WETLAND
AND
STREAM BUFFERS

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NATURAL WATER FILTERS

A relatively simple way to reduce or eliminate impacts to aquatic resources from adjacent land uses is to maintain buffers around the resources. *Buffers* are vegetated zones located between natural resources and adjacent areas subject to human alteration. In some locations, a buffer may be referred to as a *vegetated filter strip*. The emphasis on the filtering functions of buffers is derived from their widespread use to remove sediments and other waterborne nutrients and pollutants from surface runoff.

In general, riparian and wetland buffers do the following:

?? moderate runoff and stream temperatures (runoff from pavement is significantly warmer than runoff that passes through soil and vegetation, and trees provide shade for streams);
?? control the velocity, quantity and quality of stream flows;
?? enhance wildlife habitat diversity;
?? stabilize streambanks and reduce channel erosion;
?? regulate channel shape and size, reducing potential future impacts on adjacent properties;
?? provide principal energy source for the base of the food chain (detritus/leaf litter);
?? enhance food web and species richness;
?? reduce potential formation of fish migration barriers (shallow areas and accumulated sediment);
?? enhance recreational opportunities;
?? attenuate nitrogen from shallow groundwater flows to streams;
?? mitigate the effects of watershed imperviousness;
?? increase property values;
?? allow for future restoration/reforestation of stream corridors.

Recent research has shown that stream and wetland buffers can improve the quality of water resources by removing or ameliorating the effects of pollutants in runoff and increase the biological diversity and productivity of stream and wetland communities by improving habitat and adding to the organic food base. Forest buffers can function, often simultaneously, as filters, sources, transformers and sinks.

Forest buffers filter sediment and other suspended solids from surface runoff. Sediment is probably the most common and most easily recognized of the nonpoint source pollutants. Sediment suspended in the water can reduce or block sunlight penetration, adversely affecting the growth and reproduction of beneficial aquatic plants. Sediment deposited on stream bottoms can interfere with the feeding and reproduction of bottom dwelling fish and aquatic insects, weakening the food chain. Large deposits of sediment can overfill stream channels and floodplains, greatly increasing the potential for flooding. Furthermore, nutrient and pollutants adsorb to sediment particles. When sediment is transported via erosion, these nutrients and pollutants also are transported.

Several mechanisms of sediment removal work in the streamside forest. Some sediment settles out as the water flow speed is reduced by the many obstructions encountered in forest litter. Additional sediment is filtered out by the porous soil structure, vegetation and organic litter as the runoff flows over and into the floor of the forest buffer.

Phosphorus also is reduced by the filtering action of the forest buffer because about 85 percent of available phosphorus is attached to the small soil particles comprising the sediment. Approximately 4 percent of the phosphorus is bonded to the small soil particles comprising the sediment. Approximately 4 percent of the phosphorus is attached to soil particles too small to be filtered by these processes resulting in a removal of about 80 percent of phosphorus by the forest filter. The minor amount of ammonium which is bound to sediment can be filtered out in the same way. Nitrogen, too, is filtered out in large amounts by the buffer. However, dissolved phosphorus and nitrate must be removed by either microbial or biochemical transformation processes.

The forest buffer also acts as a transformer when chemical and biological processes within it change the chemical makeup of compounds. For example, under oxygenated soil conditions, bacteria and fungi in the forest buffer convert nitrogen in runoff and decaying organic debris into mineral forms. These forms can then be synthesized into proteins by plants or bacteria. When soil moisture is high enough to create anaerobic conditions in the litter and surface soil layers, denitrifying bacteria convert dissolved nitrogen into various nitrogen gasses, returning it to the atmosphere. Studies have shown that the amount of nitrogen in runoff and shallow groundwater can be reduced by as much as 80 percent after passing through a forest buffer.

The forest buffer further acts as a transformer when toxic chemicals such as pesticides are converted to non-toxic forms. Because of continued improvements in the formulation and management of pesticides, only very small amounts manage to leave the area of application. These residues, borne by runoff, are converted to non-toxic compounds by microbial decomposition, oxidation, reduction, hydrolysis, solar radiation and other biodegrading forces at work in the soil and litter of the buffer.

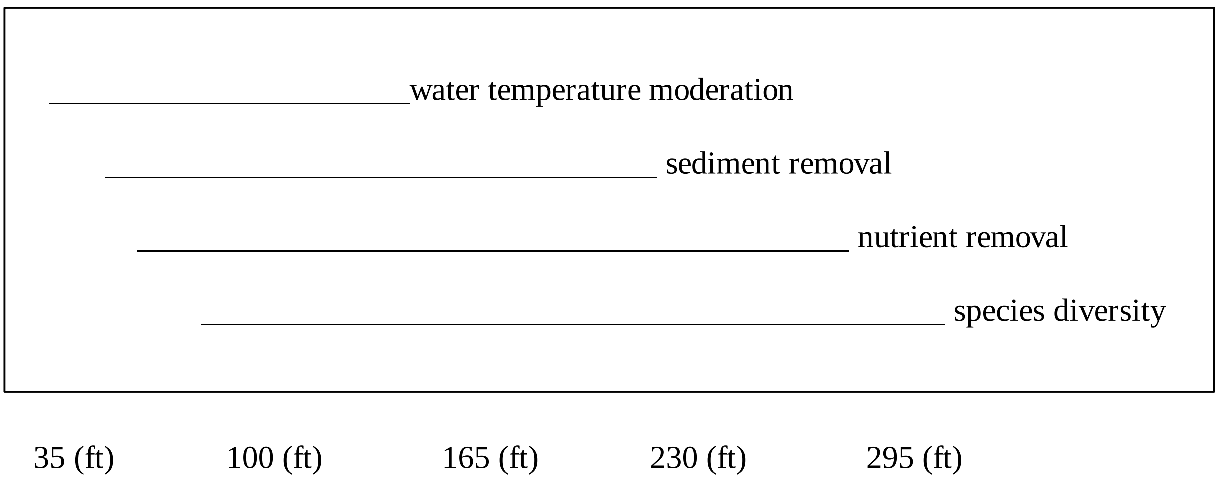
The forest buffer also functions as a sink when nutrients are taken up by plants and sequestered in plant tissue. Some estimates indicate that 25 percent of the nitrogen removed by the forest buffer is assimilated in tree growth which may be stored for long periods of time in woody tissue and possibly removed as logs or other forest products. Nitrogen and other nutrients also may be passed up the food chain when litter can be stored for longer periods as peat. Sediments filtered out by the buffer remain to become incorporated into the forest soil.

Four criteria have been identified for determining adequate buffer sizes for aquatic resources: (i) resource functional value, (ii) intensity of adjacent land use, (iii) buffer characteristics, and (iv) specific buffer functions required. Generally, smaller buffers are adequate when the buffer is in good condition (e.g., dense native vegetation, undisturbed soils), the wetland or stream is of relatively low functional value (e.g., high disturbance regime, dominated by non-native plants), and the adjacent land use has low impact potential (e.g., parkland, low density residences). Larger buffers are necessary for high value wetlands and streams that are buffered from intense adjacent land uses by buffers in poor condition.

BUFFER SIZE REQUIREMENTS

The range of generally appropriate buffer widths for several buffer functions is variable depending on the biological, chemical, and physical characteristics of the buffer. Figure 1 provides a schematic presentation of buffer widths in relation to specific pollutant reduction goals. The results illustrate that buffer sizes may vary widely, depending on specific desired functions and buffer characteristics.

Range of buffer widths providing specific buffer functions



SEDIMENT REMOVAL AND EROSION CONTROL

Vegetated buffers control erosion by blocking the flow of sediment and debris, by stabilizing streambank and wetland edges, and by promoting infiltration (Shisler et al., 1987). Buffer vegetation forms a physical barrier that slows surface flow rates and mechanically traps sediment and debris. Roots maintain soil structure and physically restrain otherwise erodible soil. Because flow rates are generally lower for sheet flow than for channelized flow, vegetation resists the formation of channels (water will flow more slowly over vegetation, allowing more time for settling of sediments and infiltration).

Wong and McCuen (1982) derived an equation to determine effective buffer widths, based on sediment particle size, slope, surface roughness, and runoff characteristics. While small buffers were found to remove small amounts of sediments, the relationship between buffer width and percent sediment removal was nonlinear; disproportionately wider buffers were required for incrementally greater sediment removal. For example, if the design criteria for sediment removal were increased from 90 to 95 percent on a 2 percent slope, then the buffer widths would have to be doubled from 100 to 200 feet.

Young et al. (1980) found that an 80-foot-wide vegetated buffer reduced the suspended sediment in feedlot runoff by 92 percent, but Schellinger and Clausen (1992) determined that a 75-foot-wide buffer removed just 33 percent of the suspended solids from dairy farm runoff. Horner and Mar (1982) reported that a 200-foot-wide grassy swale removed 80 percent of the suspended solids and total recoverable lead; Broderson (1973) also found that 200-foot-wide buffers effectively control sedimentation, even on steep slopes. According to Lynch et al. (1985), a 98-foot-wide buffer between logging activity and water resources removed an average of approximately 75 to 80 percent of the suspended sediment in stormwater. Greater sedimentation resulted from forested areas that had been commercially clear-cut and then denuded with an herbicide because of channelization, which developed following these activities. Ghaffarzadeh et al. (1992) examined sediment removal by grass vegetated filter strips ranging from 0 to 60 feet on 7 and 12 percent slopes. They found no different in vegetated filter strip performance on either slope beyond 30 feet, where 85 percent of the sediment was removed.

EXCESS NUTRIENT AND POLLUTANT REMOVAL

Buffers remove pollutants and excess nutrients from runoff, but the rate of removal appears to be a function of the length, slope and soil permeability of the buffer, the size of the contributing buffer area, and the runoff velocity. Therefore, recommended buffer widths for nutrient and pollutant attenuation vary widely. In general, the recommended width is 100 feet or more. However, few opportunities exist in the WAC 5 study area to establish 100-foot-wide buffers. Fortunately, some research indicates that lesser buffers may contribute significantly to the reduction of nonpoint source pollutants. Madison et al. (1992) examined the ability of grass vegetated filter strips (VFSs) to reduce nitrogen and phosphorus during two simulated storm events (the equivalents of the 1-year and 10-year events). Grass VFSs which were 30 feet wide had trapping efficiencies of between 96 and 99.9 percent. Vegetated filter strips wider than 30 feet did not result in further improved trapping efficiencies, according to Madison. Dillaha et al. (1989) reported that 30-foot-wide and 15-foot-wide VFSs removed an average of 84 and 70 percent of suspended solids, 79 and 61 percent of phosphorus, and 73 and 54 percent of nitrogen, respectively. Xu et al. (1992) found that nitrogen concentrations were reduced from 764 mg to approximately 0.5 mg in a 30-foot-wide mixed herbaceous and forested buffer strip in the North Carolina Piedmont. Wooded riparian buffers in the Maryland coastal region were found to remove as much as 80 percent of excess phosphorus and 89 percent of excess nitrogen, most of it in the first 62.3 feet (Shisler et al. 1987). Schueler (1987) suggested that, as an “absolute minimum,” an unmanaged/unmowed grass strip should be at least 20 feet wide, but better performance is achieved if the strip is 50 to 75 feet wide, plus an additional 4 feet per each 1 percent of the site’s slope.

MODERATION OF STORMWATER RUNOFF AND WATER TEMPERATURE

Wetland stream buffers affect the quantity as well as the quality of stormwater runoff. A vegetated buffer zone that resists channelization is effective in decreasing the rate of water flow and, in turn, increasing the rate of infiltration (Broderson, 1973). Bertulli (1981) concluded that adjacent forest vegetation and litter lowered stream water elevations from 32.3 feet to 17.3 feet for a 100-year flood.

Forested buffers adjacent to wetlands provide cover, thereby helping to maintain lower water temperatures in summer and lessen temperature decreases in winter. Broderson (1973) found that 50-foot-wide buffers provided adequate shade for small streams; further, buffer widths along slopes can decrease with increasing tree height with no significant loss of shading. Lynch et al. (1985) determined that a 100-foot-wide buffer from logging operations maintained water temperatures within 2 to 3 degrees Fahrenheit of their former average temperature.