

Road Density as an Indicator of Road Hazard

Name of indicator

Road density

Questions potentially addressed

AQ (1) How and where does the road system modify the surface and subsurface hydrology of the area? AQ (2) How and where does the road system cause surface erosion? AQ (6) How and where is the road system hydrologically connected to the stream system? How do the connections affect water quality and quantity (such as, elevated peak flow, delivery of sediments, thermal increases)

Description of indicator

Road density is a simple indicator of the concentration of roads in an area. The road density can be determined for road segments that have characteristics that are attributed, like road segments within a 100-meter buffer of stream channels. Road density maps can be created for a specific area such as a watershed or by using an Arc Macro Language program (AML) like the moving windows type explained below. It can be also used in combination with other layers such as wildlife habitat type.

Units of indicator

The units for road density are expressed as length per unit area, typically in miles of road per square mile.

Scales

May be useful at all scales larger than site. A map of road density at the Forest scale indicates locations of concentrated roads. At the watershed scale, the map can be used to compare the distribution of road density among watersheds.

Related Indicators

Road density does not directly relate to other indicators.

Utility

Probably most useful as a visual aid for finding areas with relatively high concentrations of roads. Road density is most useful where a high concentration of roads is problematic to a watershed or to wildlife. This may be the case with species that are sensitive to the disturbance and danger associated with roads.

Acquisition

Readily available if a roads coverage exists for the area. Road density can be determined by simply dividing the length of road in a polygon by the area. It can also be produced by using a road density AML, which runs in ARC/INFO GRID. This program creates a grid of road density by using a circular, moving window.

Data needs

Must have a roads coverage for the GIS process. Road density by watershed can be done manually by determining the length of roads and dividing by the area.

Accuracy and precision

This macro can produce very different results (figure 2-28), depending on the window size selected. The default setting for the window size is 1 square mile. The default setting for the cell size is 1 acre. Setting the window size less than the default will lower the density values on the road-density map because the moving window is less likely to overlap the adjacent roads. Reducing the cell size will smooth the polygon output but will add processing time. If the input roads coverage does not extend beyond the cover used to clip the output coverage, it may not be accurate around the perimeter.

Durability

Will change over time if roads are dropped or added to the roads coverage.

Monitoring value

Can be useful if a resource responds to a threshold value of road density.

Limitations

Road density may not be appropriate for some analyses because it does not reflect the character of individual roads. In some watersheds, the aquatic effects from a single problem road will be greater than in an area with high road density. This macro is very sensitive to the size of moving window selected. The roads coverage must extend beyond the boundary, if the road density along the perimeter is to be accurate.

Typical availability

Wherever a digital roads coverage exists. Road density can be determined manually for an area such as a watershed or district, but it would be very tedious to manually recreate the moving windows AML.

Where applicable

Road density is probably best applied in combination with a polygon coverage. An example of a combination is road density in riparian reserves (figure 2-33).

Examples

Road density was calculated for three watersheds (figures 2-29, -30, -31) on the Six Rivers NF, by using the default moving-window size of one square mile and a cell size of 30 X 30 meters (default is 1 acre or about 64 X 64 meters). The distribution of road density (figure 2-32) shows the Bluff Creek watershed with a fairly normal distribution. The North Fork Eel river road density has more than 18 percent of its area in the zero category because of the two wilderness areas in the

southeastern portion. The upper Mad River watershed has a road distribution that is skewed to the right because of its relatively higher road density. The Boise National Forest (figure 2-33) used road density in Riparian Habitat Conservation Areas to define priority watersheds for restoration. An example for two ranger districts (figure 2-34) highlights locations of high road density. The moving window AML was used to emphasize areas with high concentrations of road segments within 100 meters of a stream channel (figure 2-35). The Bluff Creek watershed was subdivided into upper, middle, and lower areas to show how road-segment densities may vary. The road density map (figure 2-36) shows a relatively small variation between the three areas. The connected road density map (figure 2-37) reveals that roads in the upper part of the watershed are considerably less connected than those in the middle and lower areas. The road density map for the middle and lower slope positions (figure 2-38) has even more variation between the upper area of the watershed and the other two areas.

Development needs

The moving window macro is being integrated into a software package that will have a menu interface and include other macros (See Appendix 3). This package will also calculate road densities by the analysis area that the user chooses, such as district, watershed, or subwatershed.

Tools references

Hydrologic Condition Assessment Tools – Module of Indicators for Roads Analysis (See Appendix 3)

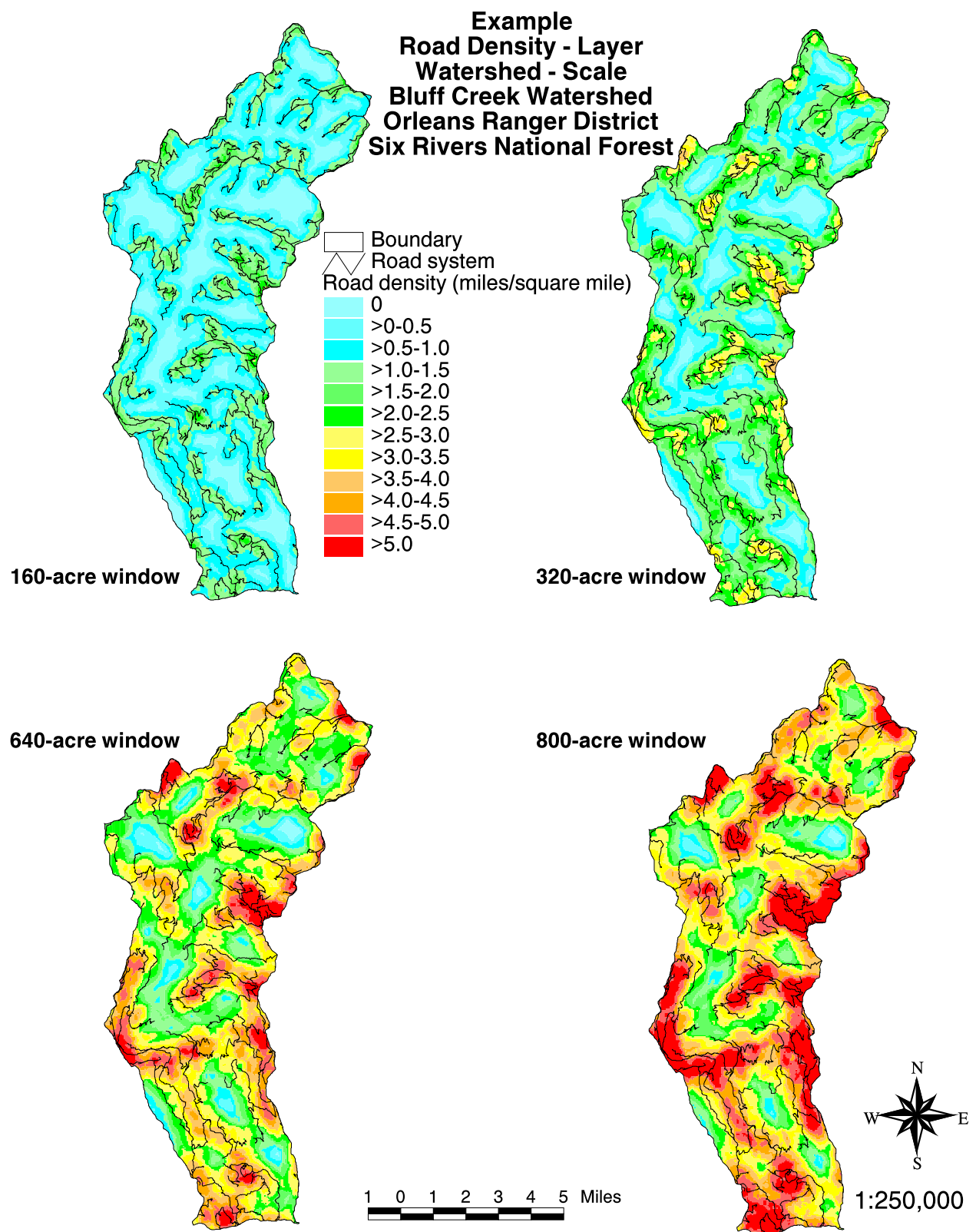


Figure 2-28. Output of road density AML for the Bluff Creek watershed with variation in size of the moving window (default is 640 acres). Note the change in values produced by varying the window size.

Example
Road Density - Layer
Watershed - Scale
Bluff Creek Watershed
Orleans Ranger District
Six Rivers National Forest

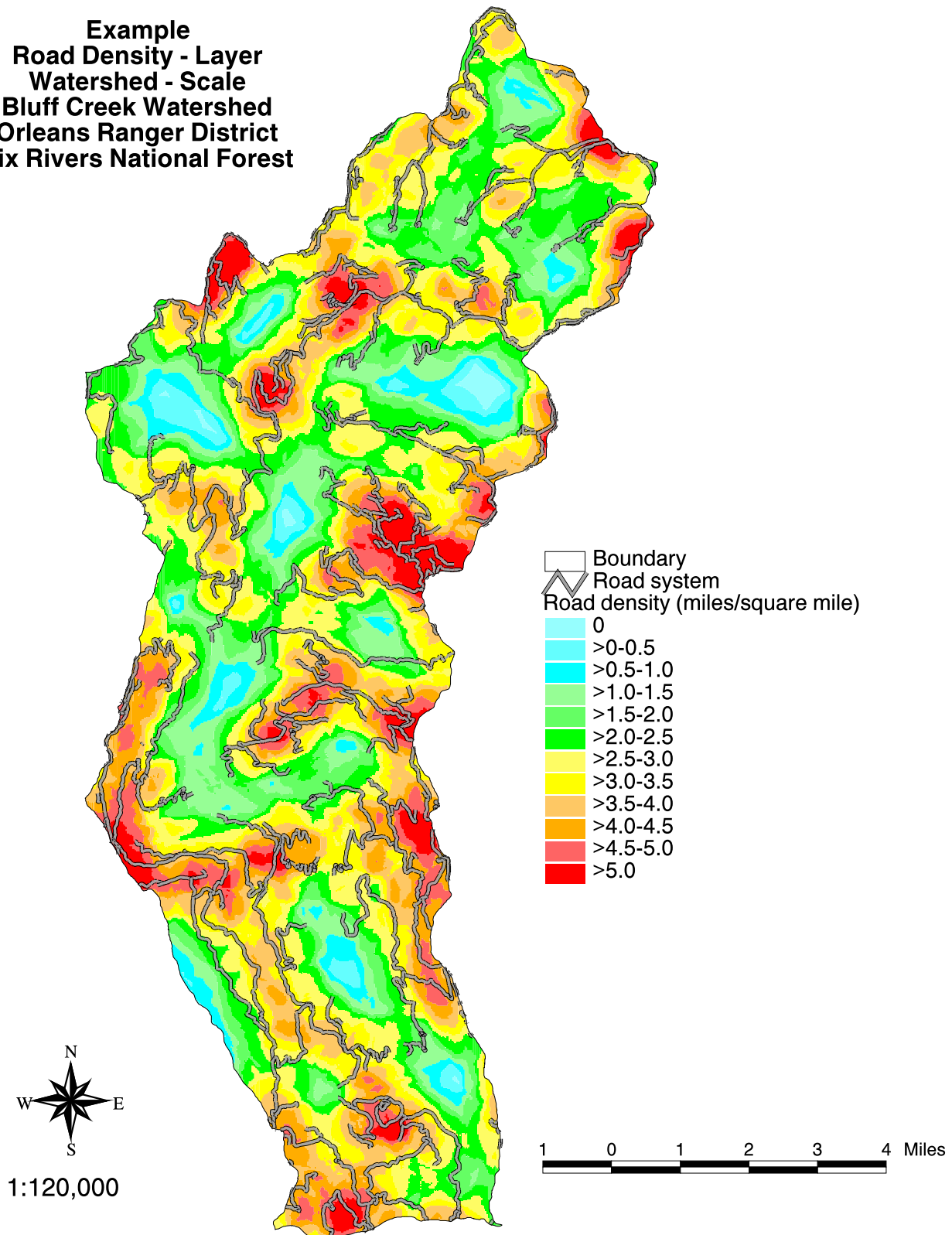


Figure 2-29. Road density for the Bluff Creek watershed, using a moving windows AML. The window size is one square mile (640 acres), and the cell size is 30 X 30 meters.

**Example
Road Density - Layer
North Fork Eel River
Mad River Ranger District
Six Rivers National Forest**

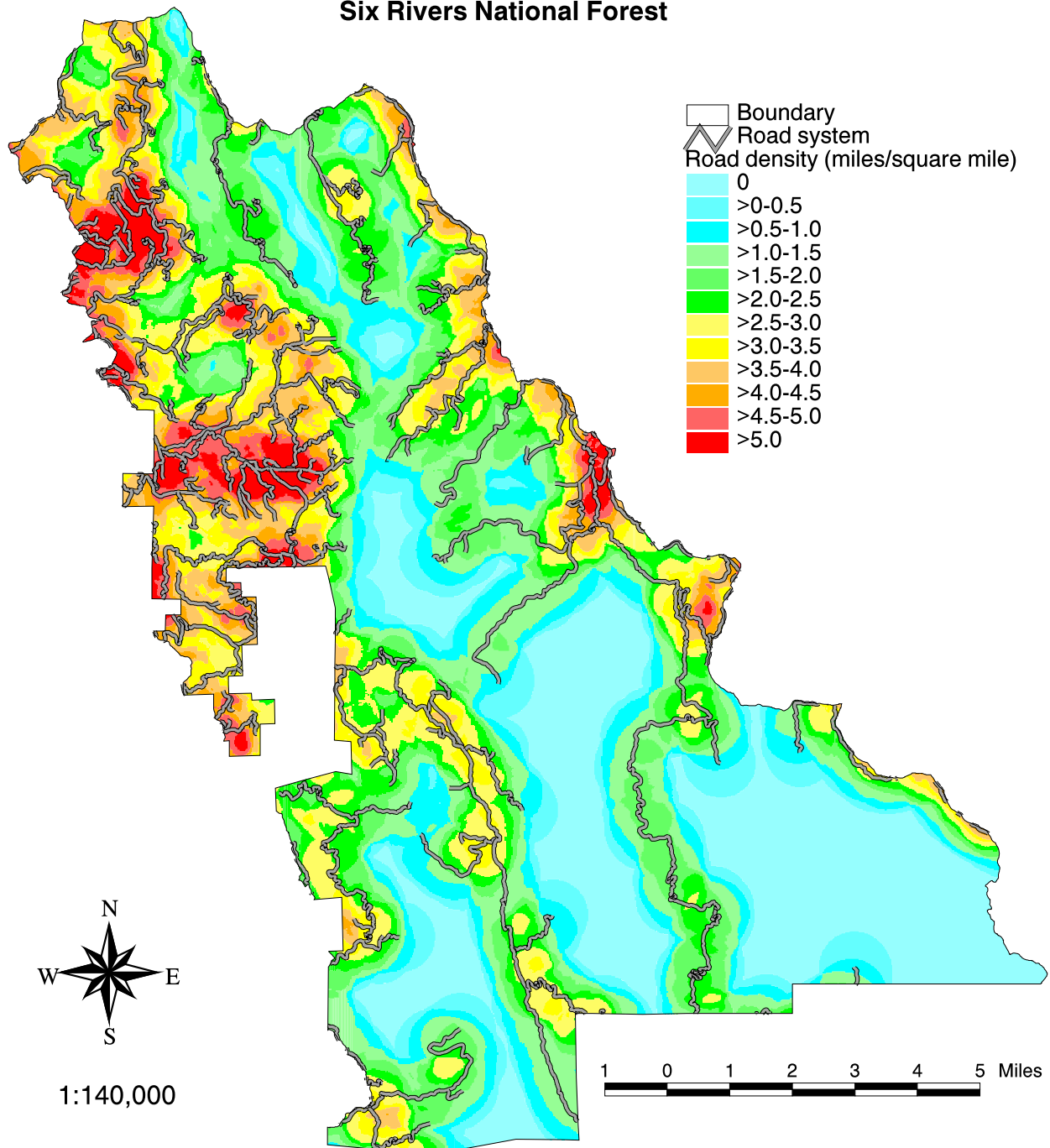


Figure 2-30. Road density for the North Fork Eel River within the Six Rivers NF. Note the difference in road density between the north and south areas of the watershed.

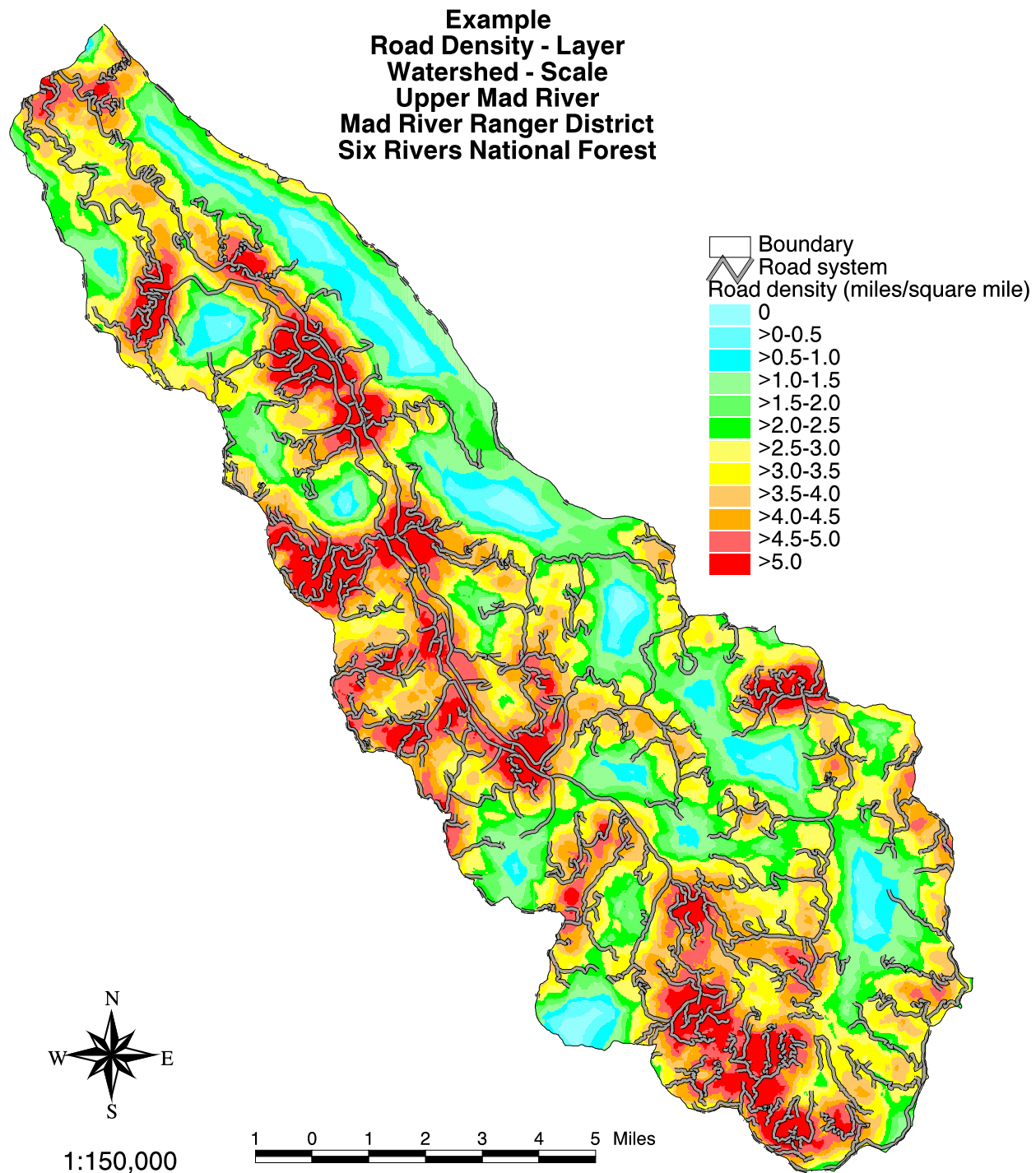


Figure 2-31. Road density for the upper Mad River watershed.

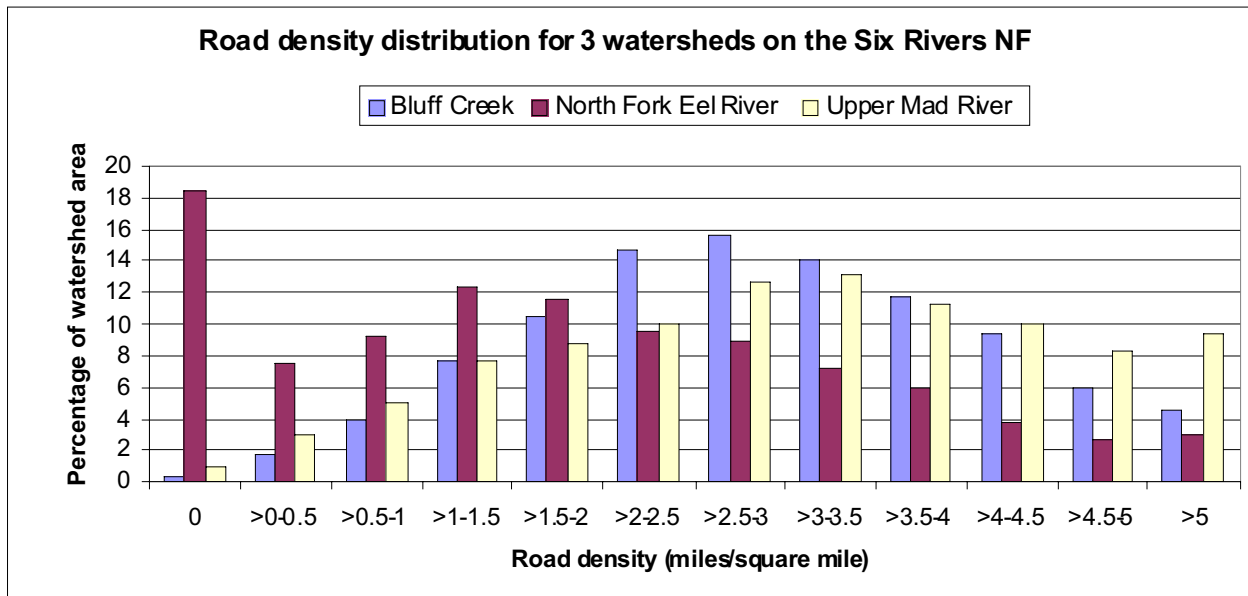


Figure 2-32. Road density distribution for three watersheds. Note the significant differences in the distributions.

Priority Watersheds Based upon Road Densities in RHCAs

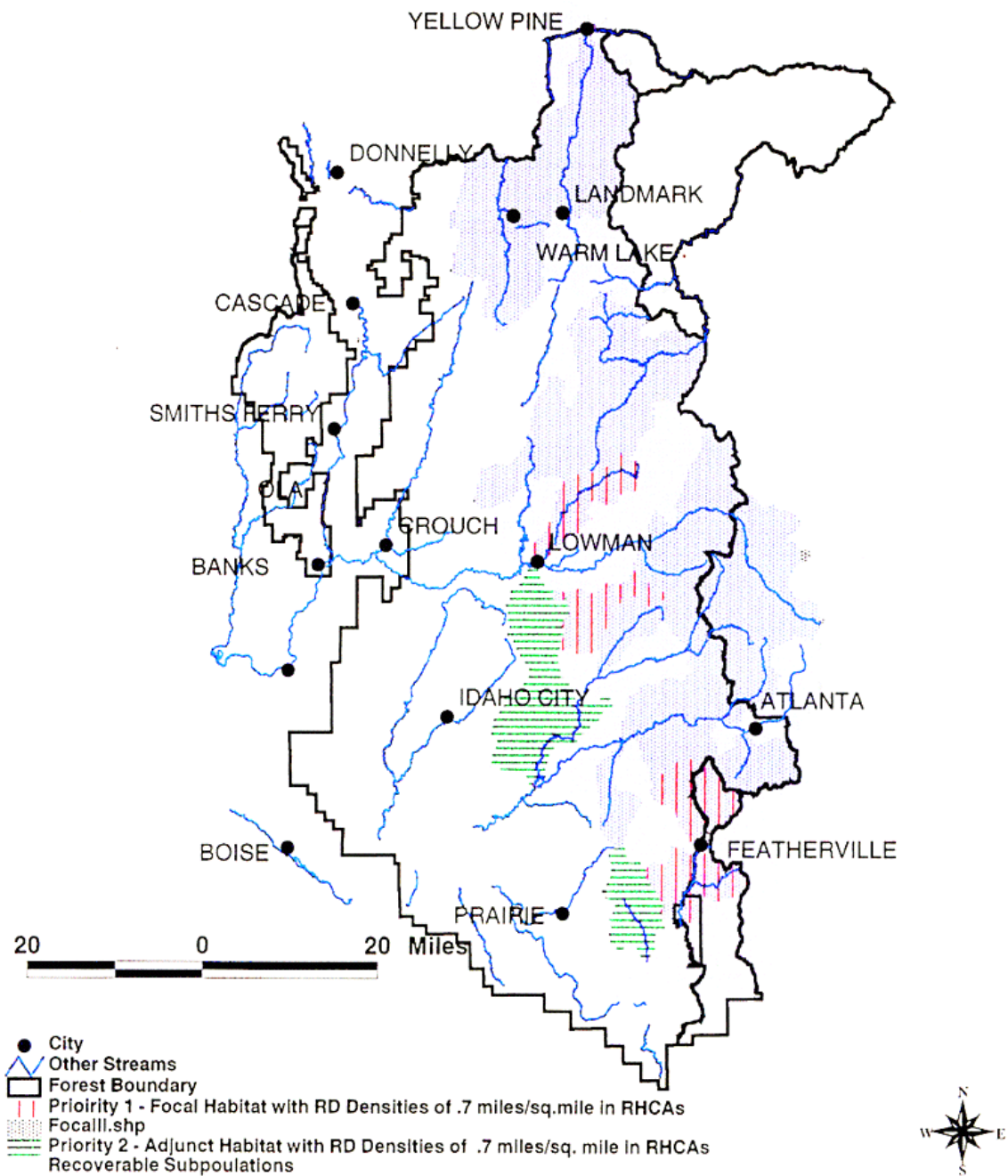


Figure 2-33. Example from the Boise National Forest using road density in Riparian Habitat Conservation Areas to select watersheds with priority for restoration.

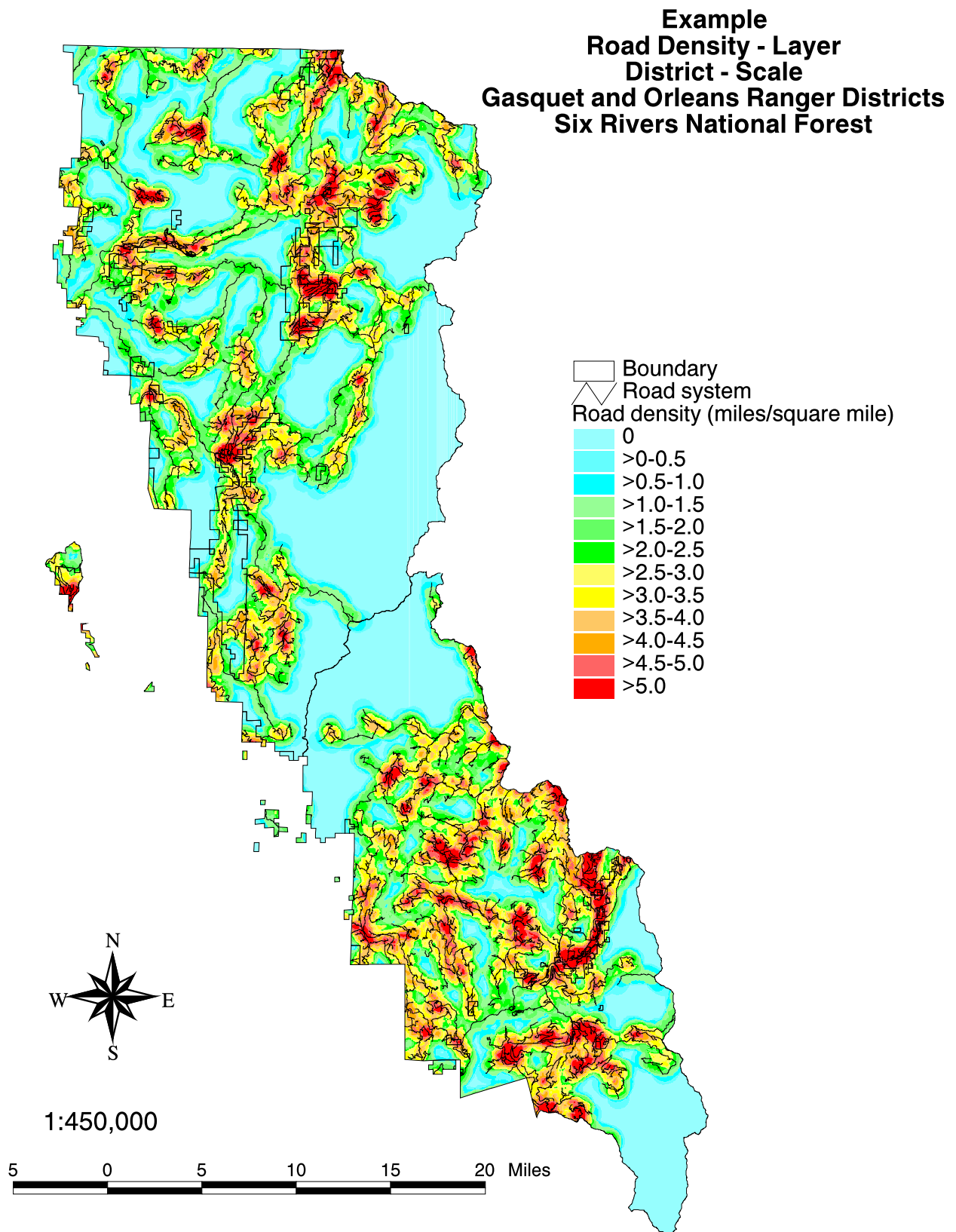


Figure 2-34. Road density for the Gasquet and Orleans Ranger Districts. The large roadless areas are wilderness.

Example
Connected Road Density - Layer
Watershed - Scale
Bluff Creek Watershed
Orleans Ranger District
Six Rivers National Forest

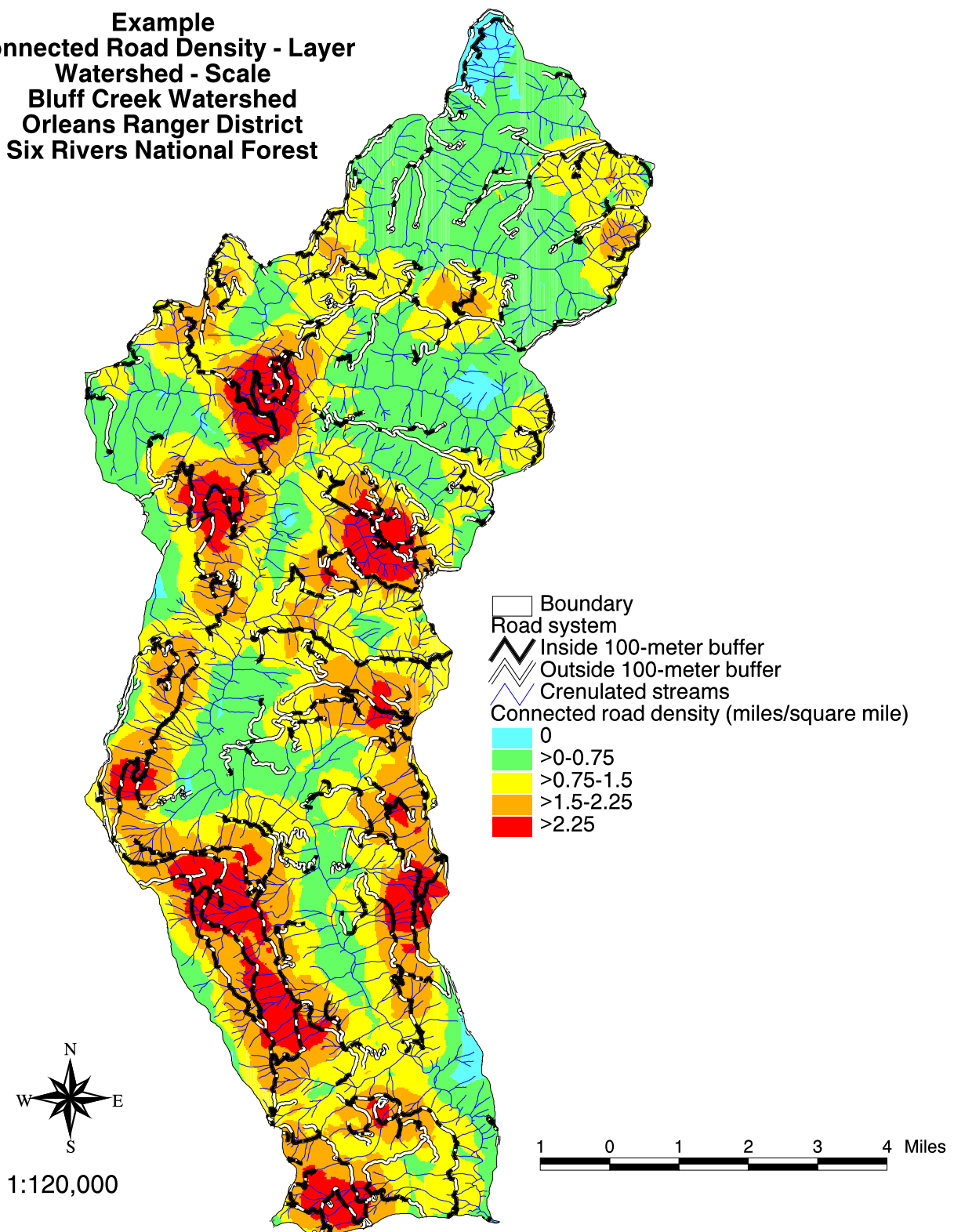


Figure 2-35. Road density in the Bluff Creek watershed for road segments within a 100-meter buffer of crenulated-contour streams. The moving window size is one square mile and the cell size is 30 X 30 meters.

**Example
Road Density - Layer
Watershed - Scale
Bluff Creek Watershed
Orleans Ranger District
Six Rivers National Forest**

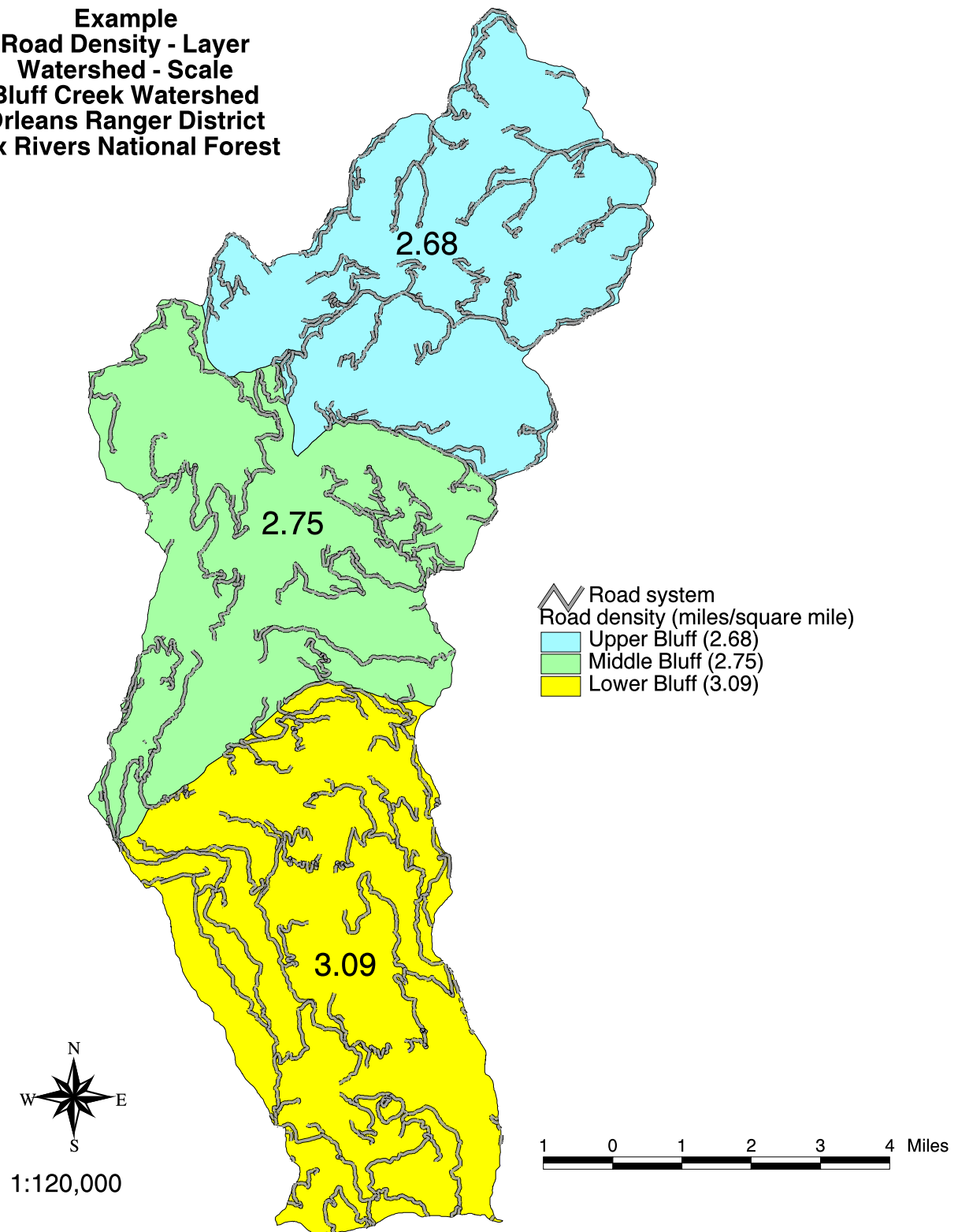


Figure 2-36. Road density for the upper, middle, and lower areas of the Bluff Creek watershed. Note the minimal differences in the road density values.

**Example
Connected Road Density - Layer
Watershed - Scale
Bluff Creek Watershed
Orleans Ranger District
Six Rivers National Forest**

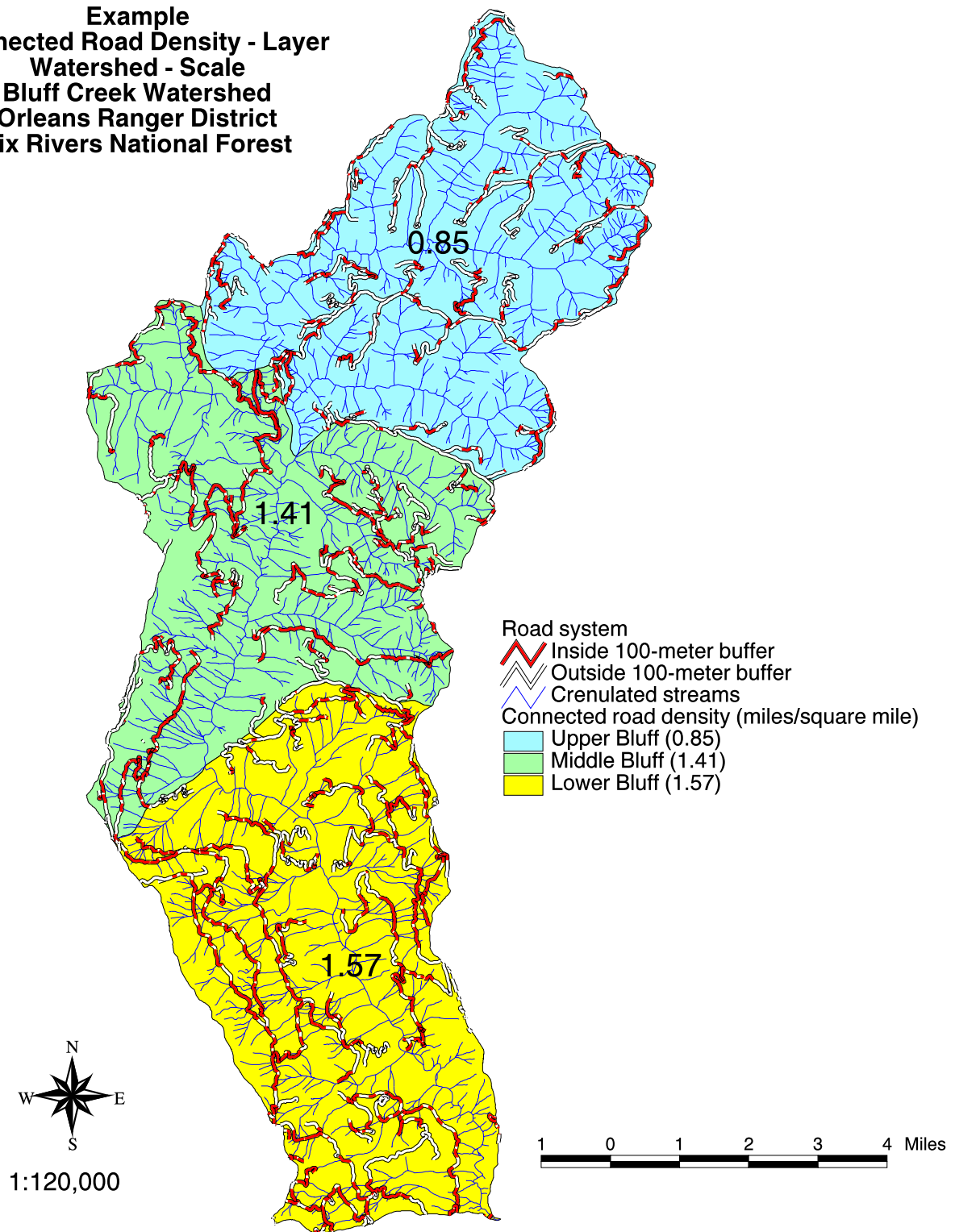


Figure 2-37. Road density for the upper, middle, and lower areas in the Bluff Creek watershed for the road segments within 100 meters of crenulated-contour streams. Note the higher densities for the middle and lower areas.

Example
Road Density - Layer
Middle and Lower Slope Positions
Watershed - Scale
Bluff Creek Watershed
Orleans Ranger District
Six Rivers National Forest

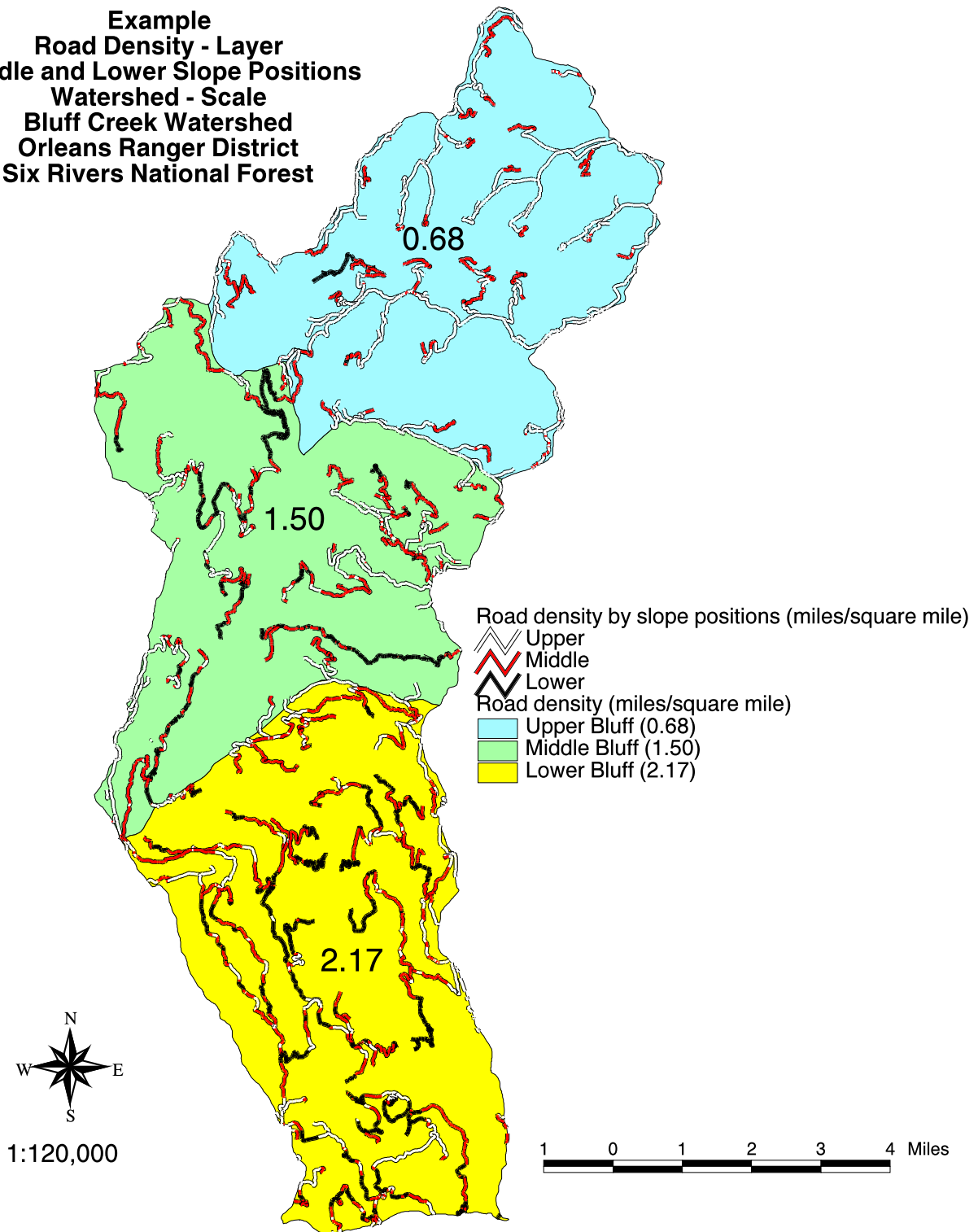


Figure 2-38. Road density for the upper, middle, and lower areas of the Bluff Creek watershed for the road segments in the middle and lower slope positions. Note the increasing density from north to south.