Stream Channel Proximity as an Indicator of Road Hazard

Name of indicator

Stream channel proximity

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 (4) How and where do road-stream crossings influence local stream channels and water quality? AQ (5) How and where does the road system create the potential for pollutants, such as chemical spills, oils, de-icing salts, or herbicides to enter surface waters? 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)? AQ (10) How and where does the road system restrict the migration and movement of aquatic organisms? AQ (11) How does the road system affect shading, litterfall, and riparian plant communities? AQ (12) How and where does the road system contribute to fishing, poaching, or direct habitat loss for at-risk aquatic species? AQ (13) What kinds of non-native aquatic species are likely to be successful in the watershed? How and where does the road system facilitate the introduction of non-native aquatic species?

Description of indicator

The stream channel proximity indicator is an attempt to address the issue of hydrologic connectivity between roads and streams. A hydrologically connected road can be defined as any road segment that has a continuous surface flowpath to a stream channel. Inboard ditches that drain to road-stream crossings are the most obvious road segments that are connected. Other situations that connect roads to streams are cross drains that create overland flow to channels, roads with fillslopes that encroach on stream channels, and landslide scars that create a surface flow path to a channel. A simple way to address connectivity with a GIS is to buffer a stream channel coverage by a “reasonable” distance and identify those road segments within the specified distance.

Units of indicator

Inside or outside of the stream-channel buffer.

Scales

Usually most useful at the watershed or subwatershed scale.

Related Indicators

Hydrologic connectivity varies with slope position. Upper slope positions are usually less connected than lower positions. In the Bluff

Creek watershed (figure 2-15), by using a 100-meter buffer of the stream channels, the percentage of road connected (inside the 100 meters) in the slope positions were upper, 30 percent; middle, 54 percent; and lower, 72 percent.

Utility

The extent of hydrologic connectivity is extremely important to roads analysis because it determines whether a geomorphic or hydrologic process will affect the aquatic environment.

Acquisition

The easiest way to use this indicator is to buffer the stream channel coverage by a specified distance.

Data needs

Requires roads and stream-channel coverages 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 buffered area to topographic maps. Manual delineation requires a topographic map with streams and roads.

Accuracy and precision

The degree of hydrologic connectivity probably varies significantly within a watershed. Addressing connectivity directly is difficult, unless an inventory of road-stream crossings and other drainage features is complete. The connected areas for the Bluff Creek watershed were approximated by a 100-meter buffer of the stream channels, as determined from contour crenulations. The buffer distance of 100 meters was used, based on field checking and on the frequency distribution of inboard ditch length in three watersheds. This distribution (figure 2-18) shows that more than 90 percent of the inboard ditch lengths in the three watersheds would be included in a 100-meter buffer of the stream channels.

Durability

The hydrologic connectivity of roads is subject to change through human intervention and natural processes. Road building almost always increases hydrologic connectivity and decommissioning decreases it. Geomorphic processes tend to increase connectivity after road building is complete, through mass wasting and gullying. Road obliteration will reduce connectivity by removing ditches and other artificial channeling structures.

Monitoring value

Reducing the miles of road in a watershed will reduce the degree of connectivity because almost all roads have some features that increase connectivity. A GIS can be used to monitor changes in hydrologic connectivity if road decommissioning and obliteration are updated.

Limitations

Using a buffer of stream channels to determine the length of road hydrologically connected to streams is only an approximation of

connectivity. In some areas, even small watersheds have significantly diverse geology and topography that affects connectivity. The way a road is built will influence the degree of connectivity. An outsloped ridgetop road will probably be much less connected than a road in a low slope position with long inboard ditches and numerous crossings. Various types of stream-channel coverages can be used to approximate the connectivity of roads. The best coverage would be one that represents the true stream channels. The blue-line streams from USGS topographic maps often significantly underestimate the true stream channels. A comparison of blue-line streams and crenulated-contour delineated channels showed that the crenulated coverage had from 3.2 to 4.5 times the length of stream channels as the blue-line coverage.

Where applicable

The proximity of roads to stream channels is useful to know in most areas. Many values are associated with watercourses and waterbodies that may be directly affected by the input of sediment or other pollutants.

Examples

The multiple watersheds area with 319 road failure sites (figure 2-20) produced a road failure/mile-of road-ratio that was more than 3 times higher for road segments within the buffer. The distribution of the road failure sites by distance from the crenulated-stream channels (figure 2-21) shows the ratio for mass-wasting road failures doubling for the interval of 0-25 meters compared to the 50-75 meter interval.

Figure 2-16 shows an interpretation of road-stream proximity from the point of view of the stream. Streams are attributed, via network analysis, with the cumulative length of upstream connected road (within 100 meters of a crenulated stream). This same type of interpretation can also be applied to most other indicators.

Development needs

Further development of this indicator would involve field sampling to determine how well the indicator represents the actual connectivity. Hydrologic connectivity probably varies significantly with the following variables:

Slope position
Hillslope gradient
Road type
Precipitation
Bedrock geology
Soil type

Tools references

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

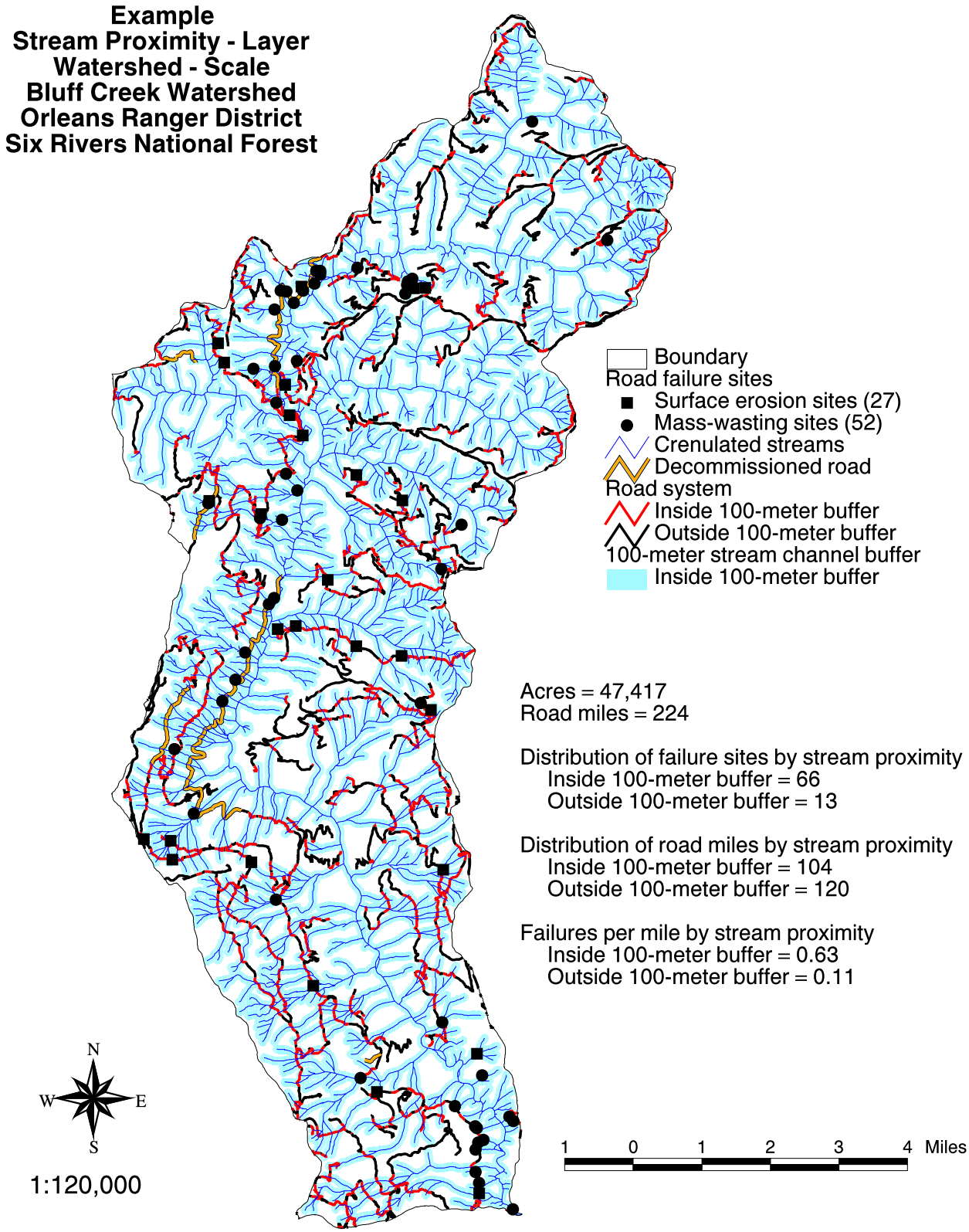

Figure 2-15. Buffered streams with a 100-meter buffer of the crenulated-contour coverage. Note the higher failure-per-mile ratio inside the buffer.

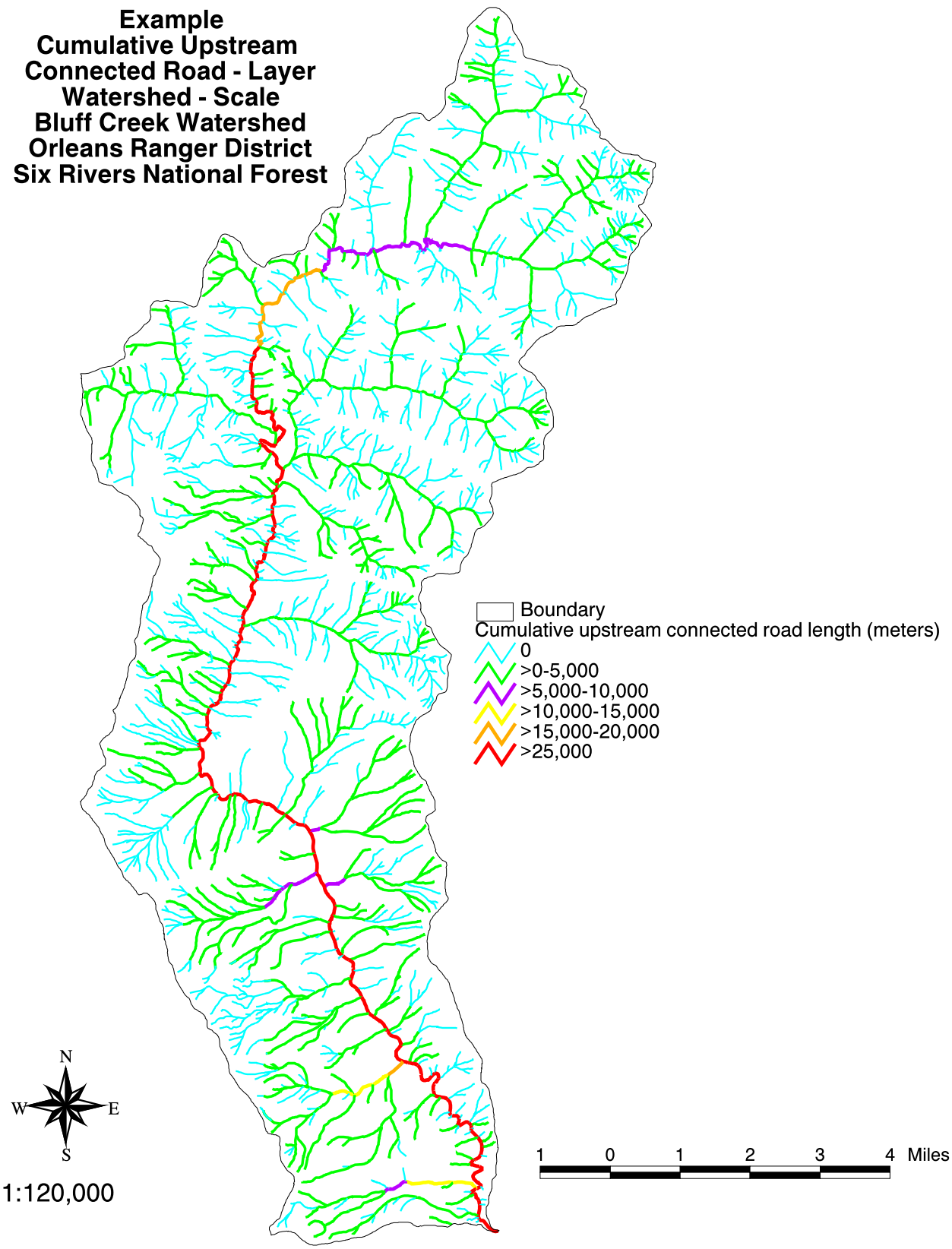

Figure 2-16. Streams attributed with the cumulative length of connected upslope road (within 100 meters of a crenulated stream). This analysis requires a fully 'routed' stream layer.

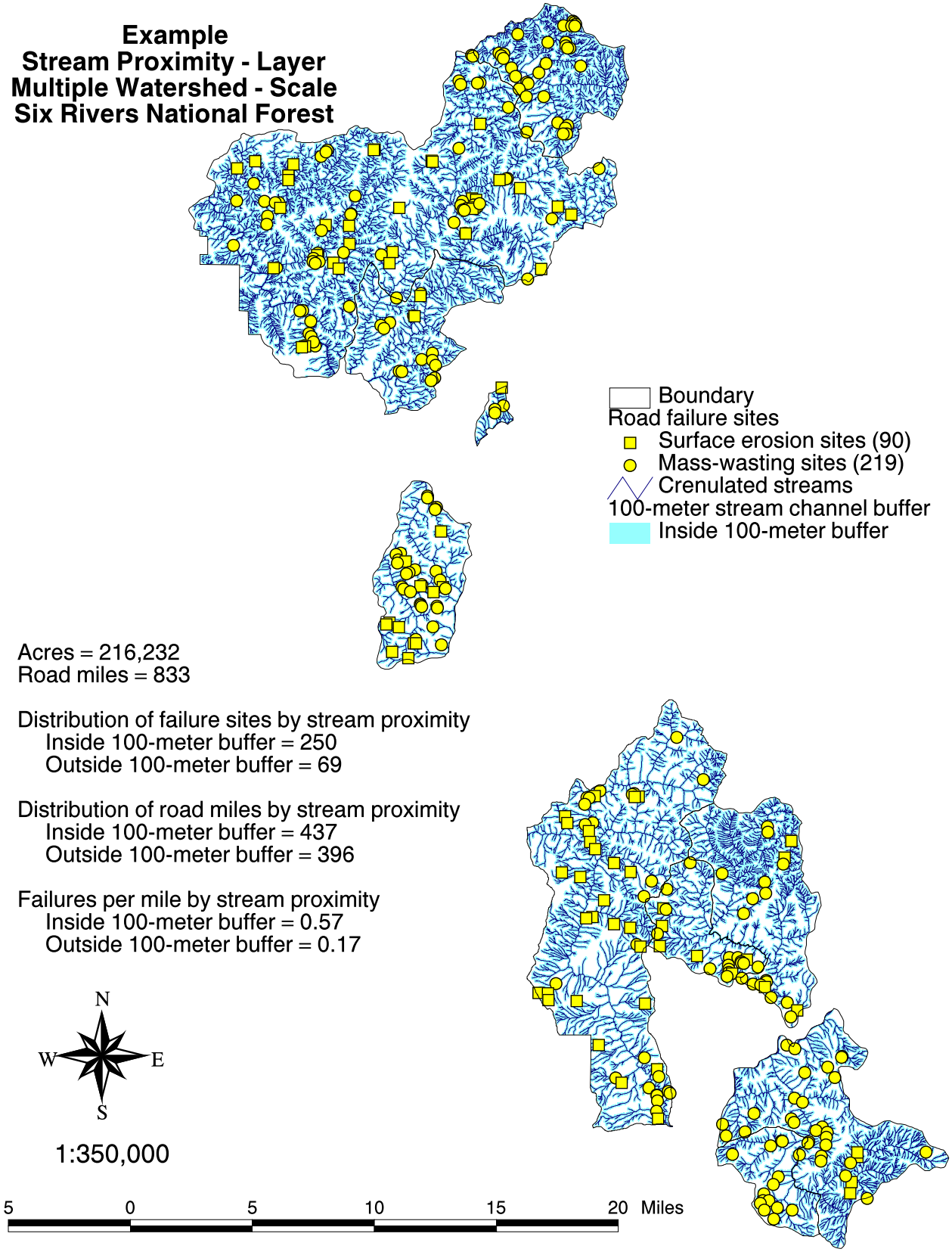

Figure 2-17. Buffered streams with a 100-meter buffer of the crenulated-contour coverage. Note the higher failure-per-mile ratio inside the buffer.

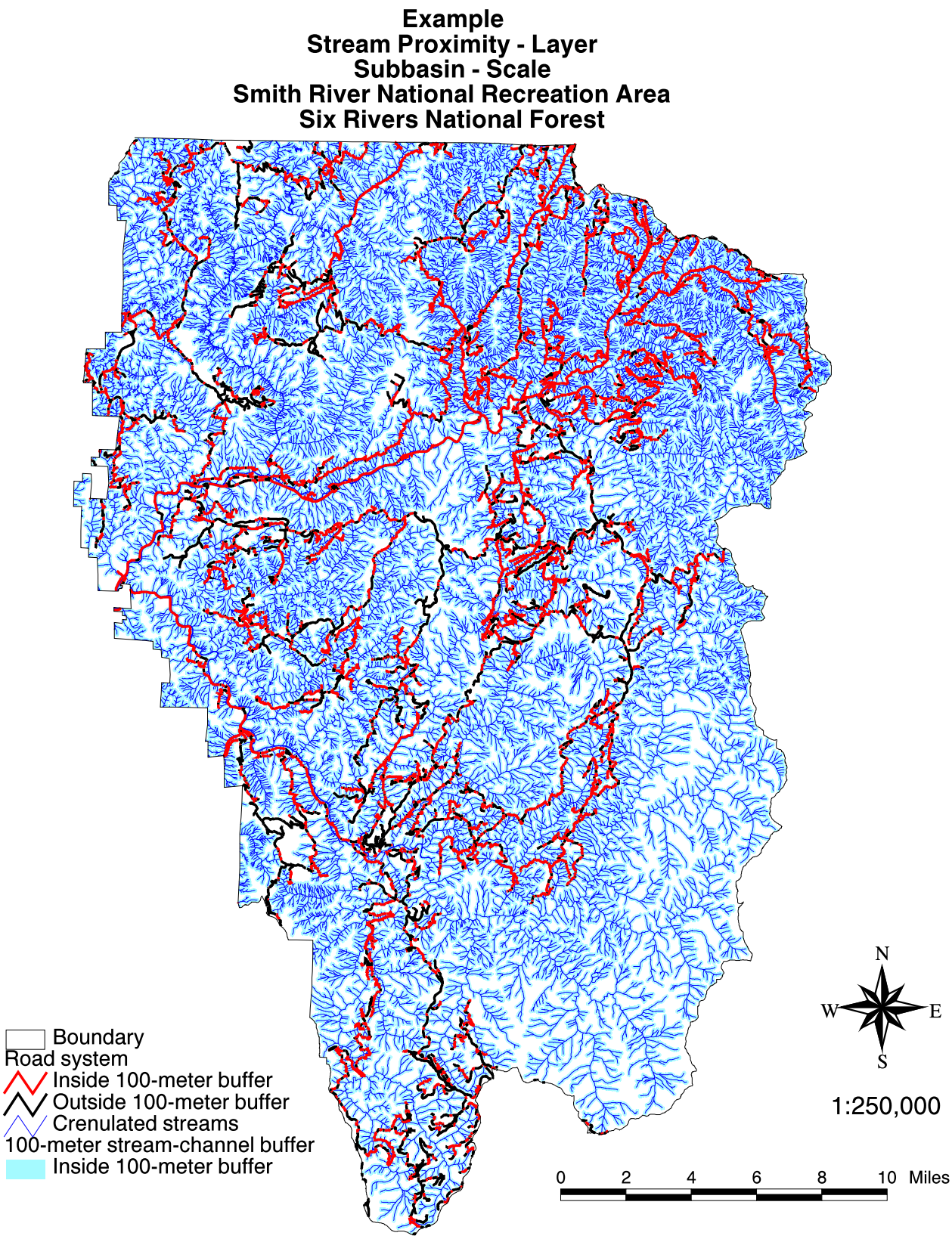

Figure 2-18. Buffered streams with a 100-meter buffer of the crenulated-contour coverage.

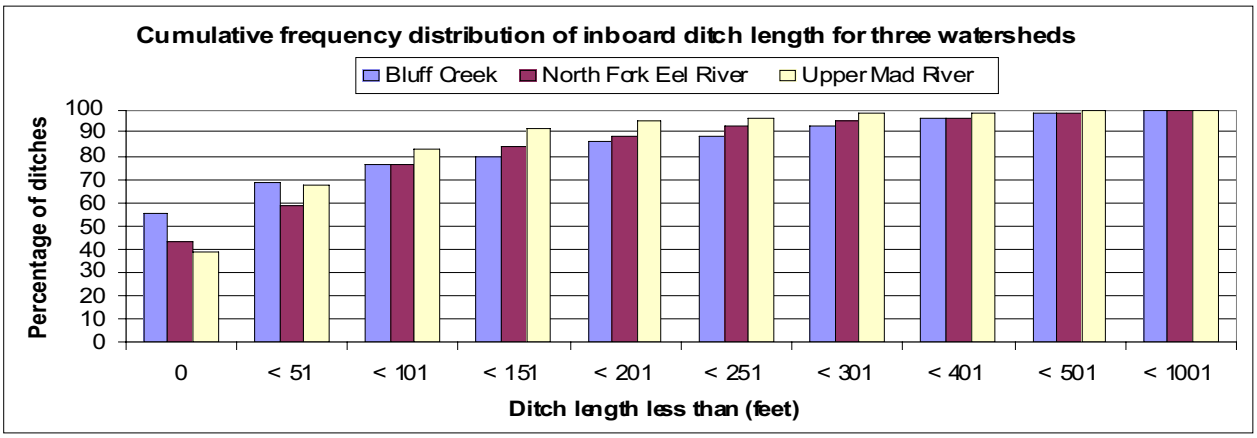

Figure 2-19. Distribution of inboard ditch length for 3 watersheds on the Six Rivers NF. Note that 90 percent are less than 300 feet long.

Table 2-5. Inboard ditch length for 3 watersheds.

Ditch Length (feet)	**Distribution of ditch length** Bluff Creek	North Fork Eel River	Upper Mad River	Ditch Length (feet)	**Percent of ditches** Bluff Creek	North Fork Eel River	Upper Mad River
0	266	333	300	0	55	43	39
1-50	67	124	216	< 51	69	59	68
51-100	35	133	120	< 101	76	76	83
101-150	20	63	62	< 151	80	84	92
151-200	28	35	26	< 201	86	88	95
201-250	11	32	16	< 251	89	93	97
251-300	19	16	9	< 301	93	95	98
301-400	19	21	8	< 401	96	97	99
401-500	8	14	3	< 501	98	99	100
501-1000	9	7	2	< 1001	100	100	100
Totals	**482**	**778**	**762**				

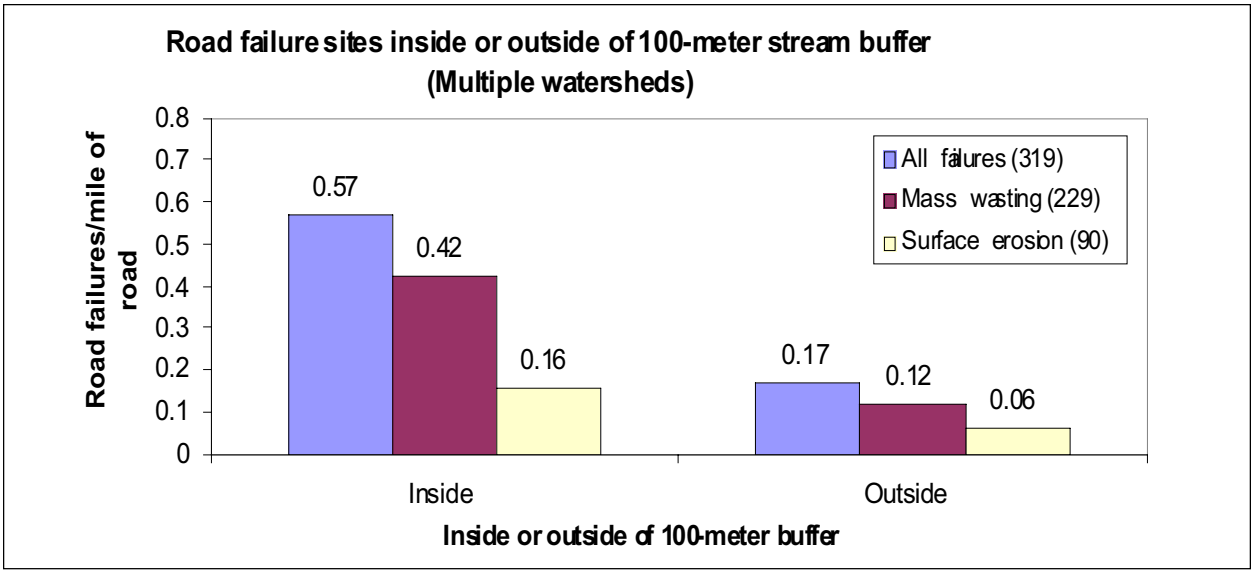

Figure 2-20. Comparison of road failure sites inside and outside of a 100-meter buffer of the crenulated-contour coverage.

Table 2-6. Distribution of 319 road failure sites in relation to 100-meter buffer.

Distribution of 319 road failure sites

	Failures per mile						
	All failures (319)	Mass wasting (229)	Surface erosion (90)	All failures	Mass wasting	Surface erosion	Road mileage
Inside	0.57	0.42	0.16	250	182	68	437
Outside	0.17	0.12	0.06	69	47	22	396

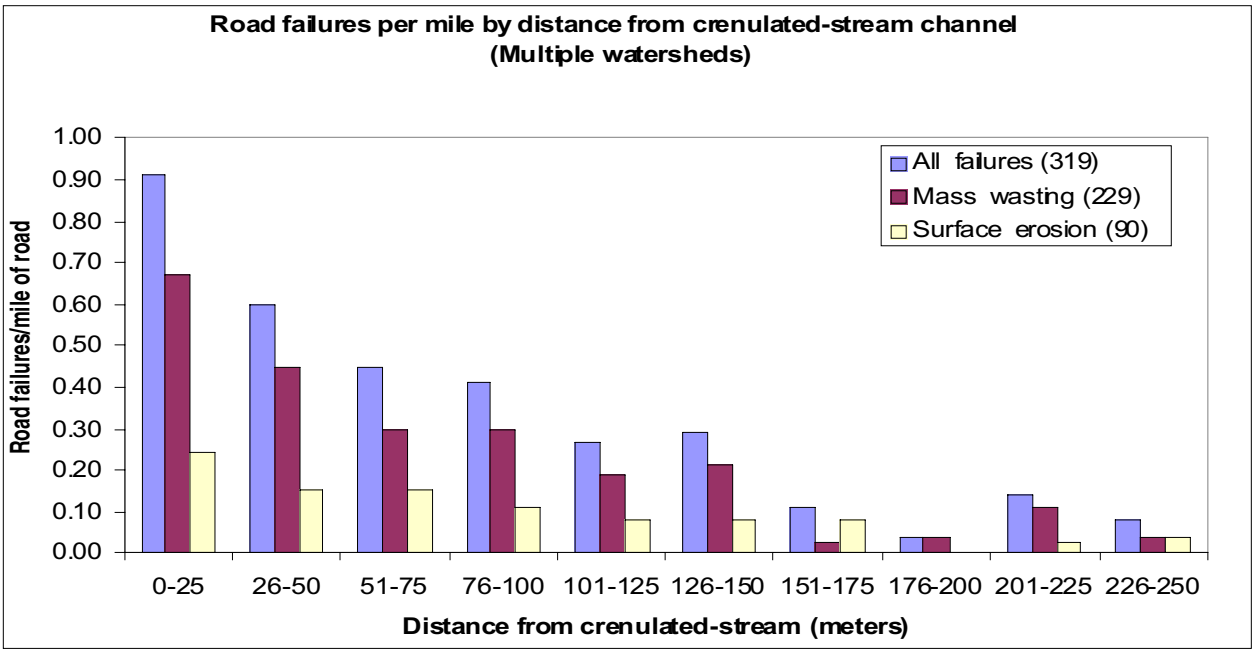

Figure 2-21. Distance of road failure sites from crenulated-stream channels.

Table 2-7. Distance of road failure sites from crenulated-contour stream channels.

Proximity to crenulated stream channel								
	Road failures per mile of road					Percent of ditches		
Distance (meters)	All failures (319)	Mass wasting (229)	Surface erosion (90)	Road mileage	Cumulative mileage	All failures (319)	Mass wasting (229)	Surface erosion (90)
0-25	0.91	0.67	0.24	88	88	80	59	21
26-50	0.60	0.45	0.15	117	205	70	53	17
51-75	0.45	0.30	0.15	122	327	55	37	18
76-100	0.41	0.30	0.11	111	437	45	33	12
101-125	0.27	0.19	0.08	96	533	26	18	8
126-150	0.29	0.21	0.08	77	610	22	16	6
151-175	0.11	0.03	0.08	61	671	7	2	5
176-200	0.04	0.04	0.00	47	718	2	2	0
201-225	0.14	0.11	0.03	35	753	5	4	1
226-250	0.08	0.04	0.04	24	777	2	1	1
251-275	Failures more than 250 feet are not included in the above chart					1	1	0
276-300						2	2	0
301-325						0	0	0
326-350						1	1	0
351-375						0	0	0
376-400						1	0	1