Appendix J:

Vegetative Buffer Equation

Vegetated buffers are the most cost effective method to protect streams from damage caused by erosion and sediment.

> ...Eroded sand is particularly damaging--when excess sand overwhelms the natural bedload transport process, sand fills in the spaces around and under rocks resulting in reduced macro-invertebrate habitat and loss of in-stream plants (C. Ohlander 1993).

The vegetated buffer equation calculates the potential sediment flow distance below a typical road drainage structure. This is the distance needed to trap sand-sized particles (0.06 to 2.0 mm) generated by road ditch and surface erosion.

Based on research conducted on the Black Hills during the summer and fall of 1993 by Coryell Ohlander (Regional Hydrologist, unpublished), the following equation determines a vegetated buffer width effective at protecting water courses from road generated sediment. This equation was found to work for typical gravel and dirt roads in most areas of the Black Hills National Forest.

The equation is: Vbfr = (10 + 10xRms + 100xGdp)/(Vcvr) where:

Vbfr = Vegetated buffer needed to trap road and ditch erosion (feet)

Rms = (The distance between drainage structures/1000)x(Road slope percent)

Gdp = Ditch cutting or gullying in the ditch bottom (0.1 feet)

Vcvr = Buffer type and vegetative cover factor (ranges from 0.1- 1.0)

There are seven basic buffer types used to characterize the general patterns of flow concentration or dispersion. These are:

S = Swales: as undisturbed vegetation and no concentrated flow;

E = Eroded: healed rills or small gullies disconnected from stream;

D = Drops: holes or depressions;

F = Fans: smooth sideslopes or ridges that allow sediment to fan out;

L = LWD: large woody debris (4 inches) oriented to create barriers;

O = Open: flow along paths or trails (disconnected from stream); and

W = Wandering: spreading flow through rocky material (2.5 inches), or hummocks.

Except for the “fan” type, the Vcvr element is controlled by the buffer type. The “fan” Vcvr factor is dependent on the density of vegetative cover made up of live plant, coarse herbaceous litter, and woody debris. Use the decimal (90 percent = .90).

BUFFER TYPE	CONDITION	Vcvr	
		EXPECTED	RANGE
Swale	Undisturbed; no rills	0.4	0.3 - 0.5
Eroded	Old rills common	0.2	0.1 - 0.2
Drops	Holes, depressions	1.0	0.9 - 1.0
Fans	Sidehill and ridge; no rills	vegetated	0.3 - 1.0
LWD	Windows, slash, natural falls	1.0	0.8 - 1.0
Open	Trails, paths; not connected	0.4	0.2 - 0.7
Wander	Cobbles, hummocks; no rills	1.0	0.8 - 1.0

For example, given:

Distance between culverts: 500 feet

Road slope: 6 percent

Ditch cutting: 0.2 feet

Buffer type: fan

60 percent well-distributed litter and rooted plant cover, on granite soil

To calculate the buffer distance, first calculate Rms:

Rms = (500/1000) x 6 percent = 3.0

Next calculate Vbfr:

Vbfr = (10 + 10x3 + 0.2x100)/0.6 = 100 feet

Therefore, 100 feet should provide an adequate buffer between the normal high water line and soil disturbance. However, if there were some reason that this buffer distance could not be met, the outcome can be changed by changing the “givens.” For example:

· rocking the ditch changes the Gdp from 0.2 to 0 (Vbfr = 67 feet);

· adding LWD changes Vcvr from 0.6 to 1.0 (Vbfr = 60 feet);

· doing both changes Vbfr from 100 feet to 40 feet

In this study (C. Ohlander, unpublished), the effects from 2-track roads, as well as single and double lane gravel roads were observed. Data was also collected from both water-barred and out-sloped roads. Roads were selected from four major geologies (schist, limestone, quartz monzonite, and sandstone and mixed shaly

sandstone). Roads were chosen with steep grades and of an age that would allow long-term effects to be studied. When possible, the roads were observed following intense thunderstorms so that the greatest effects could be noted.

The conclusion of the research was that this equation works well for determining buffer distances on the Black Hills, except for the highly erosive “red bed” sandstones in the Elk Mountain area. In this situation, the equation may provide a start, but it would be wise to add substantially to the buffer, or install a sediment basin to decrease the chance for damage to stream resources. However, even on the rest of the Forest, when the actual buffer distance is approaching the calculated buffer distance, additional measures, such as installing small sediment basins below the drainage release to protect against a sudden sediment flush which could occur during construction, need to be considered.

Literature Cited

Ohlander, C. Watershed sciences glossary. USDA-Forest Service. Region 2: Denver; 1993.