Geomorphology as an Indicator of Road Hazard

Name of indicator

Geomorphology

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 (3) How and where does the road system affect mass wasting?

Description of indicator

The geomorphology indicator uses geomorphic and landslide mapping that has been prepared for various purposes. Geomorphologists use various categories to classify geomorphic processes and features. Roads built across certain geomorphic features may have significantly higher road mass-wasting hazard. Some geomorphic features that will probably negatively affect road stability include debris slides, debris flows, debris torrents, rock slides, scarps, toe zones of deep-seated failures, and earthflows. Geomorphic features can be caused or exacerbated by roads. Having the road-related features in a GIS is helpful so the variables in the GIS can be applied to these sites. In some cases the type and frequency of geomorphic features may be correlated with bedrock geology units. An example would be a soft, fine-grained sedimentary bedrock unit that has a much higher frequency of flow type failures than a harder adjacent unit.

Units of indicator

Geomorphic processes and features are described and mapped in various ways. Some maps will have dozens of map units, and each unit may be further described with other attributes. An example would be an active debris slide scarp, that originated in 1980 and was caused by a road. Maps are sometimes produced just to document active landslides. Some maps only show mass wasting or surface erosion ratings. Expertise with geomorphology and roads is usually required to determine which features and feature attributes will be most useful for assigning road mass- wasting hazard ratings.

Scales

Will probably be most useful at watershed to district scales if the mapping has sufficient detail.

Related Indicators

Bedrock geology and climate often exert a strong influence over geomorphology. If the climate does not have significant variations across the area, bedrock geology will often be the dominant control. Type of road construction can be significant in the frequency of road

mass-wasting failures because certain types, such as sidecasting on steep slopes, may be much more prone to failure than a full bench that was end hauled.

Utility

May be useful in determining road mass-wasting hazard.

Acquisition

The sources and type of geomorphic mapping differ widely. Some timber-sale maps may be at large scales like 1:12,000. Forest Service geologic inventory mapping is often transferred from aerial photos to 1:24,000 topographic base maps. Some research may be needed to determine which of the existing maps is useful in targeting road segments with high hazard. If the maps need to be digitized, only transferring those features likely to be useful may be the simplest approach.

Accuracy and precision

Geomorphic mapping is highly interpretive, especially for vegetated dormant or ancient features. Active features such as debris slides are more likely to be consistently mapped by different interpreters. Several attributes of aerial photos can influence the product, scale, resolution, color, sun angle, date, and quality of the stereoscope. Classification schemes and amount of detail will vary. The transfer process from the photos to an orthophoto or topographic map can significantly reduce precision, especially for small (< 1 acre) polygons.

Data needs

A roads coverage is necessary if the roads are going to be attributed in GIS. If the geomorphology and roads coverages are digital the roads can be attributed easily in GIS. The process can also be done manually with a light table.

Durability

In terrain where landslides are a regular occurrence, the situation can change significantly during high-intensity precipitation events. Several years or decades may elapse between these events during which few landslides occur.

Monitoring value

Can be very useful for monitoring the geomorphic changes through time by using sequential aerial photos to asses the frequency of failures for the period between photos.

Limitations

The quality and detail of geomorphic mapping differs widely. Digital versions may not represent the best mapping or even be available. If a digital version does not exist, finding and digitizing one can be time consuming. The type of geomorphic mapping available may not significantly distinguish between features that affect road hazard. Research may be required to determine which features are more or less susceptible.

Typical availability

Geomorphic maps may only be available for portions of the area of interest. Some exploring is usually needed to find a map or version that is appropriate.

Where applicable

Wherever geomorphic mapping distinguishes between features that have significantly different effects on road hazard.

Examples

Many road-related mass-wasting failures occur as debris slides on road cut-banks or fill failures. Some of the road-related mass-wasting failures may have already been mapped on geomorphology maps. In the Bluff Creek watershed (figure 2-25), the most significant geomorphic features for road failures were debris slides. A total of 35 failures on 3.4 miles of road were either caused by the road or were located on a mapped debris slide. Some of the other geomorphic features with high ratios of failures per mile of road in Bluff Creek (figure 2-26) are debris flows and earthflow deposits. There were only 6 failures on these features compared to 35 on debris slides. A geomorphic map at the district-scale (figure 2-27) contains more than 9,000 geomorphic polygons.

Development needs

The major need with this indicator is to customize it to the specific landscape. Depending on the level of knowledge about the relation of geomorphology 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)

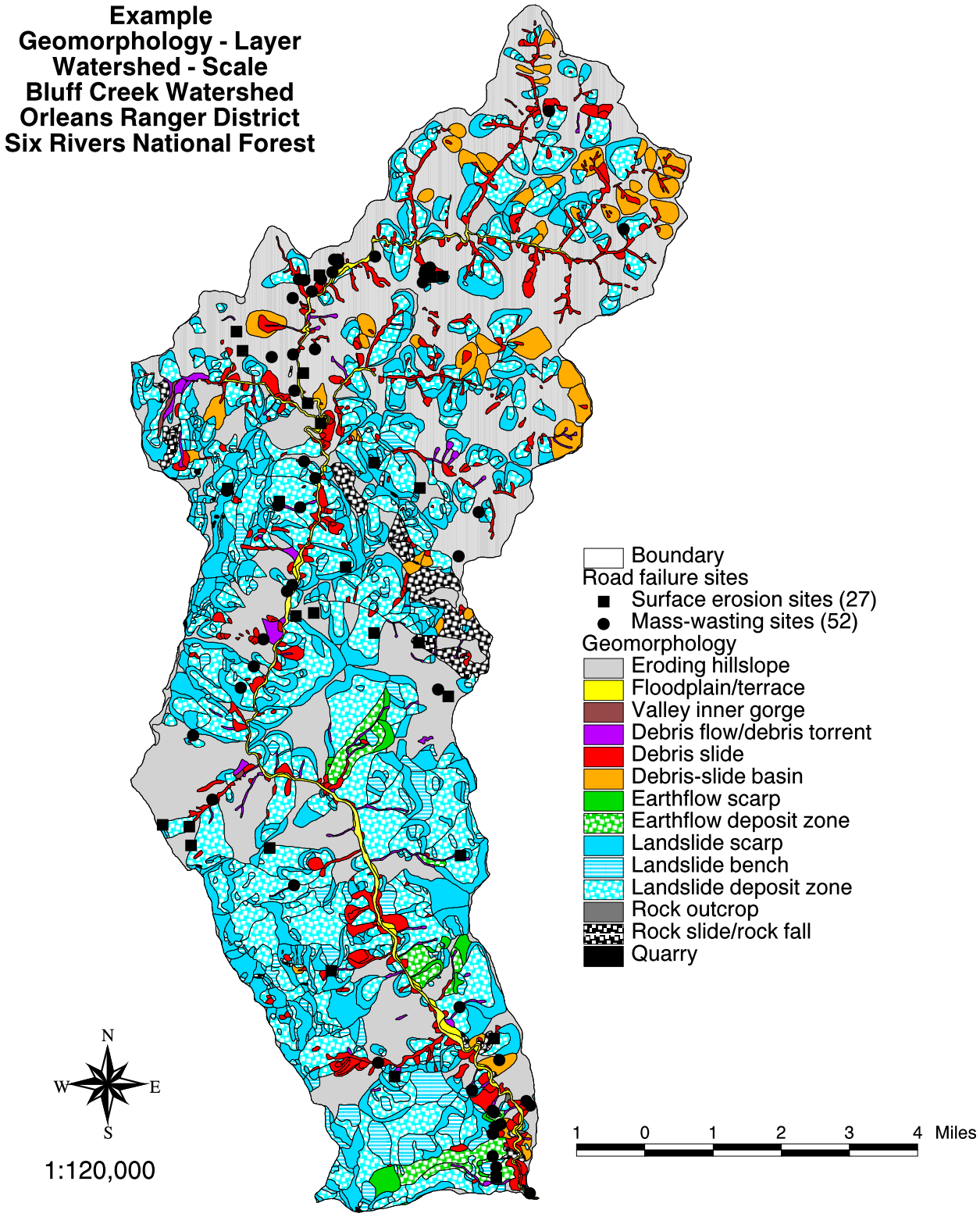

Figure 2-25. Simplified geomorphology of the Bluff Creek watershed.

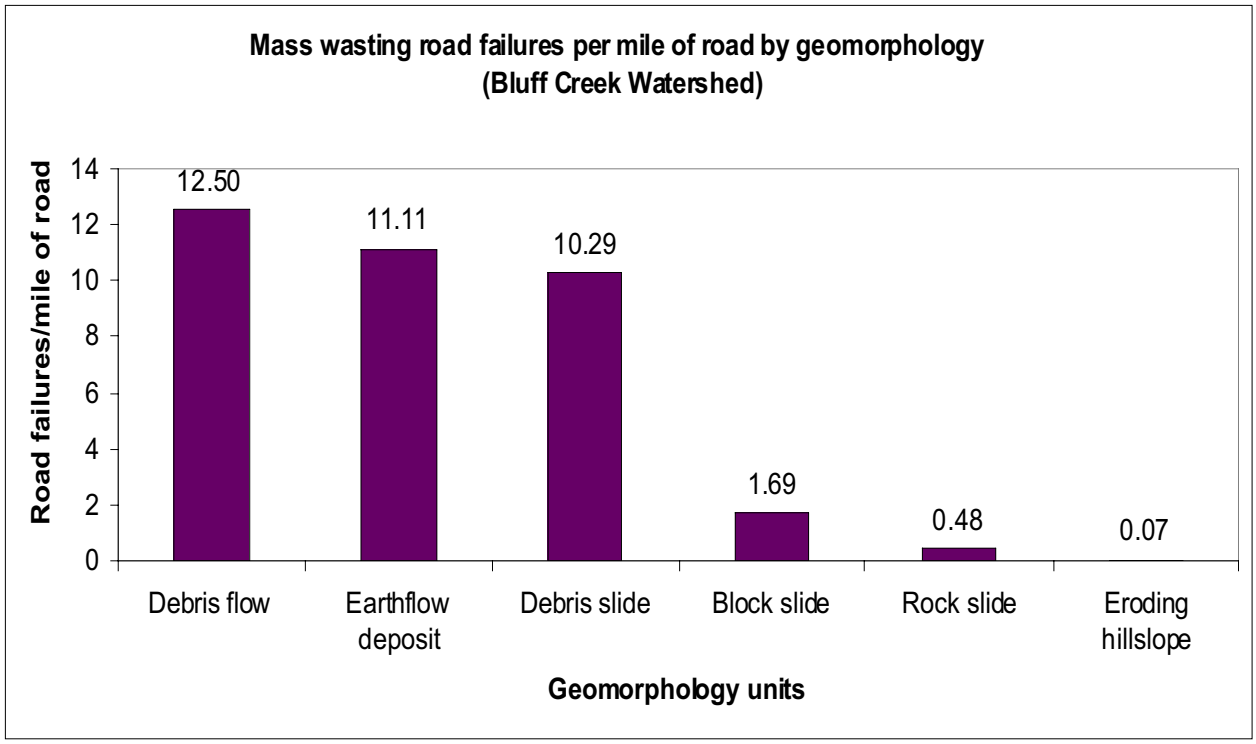

Figure 2-26. Distribution of road mass-wasting failure sites by geomorphology units.

Table 2-9. Distribution of road mileage and failure sites by geomorphology units.

Distribution by geomorphology of 52 mass wasting road failure sites

Geomorphology Feature	Failures per mile	Failures	Road Mileage
Debris flow	12.50	5	0.40
Earthflow deposit	11.11	1	0.09
Debris slide	10.29	35	3.40
Block slide	1.69	1	0.59
Rock slide	0.48	1	2.09
Eroding hillslope	0.07	7	107.00

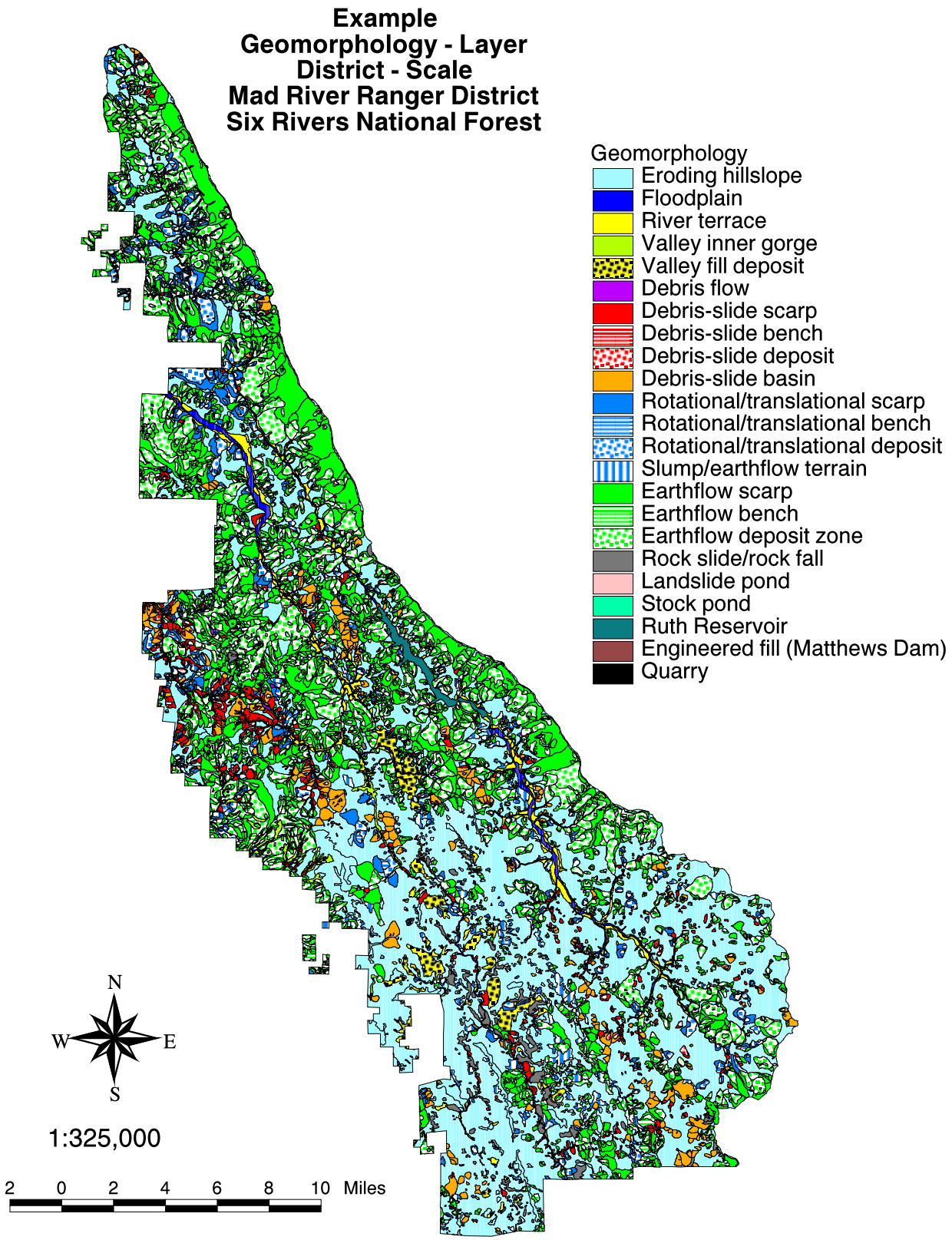

Figure 2-27. Geomorphology of the Mad River Ranger District.