Bedrock Geology as an Indicator of Road Hazard

Name of indicator

Bedrock geology

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 generate surface erosion? AQ (3) How and where does the road system affect mass wasting? 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

Bedrock geology is the parent material on which soils and vegetation develop. Geologic maps display the types and ages of the different geologic materials present in an area. The legend usually shows the geologic units in descending order from youngest to oldest. The legend may also have a brief description of the unit and its topographic expression. Bedrock geology can be a significant influence on mass wasting and surface erosion. Roads constructed on different bedrock types will often have differences in susceptibility to mass wasting and surface erosion processes.

Units of indicator

Some geologic maps have formation names subdivided into geologic units and subunits. Usually the geologic unit will be the primary category used for roads analysis. Some of the geologic units will simply have the names of their rock types, basalt, andesite, granite, sandstone, limestone, quartzite, schist, and so on. Other units will have the formation name first, such as "Wanapum Basalt." Large landslides may be mapped as Quaternary landslides. Large floodplains and young river terraces may be mapped as Quaternary alluvium.

Scales

May be useful at any scale if more than one unit is present.

Related Indicators

Bedrock geology units can influence topography because different units often have their own unique topographic expression. Resistant rock types like quartzite or limestone may be capable of maintaining steep slopes, while less resistant types like shale or mudstone may only be capable of maintaining relatively gentle slopes.

Utility

This indicator can be useful in areas with more than one bedrock unit and where enough difference exists in road-related sensitivity between the units.

Acquisition

Geologic mapping exists for most of the country. The scale and detail of mapping varies widely. There are numerous sources for mapping including the U.S. Geological Survey, State geology agencies, theses, dissertations, and the U.S. Forest Service. Some of the mapping is now available electronically and can be readily used.

Data needs

Requires a bedrock geology coverage for the GIS process. A roads coverage is necessary if the roads are going to be attributed in GIS. If a roads coverage is not available, the roads can be manually attributed by using a light table to transfer the bedrock geology polygon information to topographic maps. Manual delineation requires a geologic map and a topographic map with roads.

Accuracy and precision

Geologic mapping differs widely in quality and detail. Many of the maps that cover large areas are compilations of maps done by different individuals. Some mapping may have used only 15-minute (1:62,500) topographic maps and some, air photos at a scale of 1:15,840. It is important to locate the best version available, and if it is digital, to review the labeling to see if it matches the original map.

Durability

Geologic maps are subject to revision by new investigators and if units are redefined. Some major geologic events like volcanic eruptions may significantly change the map.

Monitoring value

Not useful for monitoring.

Limitations

The quality and detail of geologic mapping differs widely. Digital versions may not represent the best mapping available. If a digital version does not exist, finding and digitizing the information can be time-consuming. There may not be enough variation between the geologic units to significantly affect road-related processes. It may require some research to determine which units are more or less susceptible.

Typical availability

Geologic maps exist for the entire United States at various scales. Some of these maps are already in digital form. If the area of interest is not available digitally, it may be possible to digitize the map or the significant geologic contacts. The roads can also be manually attributed by increasing or decreasing the scale of the geologic map to match the roads map.

Where applicable

Wherever geologic data distinguishes between geologic units with differing responses to geomorphic processes.

Examples

One example of a failure-prone bedrock type in northern coastal California is the Franciscan melange which is a pervasively sheared argillite. This unit has many large inactive earthflows that often have small active earthflows. Roads built on this unit often have numerous cutbank slumps and drainage problems resulting from the low permeability of the fine sediments. In the Bluff Creek watershed (figure 2-22), the highest frequency of mass-wasting road failure sites in the different geologic units was in the serpentinite (figure 2-23), which had 13 road failure sites on about 15 miles of road, for a ratio of 0.87 failures per mile. The failures were all in middle and lower slope positions and had an average hillslope gradient of 60 percent.

Development needs

The major need with this indicator is to customize it to the specific landscape. Depending on the amount of knowledge about the relation of bedrock geology to road failures, it may be relatively simple to use.

Tools references

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

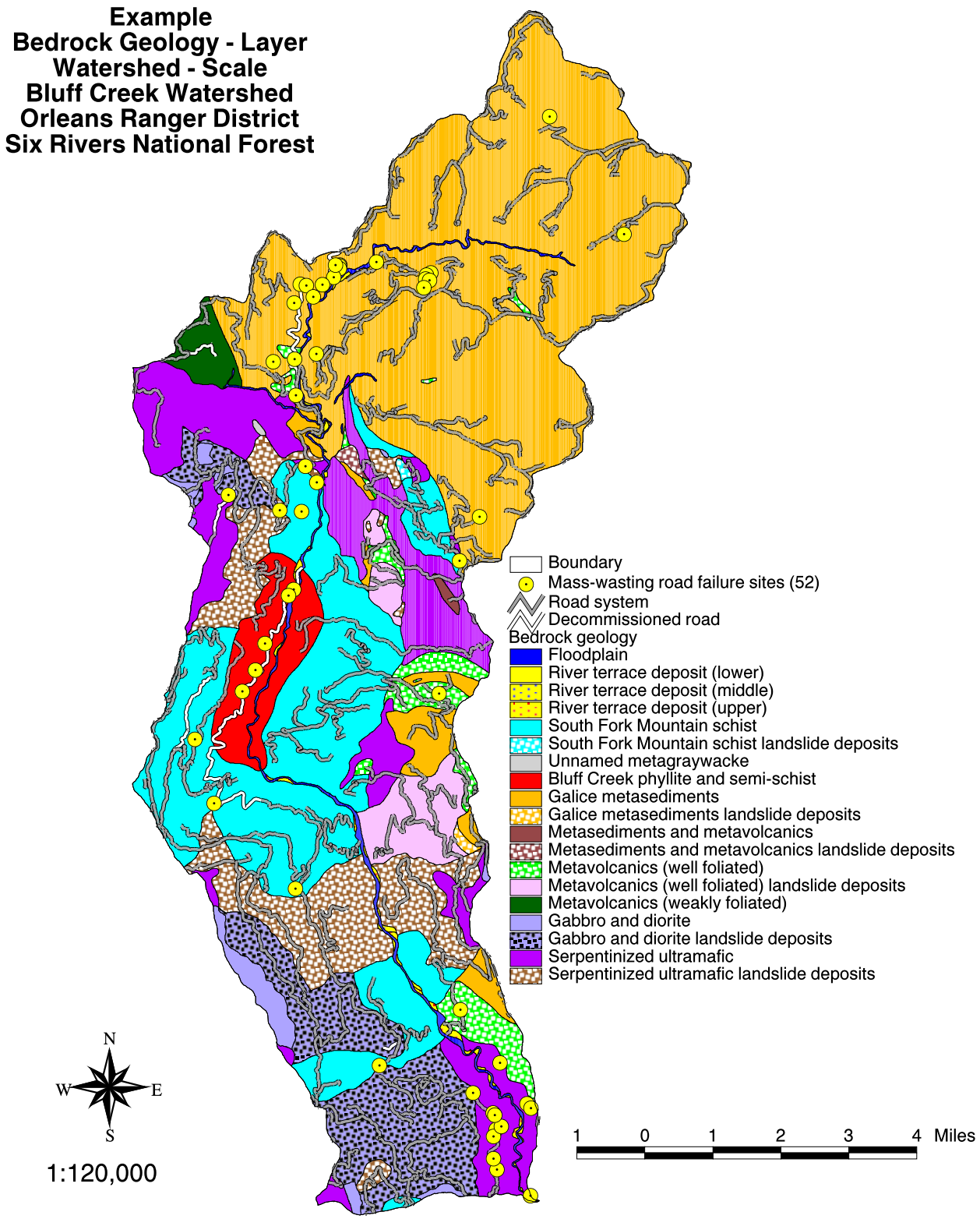

Figure 2-22. Bedrock geology for the Bluff Creek watershed. Note the clustering of road mass-wasting failures in the southern serpentinized area.

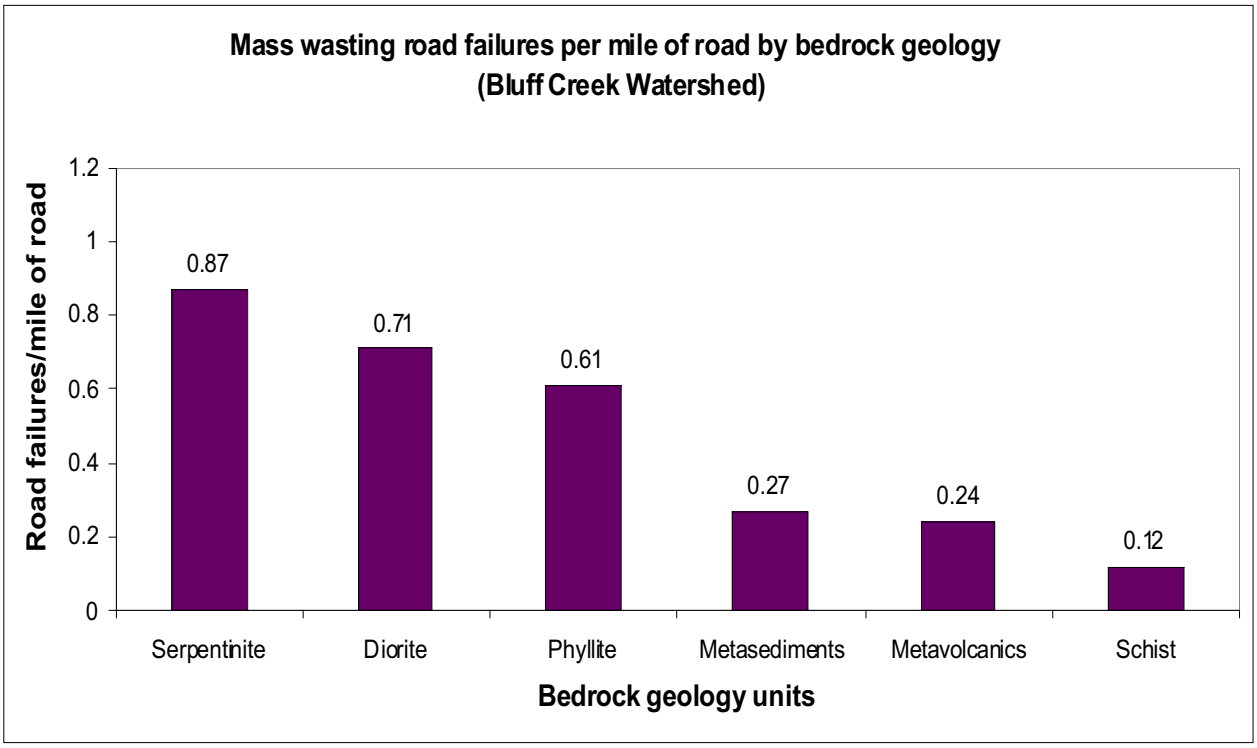

Figure 2-23. Distribution of road mass-wasting failures by bedrock geology.

Table 2-8. Distribution of road mileage and mass-wasting road failures by bedrock geology.

Distribution by bedrock geology of 52 mass wasting road failure sites

Bedrock Geology	Failures per mile	Failures	Road Mileage
Serpentinite	0.87	13	14.9
Diorite	0.71	1	1.4
Phyllite	0.61	5	8.2
Metasediments	0.27	23	85.3
Metavolcanics	0.24	2	8.3
Schist	0.12	6	50.6

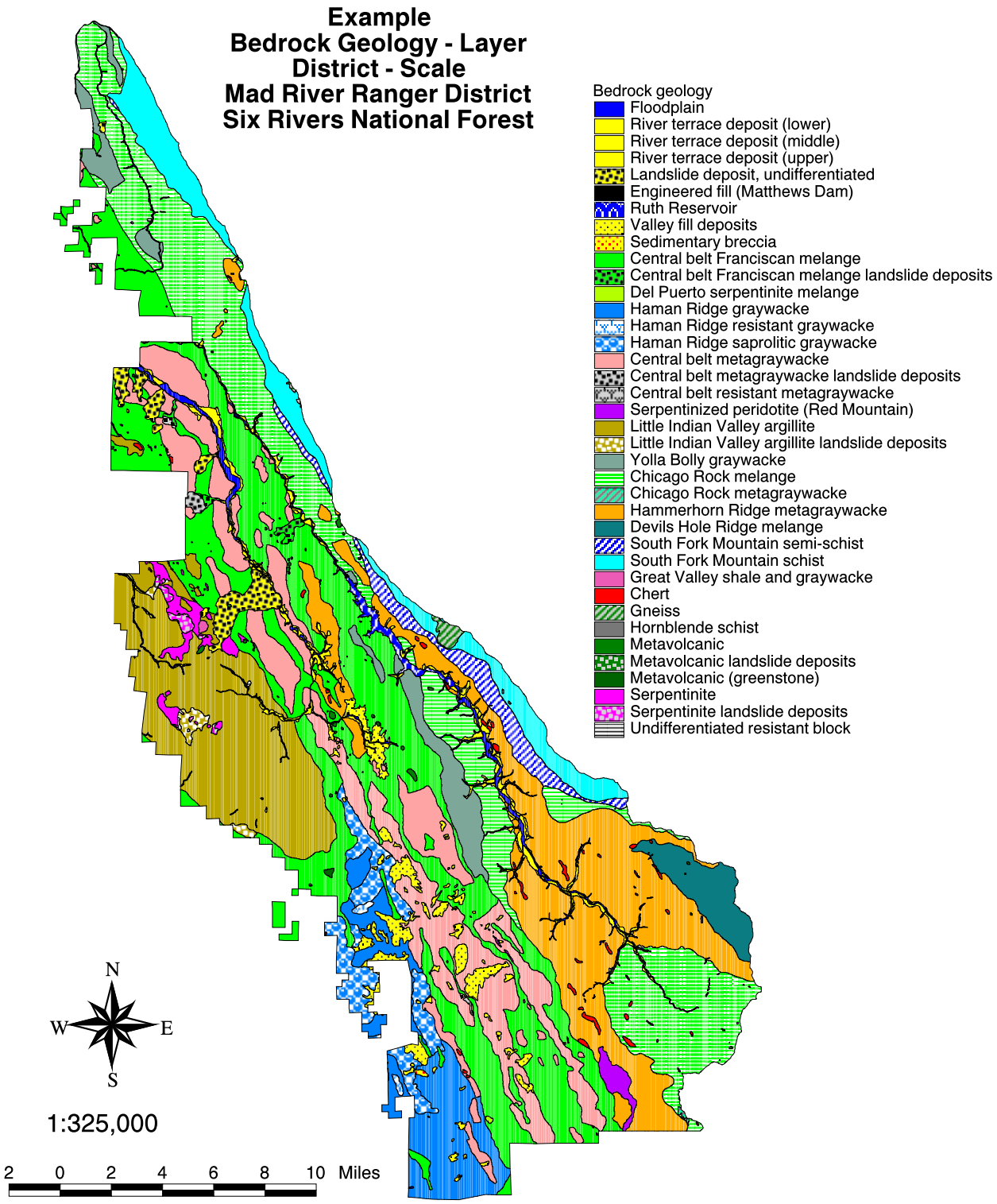

Figure 2-24. Bedrock geology map for the Mad River Ranger District.