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Water quality protection in bioenergy production: the US system of forestry Best Management Practices

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Abstract

United States federal law requires that states operate programs to address non-point source pollution. Forestry non-point source programs vary among states in their approach. Some states have laws that prescribe mandatory practices to control pollution, whereas other states use voluntary approaches of Best Management Practices (BMPs) and education and outreach programs. States routinely monitor the extent of BMP implementation so as to improve educational programs and thus improve implementation. Many states also have conducted studies to assess whether BMPs are effective in protecting water quality. A growing body of literature strongly suggests that properly implemented BMPs do protect water quality. A variety of private efforts, ranging from forestry certification systems to research support, are improving BMP implementation and effectiveness. BMPs developed for conventional forestry should be applicable to bioenergy systems. Bioenergy systems may include more frequent fertilization than conventional forestry, so managers must ensure that existing BMPs on fertilization and riparian management zones be fully implemented. Bioenergy systems using short-rotation woody crops will need careful implementation of BMPs for permanent roads and stream crossings.

Keywords: Non-point source pollution; Clean Water Act; Forestry; Timber harvesting

1. Introduction

A very important aspect of conventional forestry is protecting water quality in streams, rivers, and lakes from potential degradation from operations such as timber harvesting, site preparation, roads and skid trails, fertilization, and herbicide applications. This is no less true for bioenergy production than for conventional wood products. This paper will describe the United States' approach to forestry water quality protection and discuss its significance to bioenergy production.

2. Development of Best Management Practices

2.1. Federal basis for forestry water quality protection

Concerns about impacts to water quality from forest management go back to the birth of professional forestry in the United States [1]. Forest watershed studies began early in the 20th century when foresters began to realize the importance of water quality, both for human consumption and for aquatic biota [2]. Oregon's 1971 Forest Practices Act made it the first state in the United States to provide comprehensive water quality protection [3]. But the passage of the Federal Water Pollution Control Act Amendments of 1972 (more commonly known as the Clean Water Act) substantially accelerated the development of state water quality protection programs for forestry across the United States.

The goal of the Clean Water Act is to "…restore and maintain the chemical, physical, and biological integrity of the Nation's waters" [4]. The act differentiated water pollution into two types: point sources such as end-of-pipe discharges from industrial facilities and municipal sewage treatment plants, and non-point sources such as agriculture, urban stormwater runoff, construction, and forestry. Point source pollution was addressed by application of best available control technology. Non-point source pollution was addressed by "Best Management Practices" (BMPs),

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defined by the US Environmental Protection Agency (EPA) as: "…a practice or combination of practices, that are determined by a state, or designated area-wide planning agency, after problem assessment, examination of alternative practices, and appropriate public participation, to be the most effective, practicable (including technological, economic, and institutional considerations) means of preventing or reducing the amount of pollution generated by non-point sources to a level compatible with water quality goals" [3].

In the 1972 Clean Water Act, Section 208 required states to develop programs to address non-point source water quality problems. Amendments in 1987 added Section 319, which required states to identify the leading causes of non-point source pollution and to develop specific programs to address these causes. States may receive funds from EPA to help fund these programs, once EPA has reviewed and approved each program [5]. Most states that had not already developed forestry water quality programs under Section 208 implemented such programs soon after Section 319 was enacted.

The US EPA biennially publishes a compilation of water quality reports from US states and Native American tribes and summarizes causes of impairment in terms of total length of rivers and streams impaired and area of impaired lakes and estuaries. Impaired waters either violate water quality standards or do not meet designated uses. In the most recent report [6] EPA reported that silviculture was ranked nationally as the ninth most common cause of river and stream water quality impairment, responsible for 10.5% of the assessed river and stream length. Sediment is the pollutant most associated with silvicultural water quality impairment and generally results from improper roads and stream crossings. The most common cause of water quality impairment was agriculture, at 48% of impaired river and stream length. The extent of silvicultural water quality impairment varied substantially among states with 17 states reporting less than 5% of river and stream length impaired by silviculture. Four states reported more than 10% of river and stream length impaired by silviculture: California 67.5%, Florida 13.1%, Oregon 55.3%, and West Virginia 24.7%. The median percentage reported was 3.4%. Despite forestry not being one of the highest ranked causes of non-point source pollution, it arguably has the most sophisticated and extensively implemented programs of any non-point sector.

2.2. State forestry BMP programs

The National Association of State Foresters periodically surveys states to determine the extent of BMP implementation, assess BMP effectiveness, and catalog barriers to further improvement [7]. They reported that 27 states had developed forestry BMP programs by 1990, and by 2000 there were programs in all 50 states.

BMPs offer guidance on how to conduct various forest management practices so as to protect water resources from potential impacts such as sediment and nutrients in runoff [8]. State BMP manuals usually include sections on timber harvesting, site preparation, reforestation, stream crossings, riparian management zones, prescribed burning and fire lines, road construction and maintenance, pesticides and fertilizers, and wetlands. In wetlands there are two sets of mandatory federal BMPs: 15 BMPs for road construction in wetlands [9] and six for mechanical site preparation for establishing pine plantations in certain types of wetlands [10].

States have a considerable amount of flexibility under the Clean Water Act in their non-point source water quality programs. Some states have passed legislation that makes use of forestry BMPs mandatory and may require a permit and inspection by state agency personnel. Other states have programs in which the use of BMPs are voluntary and focus on educational and outreach programs to foresters, loggers, and landowners. Table 1 lists state river and stream length reported impaired by silviculture and the type of BMP program. For states that reported silvicultural stream impairment, those with regulatory programs had the highest average rate of river and stream impairment due to silviculture (20.4%), whereas states with purely non-regulatory programs reported had the least average impairment (1.6%). States with non-regulatory programs with enforcement capabilities averaged 3.2% of stream length impaired, and states with combination programs averaged 5.1%. However, caution must be used in interpreting these data. In most cases the assignment of impairment to a particular cause such as silviculture is made subjectively without quantitative monitoring data [11]. Regulatory states on average assessed a greater fraction of their rivers and stream lengths (45%) versus non-regulatory states (31%). The majority of states with regulatory and combination programs reported silvicultural impairment, whereas most states with voluntary programs did not. Not reporting impairment may be a policy decision rather than an accurate reflection of non-point source pollution.

Aust and Blinn [12] reviewed the scientific foundation for BMPs for timber harvesting and site preparation in the eastern US. They reported that timber harvesting and site preparation result in slight increases in stream sediment, but less when BMPs are used. Effects on water quantity and quality recovered within 2–5 years. They concluded that the body of research supports the recommended BMPs.

Blinn and Kilgore [13] reviewed 49 states' riparian BMPs. They found that riparian BMPs focused on protecting water quality in perennial and intermittent streams and lakes. Six states also included recommendations for ephemeral streams [14]. The most commonly recommended riparian zone was 15.2 m (50 ft) on each side of streams, and timber harvesting within the zone should retain 11.5–17.2 $m^2 ha^{-1}$ (50–75 $ft^2 ac^{-1}$) basal area. Some states had fixed-width riparian management zones, whereas others had recommendations that adjust width based on