forestry & natural resources
ENVIRONMENTAL FORESTRY

Forestry and Water Quality: Pollution Control Practices

P. E. Pope, Assistant Professor of Forestry

Control of water pollution resulting from forestry activities using the best management practices (BMP) approach will generally involve a combination of prevention and reduction measures which are built into the interrelated activities of the access system, the harvest system, the crop regeneration methods, and the other intermediate activities. These prevention and reduction practices modify some aspect of the interactions among land capability, silvicultural activity, created conditions, natural mechanisms, and the associated pollutants.

Due to the complexity of the interaction among all the variables and among the various practices themselves, experienced natural resource managers should make recommendations to develop a feasible BMP for the solution of a particular water quality problem and for the prevention and/or reduction of pollution. Blanket prescriptions are not safe. A practice or mix of practices that could be a feasible solution to a potential pollution problem in one situation may not be feasible in another, or may even aggravate the problem. Therefore, a feasible, implementable BMP must be determined on a site-by-site basis with full consideration for overall management objectives.

Prevention Practices

Pollution prevention practices should be carefully thought out during the planning stage rather than relying on adaptive techniques developed during the actual silvicultural operation. These practices can be applied under a wide variety of management alternatives to meet a number of objectives.

The following is a list of the general type of prevention practices. (No priority should be attached to the order of the listing.) Particular attention is paid to how these practices relate to water quality or water pollution control.

1. Correlate road and harvest plans to obtain the combination that will minimize the potential for non-point source pollution.
2. Locate access routes to avoid, to the extent possible, high hazard areas such as those known to contain a potential for landslides, highly erodible soils, and unstable stream channels. This is the most effective of all practices since the effects of poor location often cannot be overcome through project design or use of reduction practices.
3. Time the construction of stream crossings to minimize direct impact on the stream.
4. Design roads to minimize large cuts and fills immediately adjacent to stream channels. That is, make the roads fit the topography.
5. Provide for adequate surface and subsurface water control.
6. Provide for adequate reduction measures where high hazard areas cannot be avoided.
7. Select the proper operational methods and equipment for the specific site conditions.
8. Locate and lay out timber harvest areas to minimize the intensity of activities and the use of high hazard areas, particularly those immediately adjacent to stream channels.
9. Schedule activities in both time and space to control the amount of disturbance in any given watershed at any one time.
10. Minimize use of pesticides and other chemicals, and carefully analyze their need before application.
11. Minimize the use of practices which increase infiltration or the concentration of water in areas where mass soil movement (landslides) is a hazard.

The preplanning process indicated in the preceding list can be exemplified by considering a stream side management situation. Preplanning would include management direction and operational stipulations regarding the type and method of operation within this area. Some examples might be: a) maintain sufficient amount of natural ground cover and density of trees and other vegetation along streams to protect against some thermal pollution, stream bank erosion, and the direct movement of potential pollutants into the stream channel; b) locate landings, skid trails, and tractor roads to avoid paralleling the stream channels for long distances, to minimize the number of channel crossings, and to avoid dragging logs down existing drainage channels or creating artificial drainage patterns; c) use culverts of sufficient size to accommodate high flow conditions; d) fell trees away from drainage along perennial or intermittent water courses; and e) inspect periodically the stream crossings and drainage systems to insure the clearing of channels and culverts for maximum discharge capacity.

Reduction Practices

1. *Practices to reduce the erosion potential.*

Sediment produced by erosion is generally recognized as the greatest pollutant from a non-point source. Erosion of soil by water can take a variety of forms. On the land, surface erosion may consist of sheet erosion, rill erosion, and/or gully erosion. In the stream channel, erosion may consist of stream bank erosion and/or channel down cutting. Mass soil movements may also occur in various forms such as landslides, mud flows, or downward creep of entire hillsides. Table 1 lists the principal types of erosion control practices applicable to silvicultural activities, their general types of application, and some of their favorable and unfavorable features.

2. *Nutrient management practices.*

Nitrogen and phosphorous are the primary nutrients that may be affected by silvicultural activities. If not carefully controlled, additions of plant residues and fertilizers by man may increase the level of these constituents above their natural levels in streams within or below forest areas.

Nutrient cycling is an important component of the soil-plant complex and interrelated processes which are going on continuously within the forest ecosystem. Nutrients are directly related to soil formation processes and soil productivity. During this cycling process, excess amounts of organics and inorganics may be removed from the land by direct runoff, by leaching and discharge via ground water, and by association with sediment from erosion. Practices which reduce direct runoff and/or erosion also are effective in reducing the transport of excessive amounts of nutrients to receiving waters. However, in cases where the most important transport mechanism is leaching and discharge via ground water, such as in highly porous geologic materials or areas with high water tables, additional or alternative practices may have to be used to achieve the desired level of control. These alternative practices involve modified use of fertilizers and methods to dispose of forest residues (slash).

3. *Control of nutrient pollution from forest fertilization.*

While still a relatively minor operation, the application of chemical fertilizers to sizable areas of commercial forests as a means of stimulating growth of new plantations or established stands of trees has, in some areas, expanded rapidly over the last few years. Fertilizers are also applied to forest lands for a number of other silvicultural purposes such as 1) to increase the production of seed from selected trees within a forest stand or from genetically selected groups of plants within a seed tree orchard, 2) to improve the color and the needle retention in Christmas tree plantations, 3) to aid survival and initial growth of individual tree plantings, and 4) to aid establishment and growth of vegetation on road cuts and fills.

Nutrient pollution from fertilization on forest lands is controlled by using techniques which avoid direct application to surface waters. Also involved are the elimination of excessive applications, the selection of the proper fertilizer formulation, and the proper timing and method of application. The key factors in the selection of the type of fertilizer and the method of application which are most appropriate for pollution control are local soil nutrient deficiencies, the physical condition of the soil, the plant species requirements, cost factors, weather conditions, access, and topography.

Control of Nutrient Pollution Through Treatment of Forest Residues

Forest residues accumulate as a result of natural mortality of forest vegetation and from land management activities, including silviculture. These residues represent both negative and positive environmental values and may be both an impediment and an environmental variable that can be manipulated to advantage. The forest residues play a complex role in the forest system. They may act as a source of nutrients, a fire hazard, an eye-sore,a protective cover to the soil, an obstruction to the movements of man and animals and as a source of food, shade, and shelter for some wildlife species. Forest residues may also be potential sources for insects, diseases, and water pollution.

Many methods of treating forest residues, particularly residues resulting from timber harvesting, have been used in various parts of the country. Generally these methods are designed to increase utilization, to lessen fire hazard, to prepare seedbeds, to remove obstacles to planting, to improve the scenic quality of the area, and to rehabilitate stream channels.

The major treatment has been burning either over the entire harvested area or in selected locations. Large residue material, such as portions of cut trees which are unsuitable for timber and poor quality unmerchantable stems, may be turned into other marketable products such as wood chips for paper or fuel. Residue may also be disposed of or changed in physical form by some mechanical means, or it may be left without treatment subject only to the natural decomposition processes. Varying environmental conditions and management objectives indicate different treatments for forest residues.

Burning—The prescribed use of fire to modify a forest stand or to reduce the volume of forest residue to some desirable level involves careful planning. Practices to control water pollution potentials generated by prescribed burning include: 1) construction of water diversions on fire lines in hilly or steep terrain to drain the water into areas outside the burn, 2) removal of residue from natural water concentration areas prior to burning (dips in the terrain not normally considered water courses), 3) provision for an adequate strip of undistrubed surface between the prescribed burn area and water courses, 4) avoidance, to the extent possible, of intense fires on soils that are immature, highly erodible, and/or subject to the development of a nonwettable condition.

Piling residues by hand or machine for burning has long been the practice in some areas. In some cases, the residue is bunched into piles; in others, it is windrowed by a bulldozer into more or less regularly arranged patterns or rows.

Pollution control practices where residue is piled and burned may include: 1) avoiding use of equipment exerting heavy ground pressure where the soils are wet and subject to compaction, 2) avoiding location of piles within the normal high water flowage areas of natural drainage ways and water courses, 3) placing piled material in rows as nearly as possible on the contour, 4) keeping the rows fairly short and staggering them so that there is no continuous opening up or down the slope, 5) minimizing the amount of soil in the rows or piles by using tractors that have special "brush" blades with teeth, 6) avoiding the gilling of water concentration areas, and 7) back-blading on the contour and hilly or steep terrain to remove all uphill and downhill tractor ruts developed during the piling or windrowing activity.

Rearranging Residue—If land management objectives can be met, and if the volume and size are suitable, residue may be rearranged or mechanically treated and left. Such procedures might be appropriate when fire is a problem and when the maximum amount of organic material for soil protection and nutrient source outweighs other considerations. Rearranging residue includes treatment such as chipping, crushing, lopping and scattering.

Pollution control practices include: 1) disposal of material well away from stream courses, 2) restriction of use, to the extent feasible, of equipment exerting heavy ground pressure on wet or very moist soils, 3) dispersion of the material over as wide an area as practical, and 4) removal of undesirable material from stream channels and dispersion of that material over the area.

Pesticide Practices

At present, the use of pesticides in forest management for the state of Indiana is confined primarily to individual stem injection in TSI (Timber Stand Improvement) or to ground applications in plantation establishment. Under these conditions, the probability of direct pollution into stream water courses is minimal. In most instances, these pesticides are used only when they are cost effective, and their benefits often outweigh environmental impacts. Pesticides are usually applied on a periodic basis, generally at intervals of several years. Ground, and to a limited extent, aerial applications of pesticides may be used to control insects, rodents, diseases, and weeds and other undesirable vegetation.

The most important redistribution process associated with pesticide pollution is direct transport by runoff. However, the mechanisms of leaching or subsurface flows may be important in areas of highly porous geologic materials, permeable soils, or high water tables.

Practices that control erosion and runoff also reduce loss of applied pesticides. In addition to these practices, a number of other often used options exist. These options involve manipulation of the pesticide itself such as form, timing of application, etc. These can be used alone or in conjunction with the erosion and runoff control measures.

Table 1. Principal types of reduction practices for erosion control applicable to silvicultural activities with some favorable and unfavorable features in terms of water pollution control (after EPA Tech. Report 37, 1977).

Erosion Control Practice	General Types of Application	Some Favorable and Unfavorable Features
Seeding or planting of grasses or other herbaceous vegetation	Bare soils or soils with inadequate cover where tree reproduction is not desired (short-lived forbs, grasses, or legumes where tree establishment is desired). Not an effective technique for controlling pollution caused by landslides or other forms of mass soil movement.	Provides a relatively quick cover which decreases soil erosion; improves infiltration capacity of the soil, and may reduce overland flow of water. Relatively inexpensive. May require fertilization for establishment and growth. Grasses and other long-lived vegetation usually add to reforestation difficulty.
Seeding or planting of trees or other woody vegetation	Bare soil or soils with inadequate cover	Improves infiltration capacity of the soil and aids in reducing overland flow of water after litter layer of natural materials develops. Often takes 5 years or more to become effective. Can result in decrease of water yields under some circumstances. Moderate initial cost. May require fertilization for proper growth and vigor.
Dispersal of runoff concentrated by man's activities	Tractor roads, skid trails, and logging roads	Retards surface runoff by reducing slope length and area of concentration. Permits infiltration of water as it is spread onto stable surfaces. Can increase soil erosion if water is directed to unstable areas where it cannot spread and infiltrate. May require installation of energy dissipators. Moderate initial cost and some maintenance costs.
Physical treatment of the land or soil to improve infiltration or detain runoff (contour trenching, furrowing, etc.)	Areas where soil moisture or rapid surface runoff inhibit adequate plant establishment and growth	Retards surface runoff by reducing slope length and area of concentration. Increases infiltration and improves soil moisture on treated areas, thereby aiding plant establishment and growth. Loses effectiveness and can result in greater soil loss if these practices fail. Substantial initial cost and some maintenance costs.

Erosion Control Practice	General Types of Application	Some Favorable and Unfavorable Features
Debris Removal or Dispersal	Stream channels	Reduces concentration of organic materials. Removal from stream channels lessens chance of debris dams and sediment deposits forming and subsequent stream bank erosion. May result in damage to stream banks and stream bottoms if not carefully done. Must be coordinated with fisheries' habitat and other land management objectives. Moderate to substantial cost.
Mulching	Bare soils or soils with inadequate cover where steepness of slope or soil moisture conditions are critical	Aids in maintaining soil moisture and reduces the rate of overland flow, thereby allowing more water to infiltrate within the soil capacity. May have a positive or negative influence on nutrient addition depending on physiochemical environment. May also result in a higher BOD (Biological Oxygen Demand) load if washed into receiving waters. On some soils, increases need for nitrogen fertilizers. Moderate cost.
Structural measures such as debris basins, sediment ponds, retaining walls, water flow retarding structures, etc.	Stream channels, areas of mass earth movement	Retards the movement of water and associated pollutants from the land to receiving waters and/or within stream channels. Possibility of some additional pollution during construction. Moderate to substantial installation and maintenance cost.
Chemical treatment of soil (flocculents or surficants)	Certain fine textured soils and/or soils which are difficult to wet	Application of flucculents on certain fine textured soils causes aggregation of soil particles which improves infiltration capacity and aids in reducing overland flow of water. Pollution potential of chemicals varies and in many cases is unknown. The effectiveness of some flocculents is inversely related to clay content. Application of surficants, which reduce the surface tension at the water/soil interface, has been used with varying degrees of effectiveness for improving initial infiltration rates of some soils. The pollution potential of many surficants is unknown.

Control of Thermal Pollution

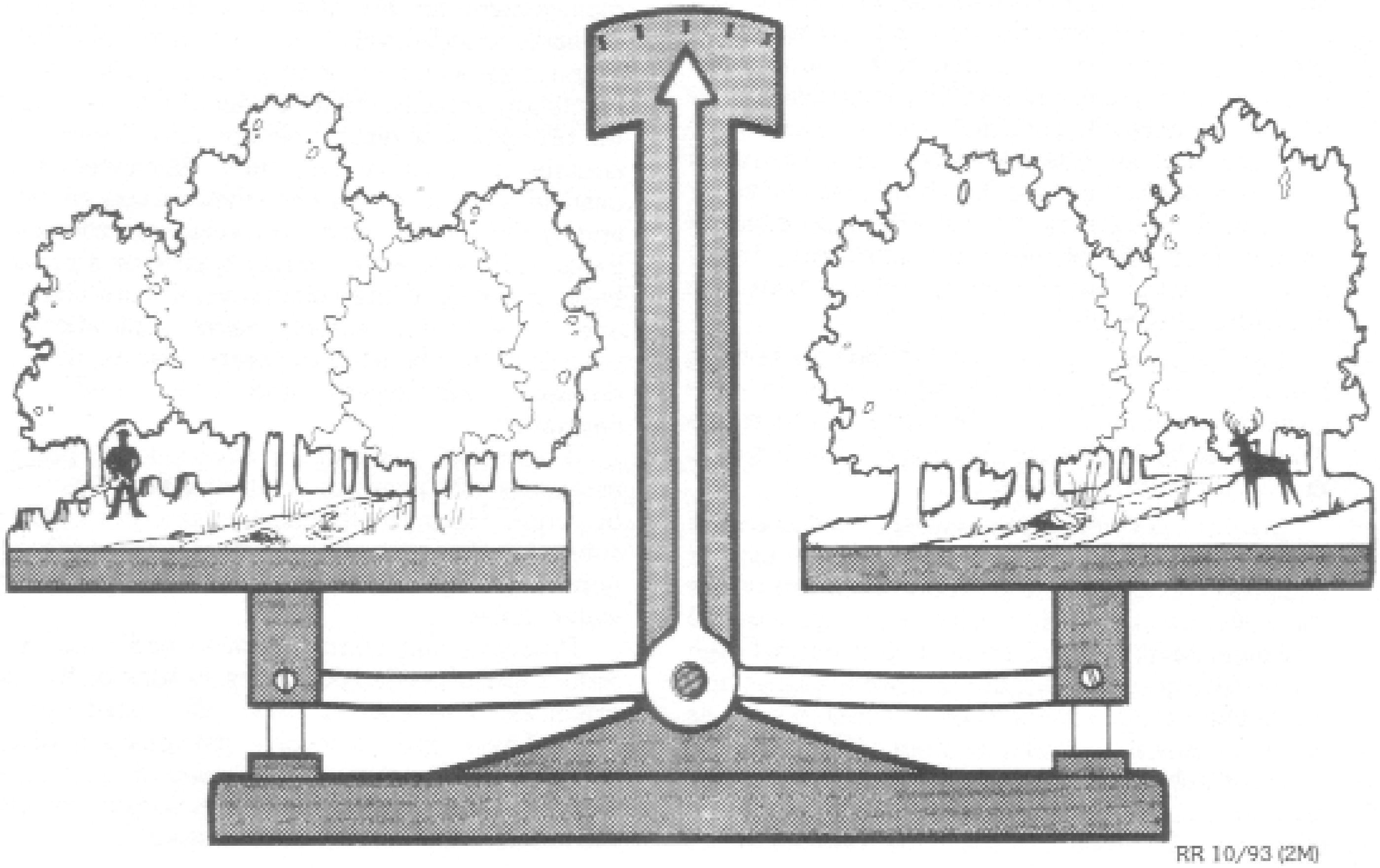
The most important factor influencing changes in stream water temperature is shade. In addition to shade provided by vegetation, water temperatures are also influenced by topography, surface area and volume of the stream, altitude, stream gradient, underground water inflow, and type of stream or channel. However, by maintaining adequate vegetation cover of such height and density as to adequately shade the stream during periods of maximum solar radiation, abnormal water temperature increases can often be prevented or minimized. The intentional reduction of shade provided by vegetation can also be used to increase water temperature to favor certain aquatic species where desirable.

If the residual vegetation is not of the proper density, the stream may not be effectively shaded, even though the vegetation is of sufficient height. In general, the most efficient shade producers are young, brushy, wide-crowned trees, but understory vegetation including many species of brush generally provide very adequate shade for small streams. The state of the art has not advanced to the point where the amount, type, location, and width of vegetation that must be left to prevent or minimize abnormal increases in water temperature in a particular stream can be prescribed with any degree of certainty. This will vary from site to site depending upon the many factors previously described. Stream characteristics such as width, volume of flow, gradient, and streambed collectively influence the effect on water temperatures of any given amount of exposure to solar radiation.

Although there has been significant progress in the development of techniques for predicting water temperature increases, these techniques have not been tested sufficiently for general application, and except for those areas where fully tested prediction techniques are available, local experience and professional judgment must be applied on a case-by-case basis.

Summary

Pollution potentials often differ widely within a relatively small geographic area. Therefore, control practices can be most accurately prescribed on a site-by-site basis. However, plans can be developed for a larger area if they allow flexibility in practice selection. Such BMP selection must correspond to detailed differences in soil and vegetation types, slope characteristics, and other natural conditions.



RR 10/93 (2M)

Cooperative Extension work in Agriculture and Home Economics, state of Indiana, Purdue University, and U.S. Department of Agriculture cooperating; H. A. Wadsworth, Director, West Lafayette, IN. Issued in furtherance of the acts of May 8 and June 30, 1914.
The Cooperative Extension Service of Purdue University is an affirmative action/equal opportunity institution.

PRINTED WITH SOY INK

Printed on Recycled Paper