Raster data extraction: An operation that uses a data set, a graphic object, or a query expression to extract data from an existing raster.

Reclassification: A local operation that reclassifies cell values of an input raster to create a new raster.

Slice: A raster data operation that divides a continuous raster into equal-interval or equal-area classes.

Zonal operation: A raster data operation that involves groups of cells of same values or like features.

REVIEW QUESTIONS

1. How can an analysis mask save time and effort for raster data operations?
2. Why is a local operation also called a cell-by-cell operation?
3. Refer to Figure 12.3. Show the output raster if the local operation uses the minimum statistic.
4. Refer to Figure 12.4. Show the output raster if the local operation uses the variety statistic.
5. Figure 12.5*c* has two cells with the same value of 4. Why?
6. Neighborhood operations are also called focal operations. What is a focal cell?
7. Describe the common types of neighborhoods used in neighborhood operations.
8. Refer to Figure 12.8. Show the output raster if the neighborhood operation uses the variety measure.
9. Refer to Figure 12.9. Show the output raster if the neighborhood operation uses the minority statistic.
10. What kinds of geometric measures can be derived from zonal operations on a single raster?
11. A zonal operation with two rasters must define one of them as the zonal raster first. What is a zonal raster?
12. Refer to Figure 12.11. Show the output raster if the zonal operation uses the range statistic.
13. Suppose you are asked to produce a raster that shows the average precipitation in each major watershed in your state. Describe the procedure you will follow to complete the task.
14. Explain the difference between the physical distance and the cost distance.
15. What is a physical distance measure operation?
16. A government agency will most likely use a vector-based buffering operation, rather than a raster-based physical distance measure operation, to define a riparian zone. Why?
17. Refer to Box 12.4. Suppose that you are given an elevation raster. How can you prepare a raster showing mean relief energy within a circle of 2.5 kilometers?

APPLICATIONS: RASTER DATA ANALYSIS

This applications section covers the basic operations of raster data analysis. Task 1 covers a local operation. Task 2 runs a local operation using the Combine function. Task 3 uses a neighborhood operation. Task 4 uses a zonal operation. And Task 5 includes a physical distance measure operation in data query. Raster data analysis typically starts by setting up an analysis environment including the area for analysis and the output cell size. However, this first step is skipped in the following tasks because no analysis mask is used and the output cell size is the same as the input cell size.

Task 1: Perform a Local Operation

What you need: *emidalat,* an elevation raster with a cell size of 30 meters.

Task 1 lets you run a local operation to convert the elevation values of *emidalat* from meters to feet.

1. Start ArcCatalog, and connect to the Chapter 12 database. Select Properties from the context menu of *emidalat* in the Catalog tree. The Raster Dataset Properties dialog shows that *emidalat* has 186 columns, 214 rows, a cell size of 30 (meters), and a value range of 855 to 1337 (meters). Also, *emidalat* is a floating-point ESRI grid.
2. Launch ArcMap. Add *emidalat* to Layers, and rename Layers Tasks 1&3. Make sure that the Spatial Analyst extension is checked in the Tools menu and the Spatial Analyst toolbar is checked in the View menu.
3. Select Raster Calculator from the Spatial Analyst dropdown menu. Enter the following expression in the Raster Calculator's expression box: [emidalat] × 3.28. Click Evaluate. *Calculation* shows *emidalat* in feet.
4. *Calculation* is a temporary raster. Right-click *Calculation,* point to Data, and select Make Permanent. Name the permanent raster *emidaft* and click Save.

Q1. What is the range of cell values in *emidaft*?

Task 2: Perform a Combine Operation

What you need: *slope_gd,* a slope raster with 4 slope classes; and *aspect_gd,* an aspect raster with flat areas and 4 principal directions.

Task 2 covers the use of the Combine function. Combine is a local operation that can work with two or more rasters. You can use Combine in either Spatial Analyst or ArcToolbox.

1. Select Data Frame from the Insert menu in ArcMap. Rename the new data frame Task 2, and add *slope_gd* and *aspect_gd* to Task 2.
2. First use Spatial Analyst to perform Combine. Select Raster Calculator from the Spatial Analyst dropdown menu. The Raster Calculator dialog does not show Combine. You need to build an expression using the Combine function. Enter Combine ([slope_gd], [aspect_gd]) in the Raster Calculator's expression box. Click Evaluate. *Calculation* shows a unique output value for each unique combination of input values. Open the attribute table of *Calculation* to find the unique combinations and their counts. Make *Calculation* permanent and name the output *combine.*

Q2. How many cells in *combine* have the combination of a slope class of 2 and an aspect class of 4?

3. Next use ArcToolbox to perform the Combine operation. Click the Show/Hide ArcToolbox Window button to open the ArcToolbox window. Double-click the Combine tool in the Spatial Analyst Tools/Local toolset. In the next dialog, select *aspect_gd* and *slope_gd* for the input rasters, and enter *slp_asp* for the output raster. Click OK to run the operation. The output should be exactly the same as *combine* from Step 2.

Task 3: Perform a Neighborhood Operation

What you need: *emidalat,* as in Task 1.

Task 3 asks you to run a neighborhood mean operation on *emidalat.*

1. Activate Tasks 1&3 in ArcMap. Select Neighborhood Statistics from the dropdown menu of Spatial Analyst. Select *emidalat* for the input data. Notice that the default statistic type is Mean, the default neighborhood is a 3-by-3 rectangle, and the output cell size is 30. Click OK to run the operation. *NbrMean of emidalat* shows the neighborhood mean of *emidalat.*
2. Make *NbrMean of emidalat* a permanent raster, and name it *emidamean.*

Q3. What other neighborhood statistics are available in Spatial Analyst besides the mean?

3. The Focal Statistics tool in the Spatial Analyst Tools/Neighborhood toolset can also accomplish the task.

Task 4: Perform a Zonal Operation

What you need: *precipgd,* a raster showing the average annual precipitation in Idaho; *hucgd,* a watershed raster.

Task 4 asks you to derive annual precipitation statistics by watershed. Both *precipgd* and *hucgd* are projected onto the same projected coordinate system and are measured in meters. The precipitation measurement unit for *precipgd* is 1/100 of an inch; for example, the cell value of 675 means 6.75 inches.

1. Select Data Frame from the Insert menu in ArcMap. Rename the new data frame Task 4, and add *precipgd* and *hucgd* to Task 4.
2. Select Zonal Statistics from the dropdown menu of Spatial Analyst. Select *hucgd* for the zone dataset, Value for the zone field, and *precipgd* for the value raster. Check the boxes to ignore NoData in calculations, to join output table to zone layer, and to chart statistic with Mean. Enter *zstats.dbf* for the output table. Click OK.
3. The chart shows the mean of *precipgd* within each zone of *hucgd.* The table shows the statistics of *precipgd,* including the minimum, maximum, range, mean, standard deviation, sum, variety, majority, minority, and median within each zone of *hucgd.*

Q4. Which watershed has the highest average annual precipitation in Idaho?

4. The Zonal Statistics tool in the Spatial Analyst Tools/Zonal toolset can also accomplish the task.

Task 5: Measure Physical Distances

What you need: *strmgd,* a raster showing streams; and *elevgd,* a raster showing elevation zones.

Task 5 asks you to locate the potential habitat of a plant species. The cell values in *strmgd* are the ID values of streams. The cell values in *elevgd* are elevation zones 1, 2, and 3. Both rasters have the cell resolution of 100 meters. The potential habitat of the plant species must meet the following criteria:

- Elevation zone 2
- Within 200 meters of streams

1. Select Data Frame from the Insert menu in ArcMap. Rename the new data frame Task 5, and add *strmgd* and *elevgd* to Task 5.
2. Click the Spatial Analyst dropdown arrow, point to Distance, and select Straight Line. In the Straight Line dialog, select *strmgd* for distance to, enter 100 (meters) for the output cell size, and opt for a temporary output raster. Click OK to run the operation.
3. *Distance to strmgd* shows continuous distance zones away from streams in *strmgd.*
4. This step is to create a new raster that shows areas within 200 meters of streams. Select Reclassify from the Spatial Analyst dropdown menu. In the Reclassify dialog, select *Distance to strmgd* for the input raster and click Classify. In the Classification dialog, first select 2 for the number of classes. Then click the first value under Break Values and enter 200. Click the empty space in the Break Values frame to unselect the second cell. Click OK to dismiss the Classification dialog. Opt for a temporary output raster in the Reclassify dialog, and click OK. *Reclass of Distance to strmgd* separates areas that are within 200 meters of streams from areas that are beyond.
5. Select Raster Calculator from the Spatial Analyst dropdown menu. Enter the following query expression in the expression box: [Reclass of Distance to strmgd] = 1 And [elevgd] = 2. (Raster Calculator dialog uses == for = and & for And.) Click Evaluate. The *Calculation* layer shows areas that meet the criteria with the value of 1.

Q5. What area percentage of *Calculation* meets the selection criteria?

6. There are four other options for completing the task. First, a feature layer can replace *strmgd* as the source for the distance measure operation. Second, you can use *Distance to strmgd* directly without reclassification. In that case, the expression in the Raster Calculator dialog should be changed to: [Distance to strmgd] <= 200 And [elevgd] = 2. Third, you can specify a maximum distance of 200 for *Distance to strmgd.* Fourth, ArcToolbox has the Euclidean Distance tool in the Spatial Analyst Tools/Distance toolset for running the distance measure operation, the Reclassify tool in the Spatial Analyst Tools/Reclass toolset for reclassification, and the Single Output Map Algebra tool in the Spatial Analyst Tools/Map Algebra toolset for raster data query.

Challenge Task

What you need: *emidalat, emidaslope,* and *emidaaspect.*

This challenge task asks you to construct a raster-based model using elevation, slope, and aspect.

1. Use the following table to reclassify *emidalat* and save the output as *emidaelev.*

Old Values	New Values
855–900	1
900–1000	2
1000–1100	3
1100–1200	4
>1200	5

2. *emidaslope* and *emidaaspect* have already been reclassified and ranked. Create a model by using the following equation: *emidaelev* + 3 × *emidaslope* + *emidaaspect.* Name the model *emidamodel.*

Q1. What is the range of cell values in *emidamodel*?

Q2. What area percentage of *emidamodel* has cell value > 20?

REFERENCES

Beguería, S., and S. M. Vicente-Serrano. 2006. Mapping the Hazard of Extreme Rainfall by Peaks over Threshold Extreme Value Analysis and Spatial Regression Techniques. *Journal of Applied Meteorology and Climatology* 45: 108–24.

Congalton, R. G. 1991. A Review of Assessing the Accuracy of Classification of Remotely Sensed Data. *Photogrammetric Engineering & Remote Sensing* 37: 35–46.

Crow, T. R., G. E. Host, and D. J. Mladenoff. 1999. Ownership and Ecosystem as Sources of Spatial Heterogeneity in a Forested Landscape, Wisconsin, USA. *Landscape Ecology* 14: 449–63.

Forman, R. T. T., and M. Godron. 1986. *Landscape Ecology.* New York: Wiley.

Herr, A. M., and L. P. Queen. 1993. Crane Habitat Evaluation Using GIS and Remote Sensing. *Photogrammetric Engineering & Remote Sensing* 59: 1531–38.

Heuvelink, G. B. M. 1998. *Error Propagation in Environmental Modelling with GIS.* London: Taylor and Francis.

Lillesand, T. M., R. W. Kiefer, and J. W. Chipman. 2004. *Remote Sensing and Image Interpretation,* 5th ed. New York: Wiley.

McGarigal, K., and B. J. Marks. 1994. *Fragstats: Spatial Pattern Analysis Program for Quantifying Landscape Structure.* Forest Science Department: Oregon State University.

Mladenoff, D. J., T. A. Sickley, R. G. Haight, and A. P. Wydeven. 1995. A Regional Landscape Analysis and Prediction of Favorable Gray Wolf Habitat in the Northern Great Lakes Regions. *Conservation Biology* 9: 279–94.

Pullar, D. 2001. MapScript: A Map Algebra Programming Language Incorporating Neighborhood Analysis. *GeoInformatica* 5: 145–63.

Renard, K. G., G. R. Foster, G. A. Weesies, D. K. McCool, and D. C. Yoder (coordinators). 1997. Predicting Soil Erosion by Water: A Guide to Conservation