation
- Euclidean Direction
- Euclidean Distance

Straight-line

- Path Distance
- Path Distance Allocation
- Path Distance Back Link

Weighted

Extraction

Generalization

The roadmap - Euclidean distance

Create Sources

(R) (F)

Source Input

Euclidean Distance

Euclidean Direction

Euclidean Allocation

Distance

Direction

Allocation

(R) Raster

(F) Feature

Optional

Euclidean tools output
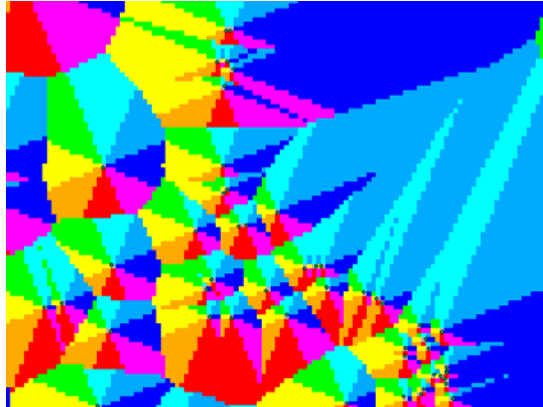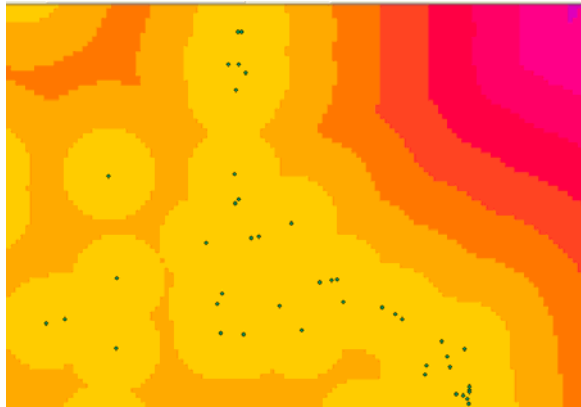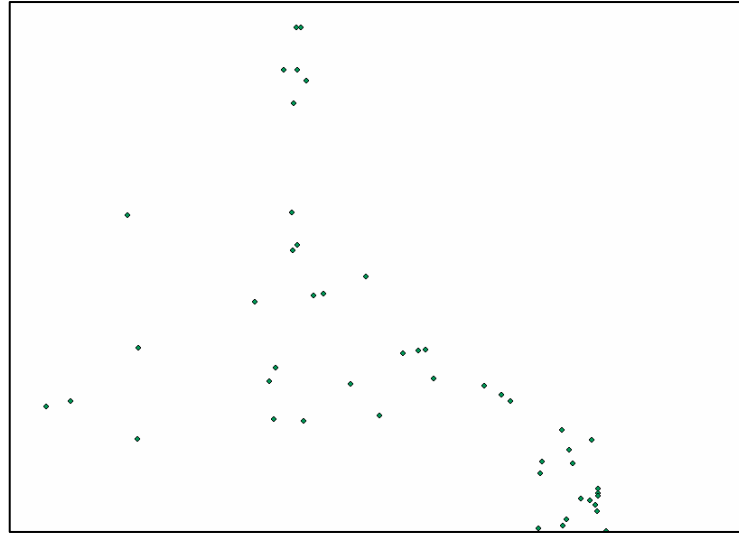
Calculating Euclidean distance

- ❑ **Calculates straight-line distance**
- ❑ **From each cell to nearest source**
- ❑ **Cell center to cell center**
- ❑ **Output in map units (e.g., feet)**
- ❑ **Source cells are output as zero**
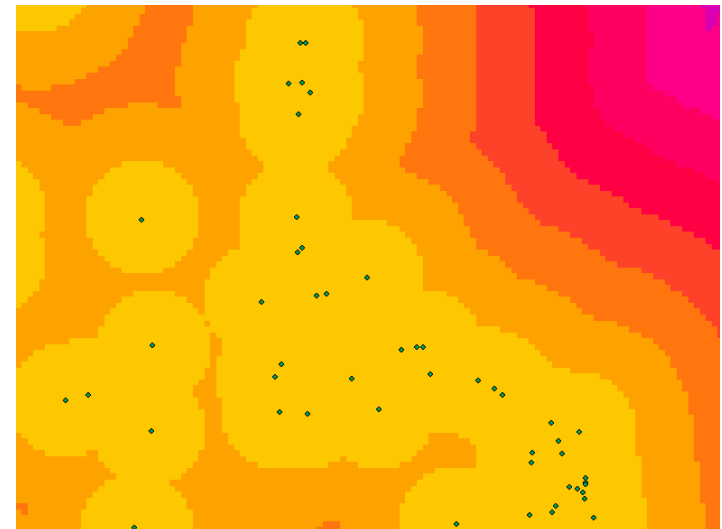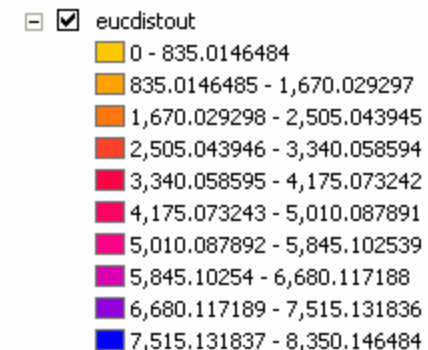- ❑ **Must create sources first**

⊟ ☑ eucdistout
- ▨ 0 - 835.0146484
- ▨ 835.0146485 - 1,670.029297
- ▨ 1,670.029298 - 2,505.043945
- ▨ 2,505.043946 - 3,340.058594
- ▨ 3,340.058595 - 4,175.073242
- ▨ 4,175.073243 - 5,010.087891
- ▨ 5,010.087892 - 5,845.102539
- ▨ 5,845.10254 - 6,680.117188
- ▨ 6,680.117189 - 7,515.131836
- ▨ 7,515.131837 - 8,350.146484

Euclidean direction and allocation

- ❑ **Direction output**
- ❑ **Compass heading from cell to nearest source, 0 to 360**
- ❑ **Allocation output**
- ❑ **Identity of the closest source cell**
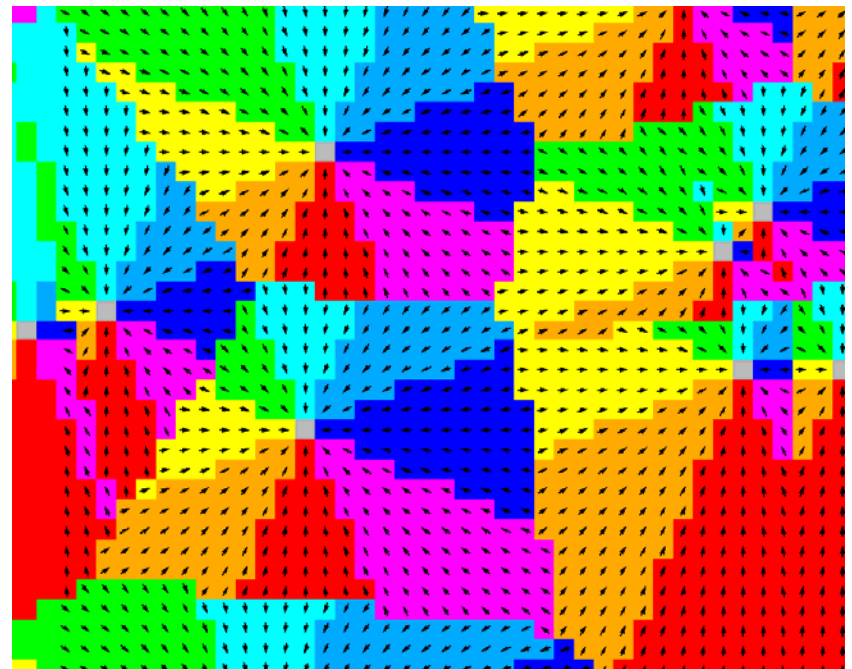
Weighted distance measurement

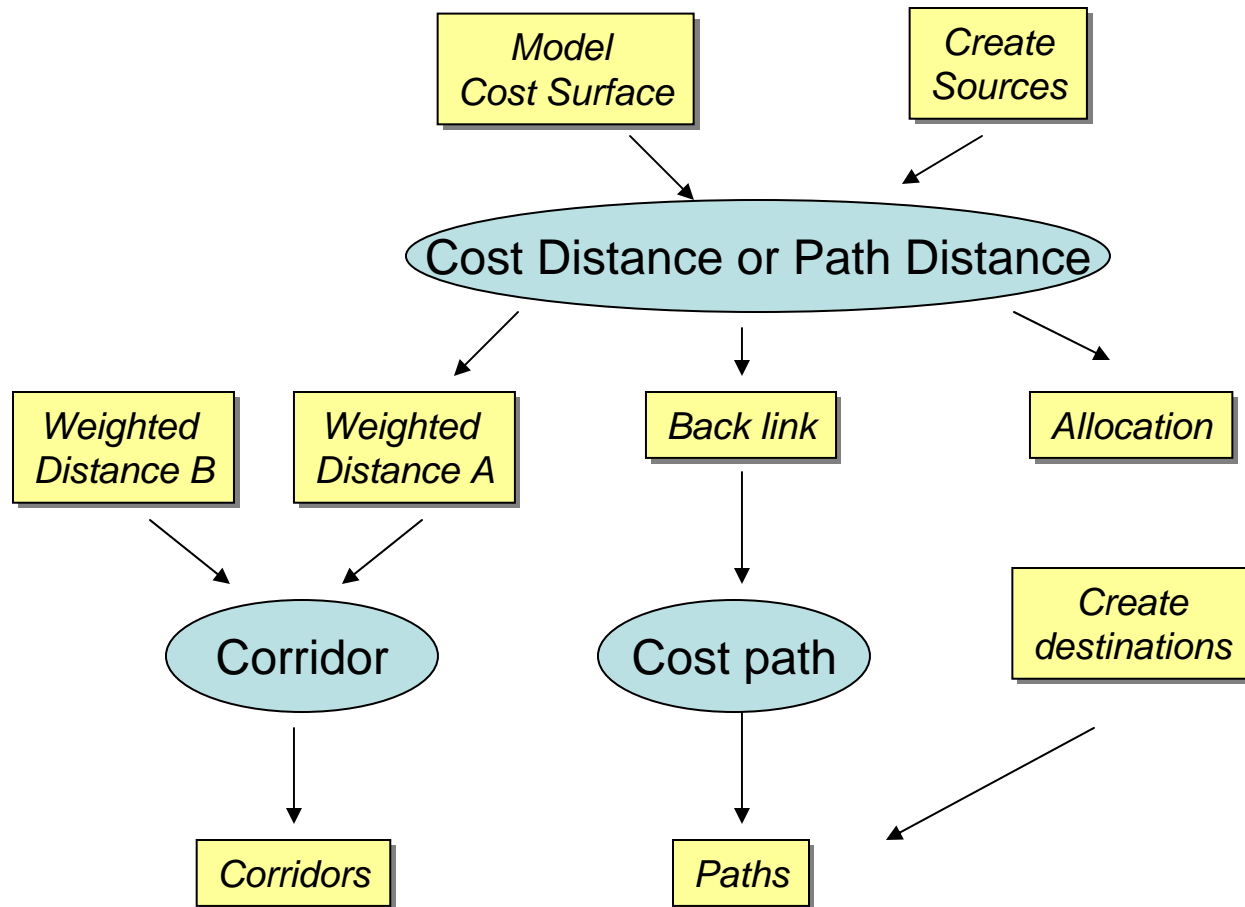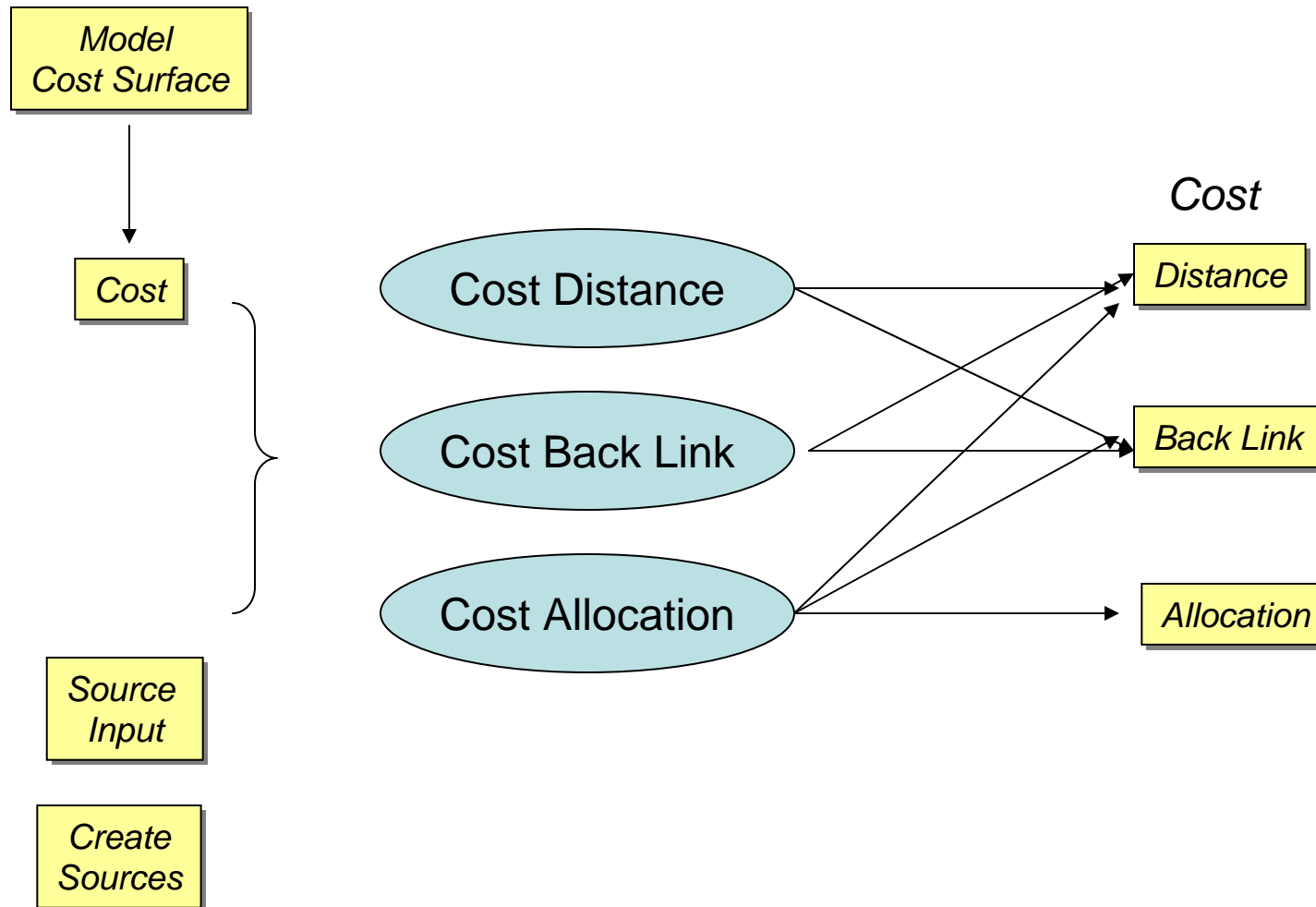- ❑ The shortest path between points is not always the best:
- ❑ Ten hours to climb over the mountain
- ❑ Five hours to follow the trail around it
- ❑ Finds the least-cost path between cells and sources
- ❑ Considers resistance to travel; an input cost surface
- ❑ Weights distance with travel costs
- ❑ Result: Accumulated travel cost to every cell
- ❑ Units are cost (e.g., time, money), not distance
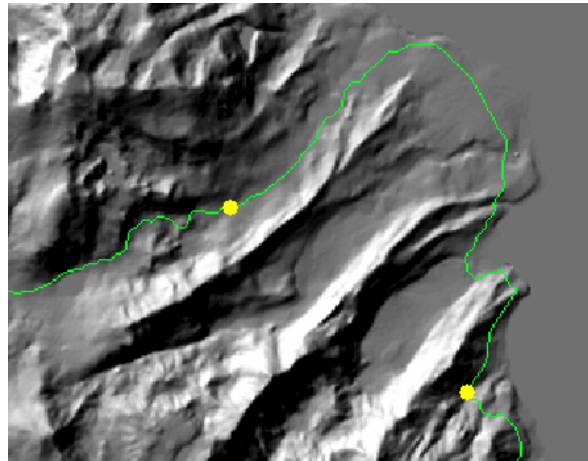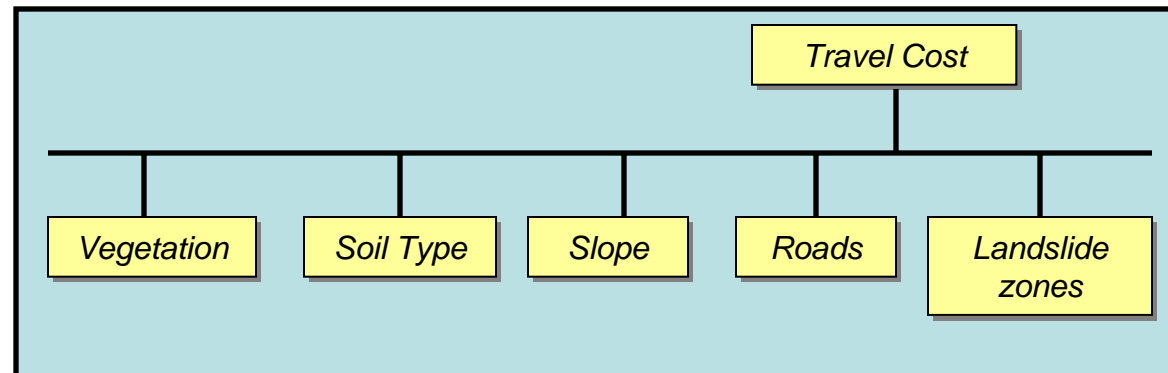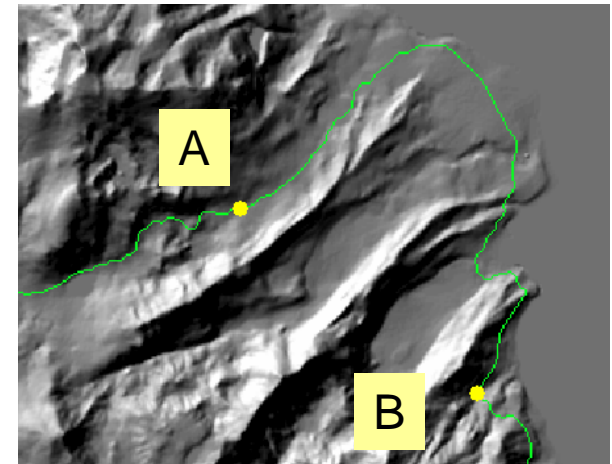
The roadmap - Weighted distance process

```
┌─────────────┐              ┌─────────────┐
│    Model    │              │   Create    │
│ Cost Surface│              │   Sources   │
└─────────────┘              └─────────────┘
          ╲                       ╱
           ╲                     ╱
      ╭──────────────────────────────────────╮
      │   Cost Distance or Path Distance      │
      ╰──────────────────────────────────────╯
        ╱              │              ╲
       ╱               │               ╲
┌──────────┐ ┌──────────┐  ┌──────────┐   ┌──────────┐
│ Weighted │ │ Weighted │  │ Back link│   │Allocation│
│Distance B│ │Distance A│  └──────────┘   └──────────┘
└──────────┘ └──────────┘       │
        ╲        ╱              │
         ╲      ╱               │            ┌─────────────┐
      ╭──────────╮          ╭──────────╮     │   Create    │
      │ Corridor │          │ Cost path│     │destinations │
      ╰──────────╯          ╰──────────╯     └─────────────┘
           │                    │                ╱
           │                    │               ╱
      ┌──────────┐          ┌──────────┐
      │ Corridors│          │  Paths   │
      └──────────┘          └──────────┘
```

The roadmap - The Cost Distance tools

Model
Cost Surface

Cost

Source
Input

Create
Sources

Cost Distance

Cost Back Link

Cost Allocation

Cost

Distance

Back Link

Allocation

Creating the cost surface

❑ **Cost to travel through each cell**
  ▪ **High values = high travel cost**

❑ **Express as cost per unit distance**
  ▪ **Dollars per foot, hours per meter, etc.**

❑ **Usually created by modeling**
  ▪ **Often considers many variables**


```
                    ┌──────────────┐
                    │ Travel Cost  │
                    └──────┬───────┘
   ┌───────────┬───────────┼───────────┬───────────┐
┌──────────┐ ┌──────────┐ ┌───────┐ ┌────────┐ ┌───────────┐
│Vegetation│ │Soil Type │ │ Slope │ │ Roads  │ │ Landslide │
└──────────┘ └──────────┘ └───────┘ └────────┘ │   zones   │
                                                └───────────┘
```

Calculating weighting distance

- ❑ **Uses distance between cells and cost to cross the cells**
- ❑ **Find average cost for two cells, multiply by distance**
    - ▪ **Orthogonal distance = (1 * cell size)**
    - ▪ **Diagonal distance = ($\sqrt{2}$ * cell size)**
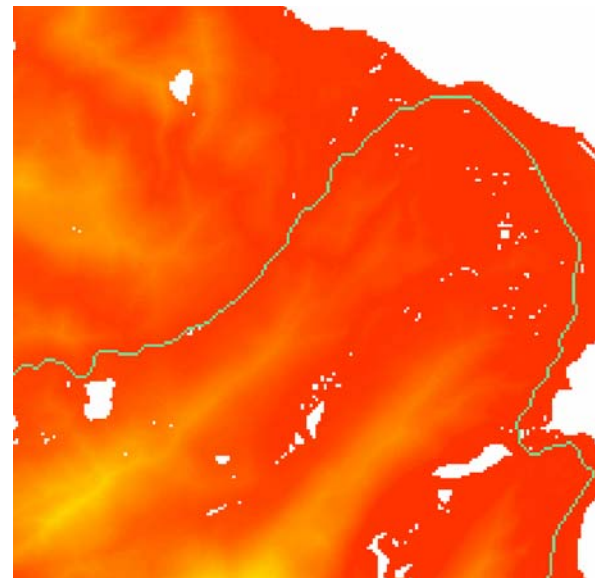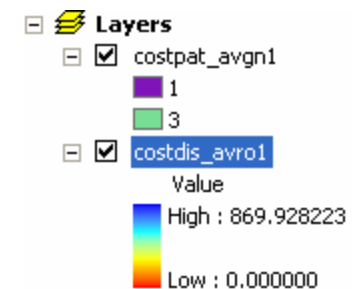
The accumulated travel cost output

- ❑ **Cost accumulates away from source cells**
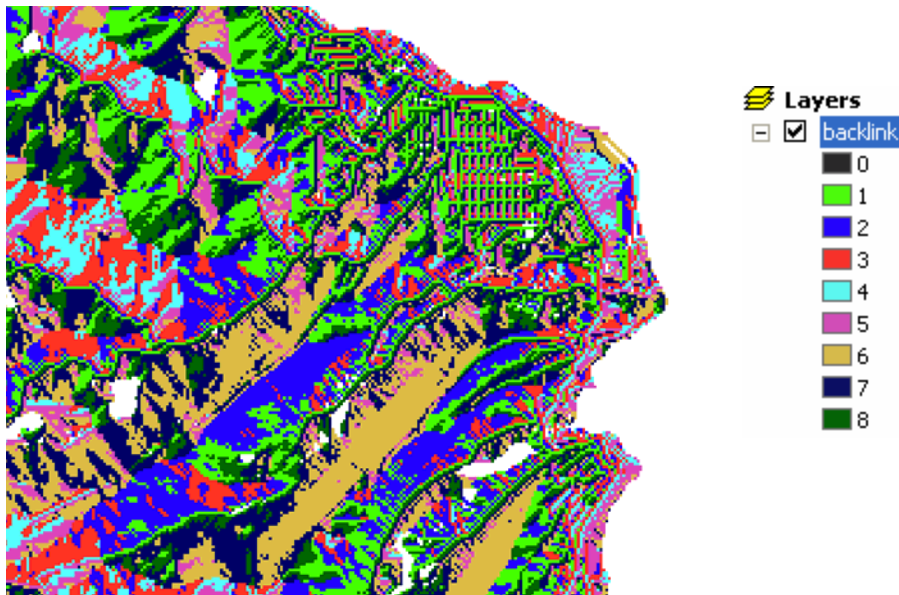 - ▪ **High values = longer travel time (for example)**
- ❑ **Use as:**
  - ▪ **A measure of accessibility**
  - ▪ **An input to Cost Path**
  - ▪ **An input to Corridor**

The backlink output

- **Direction codes point back to the "nearest" source**
  - For each cell, points to the adjacent cell on least-cost path
- **Required by the Cost Path tool**

The allocation output

- ❑ **Assigns each cell to the nearest* source**
    - ▪ **A method of assigning space**
    - ▪ **Like Thiessen polygons**
- ❑ **Use as a measure of proximity I accessibility**

– **Nearest in terms of weighted distance: time, money, etc.**

The roadmap - The Path Distance tools

The Path Distance tool

❑ **Similar to Cost Distance tool but more powerful**
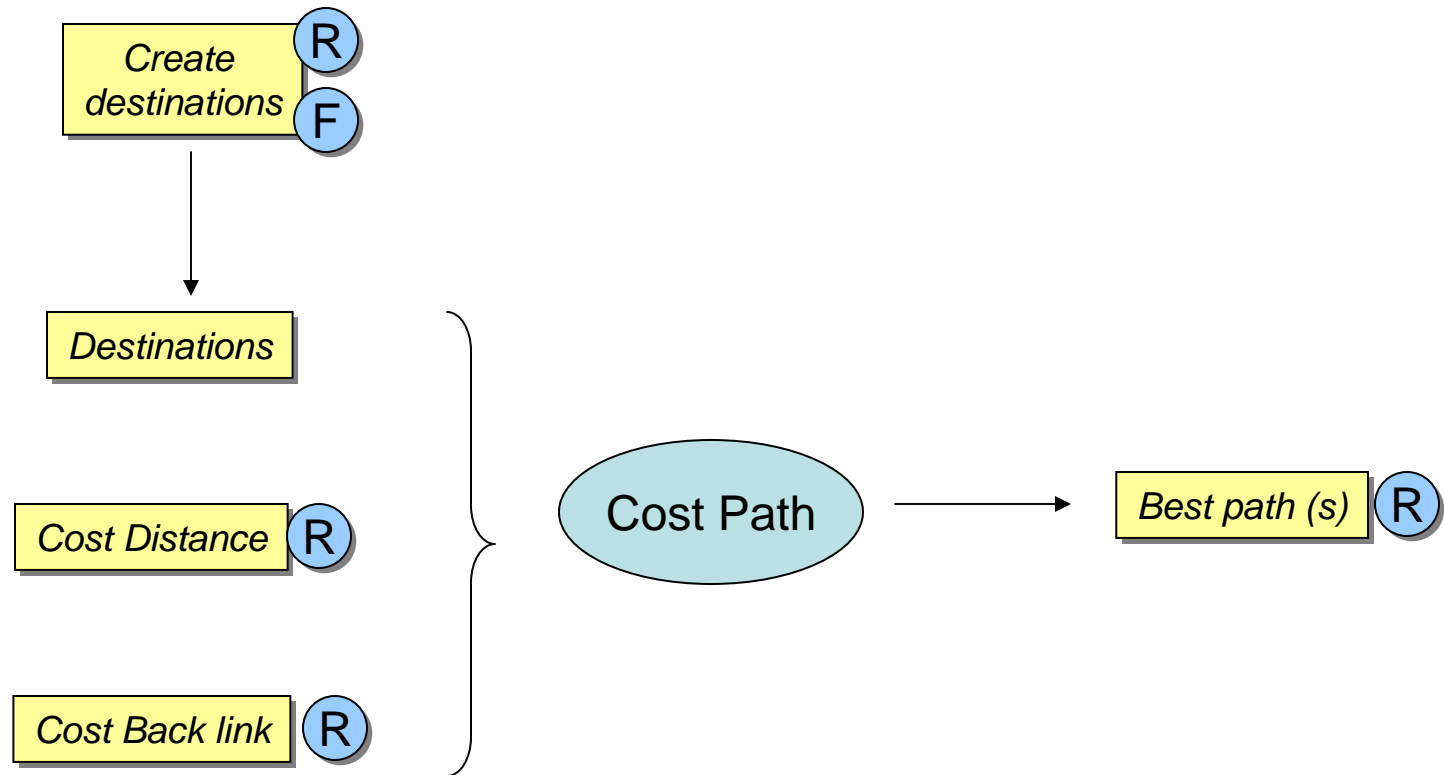❑ **Considers other factors that affect movement**

Surface Friction

Vertical Factor

True Surface Length

Horizontal Factor

The roadmap - The Cost Path tool

Create destinations ⓇⒻ

↓

Destinations

Cost Distance Ⓡ

Cost Back link Ⓡ

Cost Path → Best path (s) Ⓡ

Finding paths

❑ **Finds least-cost paths from sources to destinations**

   ▪ **Cost Path = raster lines (with attributes)**

❑ **Required inputs**

   ▪ **Destinations**

   ▪ **Cost or Path Distance outputs**

      • **Accumulated travel cost raster**

      • **Backlink raster**
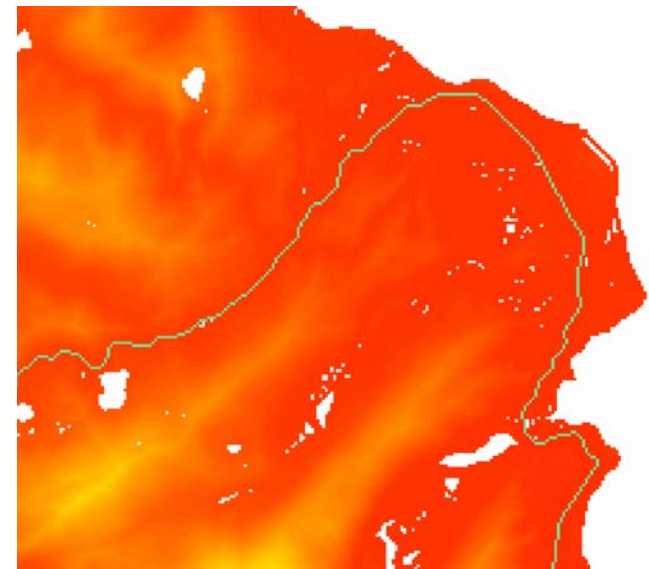
The roadmap - The Corridor tool

Cost Distance A (R)

Cost Distance B

Corridor → Corridor (s) (R)
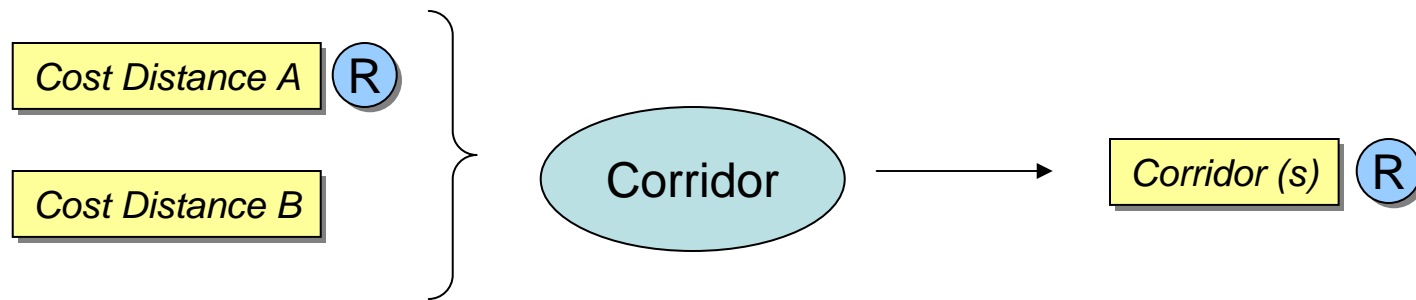
Exercise 6 overview

❑ **Find the straight line distance to Rockbound Valley**

❑ **Find the weighted distance to Rockbound Valley**

- ▪ **Create a cost surface**
  - • **Speed limit of roads**
  - • **Off-road travel costs**
- ▪ **Create the weighted distance and direction rasters**
- ▪ **Find the best path to Rockbound Valley**