



## Rocky Mountain Mapping Center

### Locating a Fire Tower Using GIS

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**Overview:** In this lesson, you will have the opportunity to use river, road, elevation, slope, land use, and land ownership data to determine the best location for three fire towers on the Rosebud Sioux lands.

#### **Skills:**

1. Tabular analysis: Creating new tables, summarizing, sorting, querying tabular data.
2. Spatial analysis: Proximity, intersection, selecting features, mapping data thematically.
3. Critical thinking: Using spatial data to make a real-world decision using a variety of data sources and types.

#### **Problem:**

In August 2002, a wildfire burned hundreds of hectares of land near St Francis, South Dakota. In the last lesson, you examined a Landsat satellite image of this wildfire. You are on an assignment from the Rosebud Sioux tribal government to create three fire lookout towers in the area to better manage future wildfires. The three fire towers need to be:

- (1) Within 200 meters of a "major" road to provide access to the fire and ecology managers.
- (2) Within 2000 meters of a major river to provide access to water for firefighting, if needed.

- (3) On a high elevation of over 840 meters to maximize the amount of terrain that can be seen from the tower (the "viewshed").
- (4) On a flat slope of 5% or less to minimize construction problems.
- (5) Near the most grassland possible, because grassland fires are the ones of the most concern.

## Data Management

Create a folder for this lesson and name it *firetower*. As you know from previous lessons, it is best to name the folder without any spaces in the name.

Click [here to download the data](#) that you will need for this lab exercise.

This file is named **firetowerlesson.zip** and totals approximately 5.7 MB.

After downloading, unzip the file using the Winzip program.

You now should have 25 files and 5 themes with the following names:

- elevation
- hydrography
- land cover
- slope
- transportation

Start ArcView GIS with a new project and a new view.

Add the themes indicated above to your view as a feature data source.

Go to View—> Properties and name your view "Fire Tower Analysis"

Save your project and give it an appropriate name, placing it into the appropriate folder *firetower*.

The data sets are in the Universal Transverse Mercator (UTM) projection and coordinate system. The UTM coordinate system is in meters. Therefore, use View--> Properties to set the map units to meters **and** the distance units to meters.

## Becoming Familiar with Your Study Area

Turn on your transportation layer and make the other layers invisible.

- 1) Use the measure tool to answer the following questions: What is the distance across your study area from north to south in meters?
  
- 2) What is the distance across your study area from east to west in meters?
  
- 3) What is the approximate total area of your study area in square meters?
  
- 4) What is the approximate total area of your study area in square kilometers?

Scroll around the study area and examine the coordinates in the upper right. These are in UTM eastings and northings. The larger number is the northings, representing the distance north of the equator.

- 5) What is the distance north of the equator of the southern edge of the study area in meters?
  
- 6) What is the distance north of the equator of the southern edge of the study area in kilometers?

Examine the cluster of roads at easting 349302 and northing 4788378. This is the community of Rosebud, the tribal headquarters of the Rosebud Sioux Tribe. Examine the cluster of roads at easting 345314 and northing 4778485. This is the community of St Francis.

Use the Text button (T)  to add the following text:

Near the location of Rosebud, type Rosebud.

Near the location of St Francis, type St Francis.

7) How far, in kilometers, is St Francis from Rosebud?

Change the transportation legend to Unique Value and classify the roads on the Census Feature Classification Code (CFCC). (**not** CFCC1 or CFCC2). Examine the legend before clicking on Apply.

8) What code is the most common road type in your dataset?

Click Apply. These are the major roads and will be the only ones you will consider in locating your fire towers.

Turn off roads and turn on and examine your rivers. Change the rivers legend to Unique Value and classify the rivers on the Census Feature Classification Code (CFCC).

9) What feature does CFCC code H01 represent?

10) Where are most of the H01 features located in the study area?

11) What is the CFCC code that represents major rivers, such as the Little White River and Rosebud Creek?

The major rivers will be the type of rivers you will consider in locating your fire towers.

Examine the elevation theme's table.



The elevation theme was created from the USGS National Elevation Dataset, <http://edcnts12.cr.usgs.gov/ned/default.asp>. The elevations in this area range from 724 meters to 929 meters above sea level. The elevation data was reclassified into the classes (categories) that you see in the table.

12) How many elevation classes are in the table?

Exit the table and change the legend for elevation to map elevation as a graduated color map on the field gridcode.

13) Make at least two observations about the elevations in your study area.

Turn off the elevation theme.

Examine the slope theme's table.



The slope theme was created from the USGS National Elevation Dataset. The slopes in this area range from 0 to 41% slope. The slope data was reclassified into the classes (categories) that you see in the table.

14) How many slope classes are in the table?

Make the slope theme visible. The slopes should be mapped as tan to gentle slope to brown for a steep slope. If they are not mapped this way, change the legend editor to graduated color map on the field gridcode with a transparent outline (due to the many polygons that make up the slope map).

15) Make at least two observations about the slopes in your study area.

Turn off the slope theme.

Examine the land cover theme's table.  The land cover data is from the USGS 1992 National Land Cover Dataset, <http://landcover.usgs.gov>. The land cover class is given in the field gridcode.

16) How many land cover polygons exist?

17) How many land cover *classes* exist?


18) What field indicates the class of land cover?

19) Make a unique value map on the field you indicated above. Make at least three observations about the land cover type and pattern in your study area.

20) What is the most common land cover class near streams?

21) What is the most common land cover class away from streams?

22) Why do you think the land cover class changes near streams?

Examine the land cover theme's table  again. Use Field-->Summarize on the field that you indicated above (the land cover class field) to answer the following:

23) What are the three most common land cover classes in this region?

Each code corresponds to a specific land cover type. Examine the Land Use and Land Cover classification system below:

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### Water

- 11 Open Water
- 12 Perennial Ice/Snow

### Developed

- 21 Low Intensity Residential
- 22 High Intensity Residential
- 23 Commercial/Industrial/Transportation

### Barren

- 31 Bare Rock/Sand/Clay
- 32 Quarries/Strip Mines/Gravel Pits
- 33 Transitional

### Forested Upland

- 41 Deciduous Forest
- 42 Evergreen Forest
- 43 Mixed Forest

### Shrubland

- 51 Shrubland

### Non-Natural Woody

- 61 Orchards/Vineyards/Other

## Herbaceous Upland Natural/Semi-natural Vegetation

71 Grasslands/Herbaceous

## Herbaceous Planted/Cultivated

81 Pasture/Hay

82 Row Crops

83 Small Grains

84 Fallow

85 Urban/Recreational Grasses

## Wetlands

91 Woody Wetlands

92 - Emergent Herbaceous Wetlands

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24) What are the three most common land cover types in this region of South Dakota, according to what you see on your map? List the names of the land cover types this time rather than the class numbers (such as "woody wetlands", rather than 91).

25) Does the answer you gave to the three most common land cover types surprise you, given what you know about this area of the United States?

26) Does your land cover table indicate the *number of polygons* where the land cover occurs or the *amount of area* covered by that land cover class?

Therefore, to assess how much area is covered by each land cover category for



planning your fire towers, you need to first create a field that can hold the data, and then run statistics on that field.

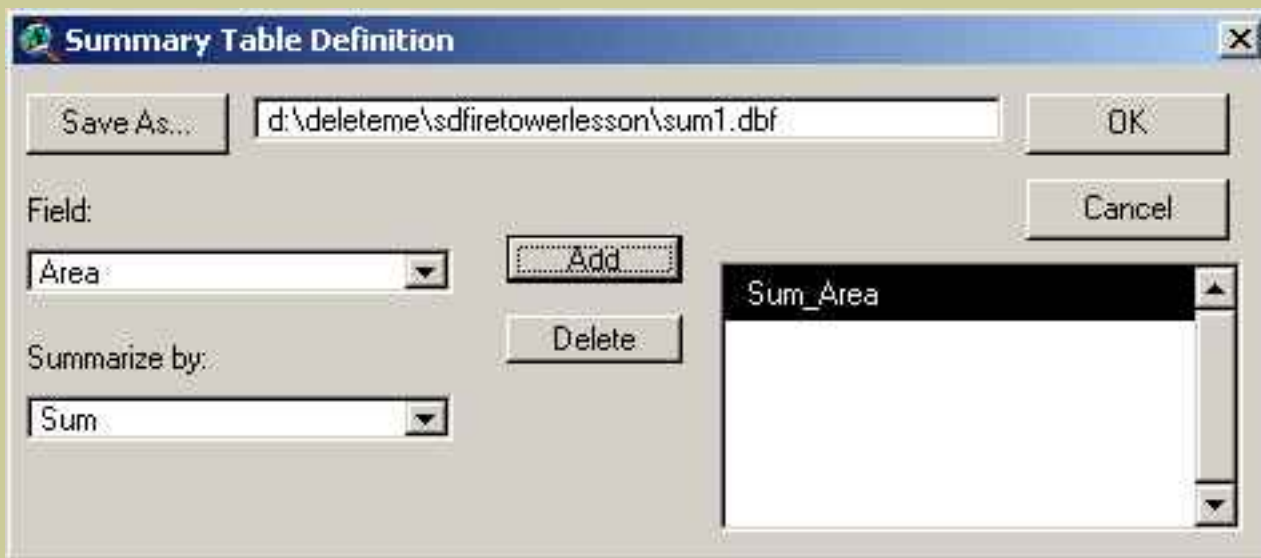
Start editing the table and create a new field named "area". Use the field calculate button to calculate this field to the following formula, preserving the square brackets in the formula: **[shape].returnarea**

Stop editing and save your edits.

Examine the data in your new area field.

27) What data does the new field contain?

Access the menu Field-->Summarize to create a summary table on the field landcoverclass. In the dialog box that appears, use area for the field and summarize by sum, as shown below:



Press "add" so it appears the right side of the box. Give the resulting table an appropriate name, and select "OK."

28) In your new table, sort the field sum\_area. Explain in your own words what this table is telling you.

29) What are the 3 types of land cover that are most predominant in your area of

study?


30) Does this correspond with your answer to question 24 above, from your examination of the map?

## Planning Fire Towers

Now that you are familiar with your data, you can address the problem of locating the three fire towers. Recall your criteria where the fire towers need to be located:

- (1) Within 200 meters of a "major" road to provide access to the fire and ecology managers.
- (2) Within 2000 meters of a major river to provide access to water for firefighting, if needed.
- (3) On a high elevation of over 840 meters to maximize the amount of terrain that can be seen from the tower (the "viewshed").
- (4) On a flat slope of 5% or less to minimize construction problems.
- (5) Near the most grassland possible, because grassland fires are the ones of the most concern.

30) Because the first and second criteria specify that the tower needs to be in proximity to roads and rivers, what type of GIS function will you need to perform on them?

Using the query tool , select the roads that meet the criteria of "major"--that is, roads with a CFCC of A41.

31) What percentage of the roads in the dataset are selected? Show your work.

Now that you've selected the roads under consideration, use the Theme menu to create a buffer around only these major roads. Make sure you use only the *selected roads* in your buffers (the major roads) and use the criteria above to determine the buffer distance. Dissolve barriers between buffers. **Save your results as a new theme** named roadsbuffer in your firetower folder.

32) Make an observation of the buffers around roads in your own words.

33) Zoom in on one of the buffers and measure across it. Is the buffer 200 meters from the road to the edge of the buffer, or 200 meters across the entire buffer?

Next, using the query tool, select the **rivers** that meet the criteria of "major", that you identified above.

34) What percentage of the total hydrography features are selected? Show your work.

Now that you've selected the rivers under consideration, use the Theme menu to create a buffer around only these major rivers. Make sure you use only the *selected rivers* (the major rivers) in your buffers and use the criteria above to determine the buffer distance. Dissolve barriers, and save your results in a new theme named riversbuffer in your firetower folder.

35) Is your buffered rivers theme a point, line, or polygon theme?

You have just addressed the rivers and roads criteria for your fire towers, criteria (1) and (2).

Next, turn your attention to criteria (3), your elevation data. Recall that the elevation

criteria was to locate your fire towers on high hills of over 840 meters. The elevation data you are working with was reclassified from the original raw elevations.

Categories of elevation of 6 and above correspond to an elevation of 840 meters and higher.

36) Knowing this information, state what your elevation query statement needs to be:

37) After querying the appropriate elevations, indicate how many elevation polygons are under consideration:

38) Examine your map and note the terrain highlighted in yellow . In what parts of the study area are the suitable elevations?

Save your selected elevations to its own shapefile by accessing this menu: Theme-->Convert to shapefile. Name your new theme elevhigh and store it in the firetower folder.

39) Compare the number of polygons in your new table to the number selected that you indicated in question 37. Explain the reason for the two numbers.

You have now worked with the first three criteria, for rivers, roads, and elevation. Next, turn your attention to criteria (4), slope of the land. Recall that the slope criteria was to locate your fire towers on flat slopes of 5% or less. The slope data you are working with was reclassified from the original raw slopes. Categories of slopes of 1 and 2 correspond to a slope of 5% or less.

40) Knowing this information, state what your slope query statement needs to be:

41) After selecting the appropriate slopes, indicate how many slope polygons are under consideration:

Save your selected slopes to its own shapefile by accessing this menu: Theme-->Convert to shapefile. Name your new theme "*flat*" and store the flat file it in the firetower folder.

42) Examine your "flat" map. In what parts of the study area are the suitable slopes (flat ground)?

You have now worked with four of your criteria: rivers, roads, elevation, and slope. Now, you need to find out where ALL 4 of the criteria are met. To do this, you'll need to do run three intersections. You can only intersect 2 data sets at a time. Therefore, you will need to intersect as follows. Use the following theme names:

Rivers buffer intersected with roads buffer: riv\_rd [A]

Result of [A] intersected with suitable elevation (elevhigh): riv\_rd\_high [B]

Result of [B] intersected with suitable (flat) slopes: riv\_rd\_high\_flat [C]

Recall from a previous lesson that to run intersect, you need to first go to File-->Extensions and engage the Geoprocessing extension.

Now, you have a new choice on the bottom of your View menu called Geoprocessing Wizard.

Engage the GeoProcessing Wizard and run your three intersections. You will use the geoprocessing wizard on the first two intersections, and a select by theme for the third, to avoid computer processing delays.

First, intersect rivers and roads using the Geoprocessing Wizard and save the result as the theme riv\_rd.


43) Make two observations about the pattern, shape, and the number of records in your rivers and roads intersection map (riv\_rd).

Now, using the Geoprocessing Wizard, intersect your rivers and roads intersection

result (*riv\_rd*) with suitable elevation (*elevhigh*) to create *riv\_rd\_high*.

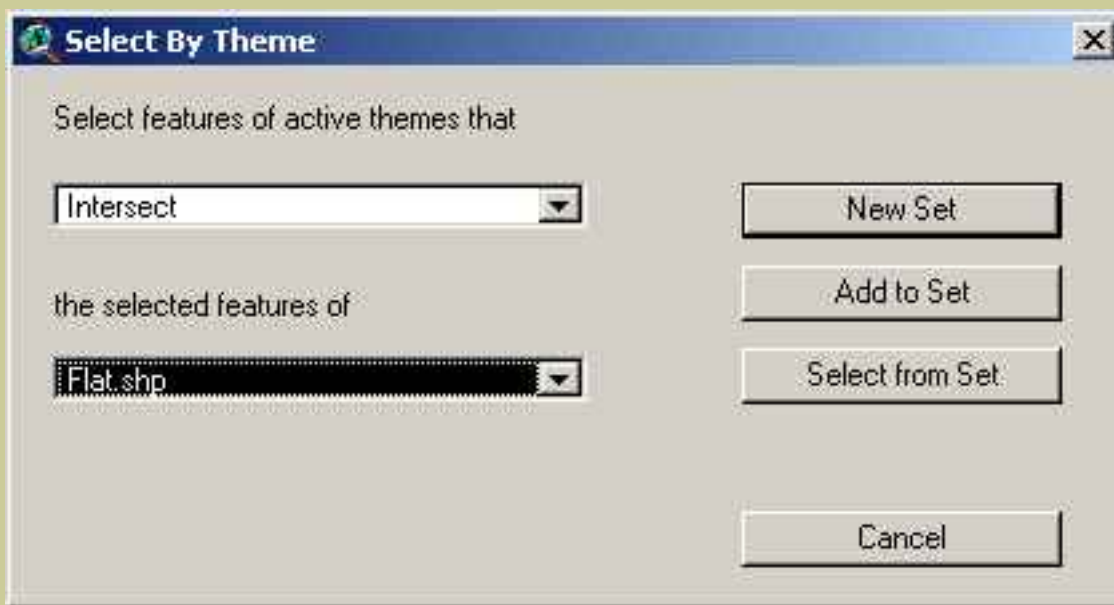
44) Make two observations about the pattern, shape, and the number of records in your resulting map (*riv\_rd\_high*).

Finally, intersect this result *riv\_rd\_high* with *flat* to create *riv\_rd\_high\_flat* as follows:


First, clear any selections in the flat file: 

Second, make *riv\_rd\_high* the active theme (raised up).

Third, use Theme--> Select By Theme to "select features of active themes" that INTERSECT the selected features of the flat file:



This will select all of the flat areas that are also near roads, near rivers, and on high ground.

Access the table of your file *riv\_rd\_high*. 

45) How many areas are selected?

Save these selected areas to their own theme by using Theme--> Convert to

shapefile. Name the shapefile riv\_rd\_high\_flat and save it in your firetower folder. Go to Theme--> Properties and rename riv\_rd\_high\_flat to finalfiretowers.


46) Make at least two observations about the pattern, shape, and the number of records in your final fire towers map.

Make the rivers theme active and then use the label button to label several rivers.

Looking at the pattern of the distribution of your final sites, they seem to be clustered in several groups in the southwestern part of the study area, and several groups in the northeast part of the study area.

47) Describe the location of these clusters in relation to St Francis, Rosebud, and the rivers.

Your final criteria (5) is to note that the primary wildfire concern is with grasslands. Change the legend for grasslands to map as single symbol. Make the outline of the polygons transparent.

Next, select grasslands from the landcover theme using the query tool. 

48) How many polygons exist in the land cover data set?

49) Of these, how many polygons are grasslands?

Turn off all themes except landcover and finalfiretowers. Recall that you want to select sites are located near major stands of grassland.

50) Pick the three sites that, in your judgment, make the best sites for the fire towers. For each, Indicate its UTM coordinate, distance from St Francis, and direction from St Francis:

Site	UTM	Distance from St Francis	Direction from St Francis
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51) Justify your reasons for selecting the three sites for the fire towers.

52 Create a layout for printing that contains the results of your study sites along with roads and hydrography, as follows:

View —> Layout. Create your layout. With the text tool, add your name, date, and change the title of the map to something that reflects what the map displays.

Print the layout.

Save your project. Close your project and exit ArcView.

52) Summarize in a few sentences what you have learned about locating fire towers in this lesson.

53) Summarize in a few sentences what you have learned about GIS in this lesson.



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URL: <http://rockyweb.cr.usgs.gov/public/outreach/sgu/firetowerlesson.html>

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